AFRICA, HEU MINIMIZATION: PROGRESS AND NEXT STEPS

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INTRODUCTION

Between 1956 and 2012, 13 research reactors have been built in nine of fifty four African countries. Of these, four have been shut down, one has been decommissioned, one was cancelled, and seven are operational. Four of the operating seven were originally fueled with HEU, of which, two have been converted to LEU. The remaining two HEU-fueled reactors are Chinese-built MNSRs in Ghana and Nigeria. However, HEU can be directly used to make a terrorist nuclear device. There is therefore a growing global agreement to phase-out civilian sector HEU uses. One HEU minimization approach and eventual elimination in civilian applications is HEU-LEU conversion. Twenty percent HEU enrichment (or below) is internationally recognized to be fully adequate isotopic barrier to weapon usability of 235U. This study evaluates what progress has been made in HEU minimization efforts in Africa and assesses effectiveness of those efforts based on technical foundation parameters.

OBJECTIVE

To review some of the key debates relating to research reactor and medical isotope production target conversion from HEU to LEU in the continent.

METHODS

A literature review was conducted that covered both theoretical contributions and published studies of the processes and outcomes of HEU minimization activities that have been carried out in four countries: Ghana, Libya, Nigeria and South Africa.

HEU-FUELLED RESEARCH REACTORS IN AFRICA

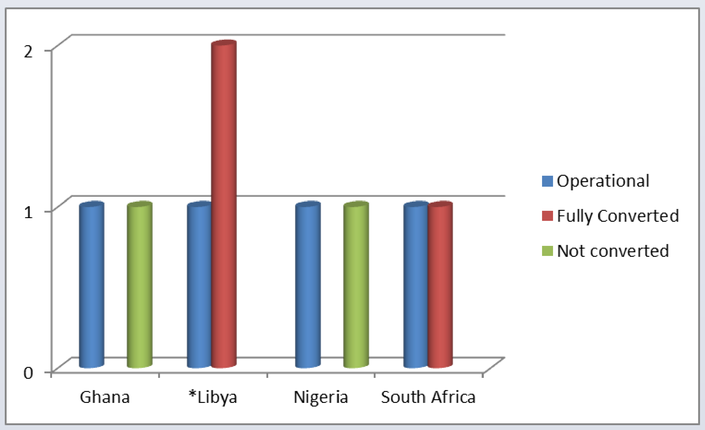

Table 1: List of reactors targeted for the study. All data were obtained from IAEA Research Reactor Database (RRDB), International Panel on Fissile Material (IPFM), and National Academies Press (NAP). Note that one reactor in (*) Libya, the critical assembly, is not listed in the IAEA reactor database.

FULLY CONVERTED REACTORS

SOUTH AFRICA'S SAFARI-1

- SAFARI-1 is a 20 MW tank-in-pool type light water reactor, based on the U.S. Oak Ridge Reactor. It began operation in 1965.
- It was fuelled solely with South African inventory HEU (UAl alloy) and the medical isotope production target plates were also manufactured from that original South African HEU inventory between the mid 80s and 2009.
- In 2001, a US-South Africa technical and economic feasibility study under the RERTR programme indicated fuel conversion was possible with minimal financial and operational risk and no change to fuel and core geometry.
- 2005, the government authorized conversion of SAFARI-1.
- NECSA adopted a three-phase approach to LEU conversion:1) Convert SAFARI-1 to LEU Fuel; 2) Convert from HEU to LEU targets for 99Mo production; and 3) Convert the Fuel Plant to LEU Fuel and Target production
- NECSA entered into a technology transfer agreement with the experienced high density silicide manufacturer AREVA CERCA in French in order to address technical challenges that confronted the MTR Fuel development team.
- 2006, first test irradiations of LEU fuel commenced.
- August 2008, National Nuclear Regulator approved conversion.
- September 2008, conversion commenced.
- 2009, conversion completed.
- In 2009, SAFARI-1 started running on LEU (U Silicide) fuel and producing medical isotope (99Mo) using LEU targets.
- 2010, following a NNSA $25 million award to NECSA towards LEU-based medical isotope production, South Africa produced and supplied the world's first large-scale quantity of Mo-99 using LEU.
- I2011, 6.3 kilograms of U.S.-origin HEU spent fuel was removed from Pelindaba and returned to the US under the GTRI Gap Material Programme.
- Full conversion of SAFARI-1 is an important step in achieving nuclear security goal in the continent.

LIBYA'S IRT-1 and ITS CRITICAL ASSEMBLY

- The IRT-1 is a Russian-built 10 MW pool type research reactor cooled and moderated by light water that began operation in 1981.
- 2003, Foreign Minister Abd al Rahman Shalgam read a statement on Libyan national television announcing the government's decision to dismantle its WMD programme and delivery systems under international supervision.
- January 2004, sensitive items were removed from Libya through a US-UK-Libya joint operation under IAEA supervision.
- March 2004, 17 kg of fresh HEU fuel from IRT-1 reactor was shipped to Russia.
- 2005, feasibility study indicated that changing the IRT-1 reactor fuel from IRT-2M HEU to IRT-4M LEU was technically and economically possible.

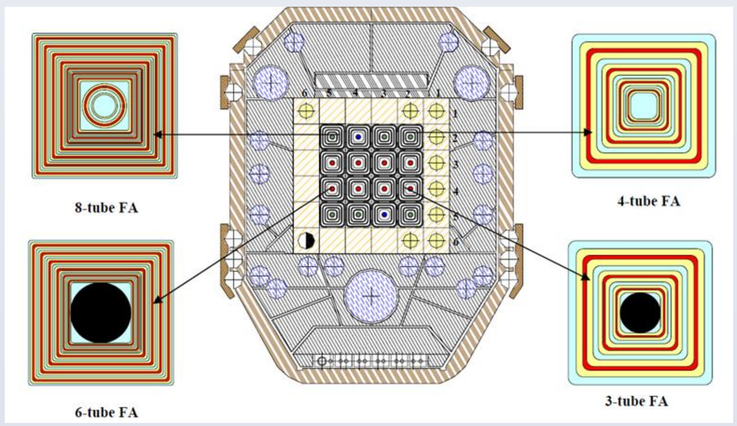

Fig. 1: Cross section of the 4-tube and 3-tube IR-2M 8-tube and 6-tube IR-4M fuel assemblies and core layout by Omran Abuzid Abulgasem, Faisel Abdula Abuatweirat, and AbduAlhamed Kh. Ajaj. The 3- tube HEU and 6-tube LEU fuel assemblies are to contain safety and shim control rods.

- January 2006, IAEA provided assistance to Libya on quality assurance in assessing control aspects of proposed LEU fuel at the fabrication plant.
- 2006, IRT-1 reactor and its associated critical assembly fuels were converted from HEU fuel to LEU fuel under a U.S.-Libya agreement.
- July 2006, Libya returned 3 Kg of fresh HEU from IRT-1 Tajoura research reactor to Russia under a U.S.-Russian intergovernmental agreement for the conversion of foreign research reactors built under Soviet projects.
- February 2007, the IAEA further assisted Libya in installing and starting up new devices and in training the Libyan operating staff at the site.
- December 2009, 20 kg HEU fuel was returned to Russia under "take-back" programme.

SCHEDULED FOR CONVERSION

GHANA'S GHARR-1 AND NIGERIA'S NIRR-1

- The last two HEU-fuelled research reactors in Africa are both Chines built Miniature Neutron Source Reactors (MNSRs, 30 kW), in Ghana and Nigeria.
- Each has a single control rod performing all safety functions with a core consisting of about 1 kilogram of HEU that is enriched to 90% or greater.
- They are scheduled for conversion in 2014.
- They jointly offer an opportunity for regional and international collaboration and interaction towards eliminating the use of HEU in civilian applications in Africa.
- February 2006, start of Ghana-US-Nigeria HEU-LEU collaboration on GHARR-1/NIRR facilities at ANL
- June 2006, the IAEA initiated a Coordinated Research Project (CRP) to assist MNSR operating countries in the conversion of these reactors to LEU.
- Studies performed under CRP established feasibility of conversion
- Generic safety analysis for the LEU fuel enable the development of updated SARs for each reactor to facilitate conversion

GHANA'S GHARR-1 AND NIGERIA'S NIRR-1

- September 2010, Chinese MNSR designer and supplier, Institute of Atomic Energy (CIAE) and the US's Argonne National Laboratory (ANL) signed an agreement to collaborate in building a Zero Power Test Facility to support the conversion of the MNSRs to LEU, a key ingredient in the conversion process.
- 2011, established a MNSR Working Group to coordinate common conversion and fuel take-back activities too China.
- 2012, completed Safety Analysis Report.
- Conversion will require facility changes: (1) Replace the current 90.2% UAl_4 HEU with 12.5 % UO_2 LEU fuel elements, (2) Increase cadmium component to Improve the control rod shutdown margin, and (3) Increase the power level by 13% to match the original HEU core flux.

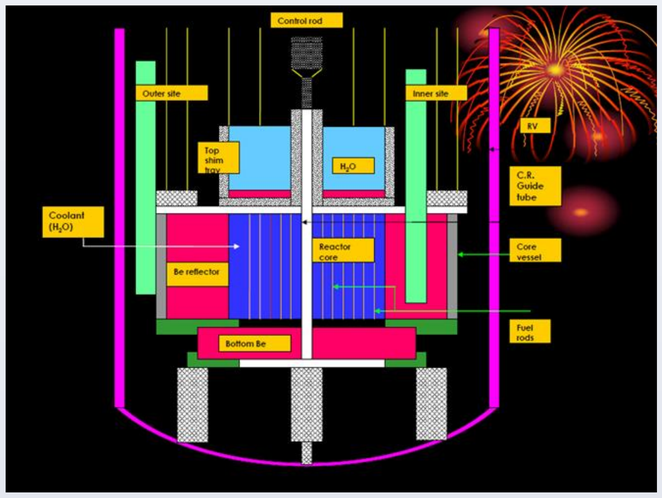

Fig.2: MCNP plot of vertical cross section of GHARR-1 reactor (single control rod) and showing structural supports by S. Anim-Sampong, B.T. Maakuu, E.H.K. Akaho

CONCLUSIONS AND NEXT STEPS

- Increase close technical and political cooperation between research institutes and government organizations is key to the progress in the reactor conversion projects and, ultimately, an absolute requirement for their success
- Fuel availability and supply assurance is important to MNSR operators
- IAEA Coordinated Research Project is which is helping participating GHARR-1 and NIRR-1 operators to collaborate and progress on MNSR conversion studies.
- Take-back approach and Gap Material Program for both HEU and future LEU minimize cost associated with post conversion waste management.
- Full conversion of GHARR-1 and NIRR-1 reactors is will mean zero annual HEU consumption in Africa and zero chance of a nuclear terrorist attack.
- Government's financial and resource commitments for projects is key to ensure that President Obama's goal of securing all vulnerable nuclear material by 2014 is achieved

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