U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration
Defense Nuclear Nonproliferation

Global Threat Reduction Initiative

National Nuclear Security Administration
Defense Nuclear Nonproliferation

Defense Nuclear Nonproliferation's Isotope Needs: GTRI's Molybdenum-99 Program Overview

2nd Workshop on Isotope Federal Supply and Demand

September 19th, 2013

GTRI Mission & Program Goals

Mission

Reduce and protect vulnerable nuclear and radiological material located at civilian sites worldwide.

Goals

1. Convert
2. Remove
3. Protect

Convert

Convert research reactors and isotope production facilities from the use of highly enriched uranium (HEU) to low enriched uranium (LEU)

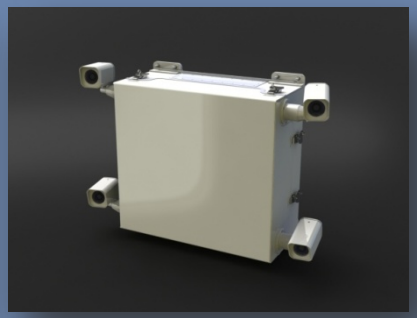
These efforts result in permanent threat reduction by minimizing and, to the extent possible, eliminating the need for HEU in civilian applications – each reactor converted or shut down eliminates a source of bomb material.

Remove

Remove and dispose of excess nuclear and radiological materials.

These efforts result in permanent threat reduction by eliminating bomb material at civilian sites – each kilogram or curie of this dangerous material that is removed reduces the risk of a terrorist bomb.

Protect

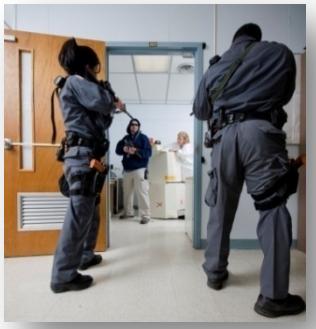


Protect high priority nuclear and radiological materials from theft and sabotage

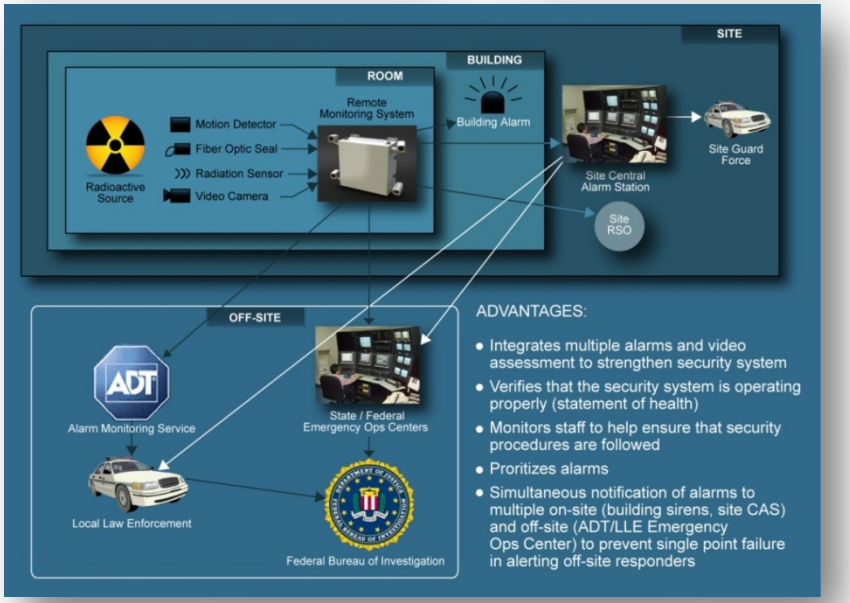
These efforts result in threat reduction by improving security on the bomb material remaining at civilian sites – each vulnerable building that is protected reduces the risk until a permanent threat reduction solution can be implemented.

GTRI's Domestic Radiological Mission

- **GTRI provides voluntary security assistance which include:**
  - **Removal of disused or unwanted radioactive sources;**
  - Voluntary security upgrades;
  - Specialized training for local law enforcement;
  - No-fault table top exercises;
  - Transportation Security



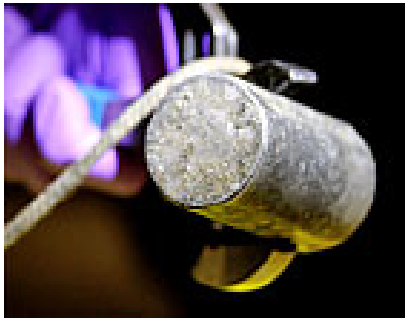
- **GTRI voluntary security enhancements are:**
  - **<u>Complementary to and do not replace</u>** the licensees requirements to meet Nuclear Regulatory Commission (NRC) and Agreement State regulatory requirements;
  - **<u>Sound, cost-effective, and prudent best practices</u>** which further improve security above regulatory requirements.



Off-Site Source Recovery Project (OSRP)

- Every year, thousands of sources become disused and unwanted in the United States.
- While secure storage is a temporary measure, the longer sources remain disused or unwanted the chances increase that they will become unsecured or abandoned. Thus, permanent disposal is essential.
- GTRI works with States, Low Level Waste Compacts and the NRC to develop more commercial disposal options and incentives (positive and negative) to encourage licensees to use commercial disposal.
- Licensees in most States do not have disposal for beta/gamma-emitting sources >30 curies or for actinide sources.
- Where commercial disposal is not available, GTRI takes title to disused sources, in the interest of national security, under AEA authorities, and works with DOE/EM to disposition them.

- **OSRP - http://osrp.lanl.gov/**
  - To date, GTRI has recovered nearly 33,000 sources totaling over 870,000 decayed Ci
  - GTRI primarily recovers Cs-137, Co-60, Sr-90, **Am-241**, Pu-238, Pu-239, **Ra-226**



Areas of Mutual Interest

Radium-226: GTRI can communicate Isotope Sales interest in acquiring Ra-226 to licensees with larger quantities of disused Ra-226. GTRI cannot fund transport of Ra-226 to a National Laboratory or assist with disposition of unsealed sources.

Alternative Technologies: From a national security standpoint and a low level waste standpoint, Alternative Technologies (e.g. x-rays, linacs, etc.) are ***preferable to devices containing sealed sources.***

GTRI is partnering with NA-22 (Research and Development) and experts in the field to learn more about non-radioactive, alternative technologies for permanent threat reduction.

> What is learned will inform both the recommendations of the Energy Policy Act-required Interagency 2014 Radiation Protection and Security ***Task Force Report*** as well as ***future GTRI implementation strategy.***

The World Institute for Nuclear Security (WINS) is hosting an ***international workshop on non-radioactive alternative technologies*** in October in Brussels, Belgium.

GTRI is working with the Low Level Waste Forum, the NRC and State regulators to find ways for ***licensees to better fully realize costs and liabilities*** associated with owning sources (e.g. financial assurance requirements, liability/insurance, license fees and restrictions).

GTRI's Conversion Projects

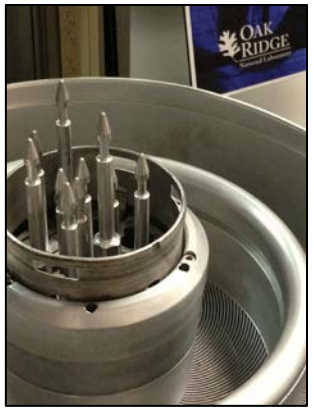
GTRI's Conversion Objective: Work domestically and internationally to convert or verify the shut down of ~200 HEU-fueled research reactors and isotope production facilities by 2030

GTRI's Convert Program is organized into three elements:

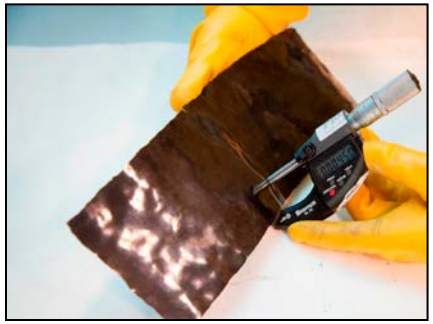
1. Reactor Conversion
   - Converting HEU-fueled research reactors worldwide to the use of LEU fuel

2. Isotope Production Conversion (Mo-99)
   - Converting HEU-based isotope production facilities to the use of LEU targets
   - Accelerating commercial production of non-HEU-based Mo-99 in the United States

3. Fuel Development
   - Developing a new high-density LEU fuel to convert the U.S. high-performance research reactors that cannot convert on existing fuels
   - Providing technical support to European and Russian partners in their development of new high-density LEU fuels for the conversion of their high-performance research reactors



Mock-up core for the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory

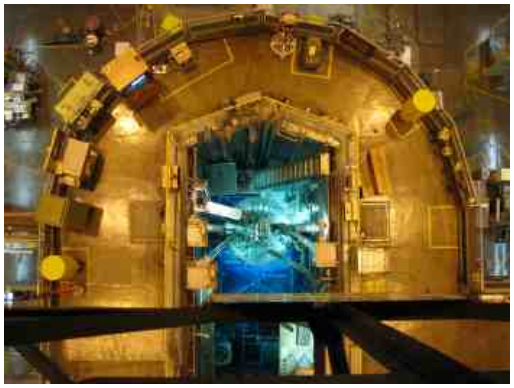


Uranium metal foil produced by Y-12 National Security Complex for use in next generation LEU Mo-99 targets

What is Mo-99?

- Molybdenum-99 (Mo-99) is the parent product of Tc-99m, a radioisotope used in approximately 50,000 medical diagnostic tests per day in the U.S. (over 18 million per year in the U.S.)
- Primary uses include detection of heart disease, cancer, study of organ structure and function, and other applications.
- Mo-99 has a short half life (66 hours) and cannot be stockpiled
- U.S. demand is approximately 50% of the world market
  - The historic global demand is ~12,000 6-day curies per week
  - The U.S. consumes ~6,000 6-day curies per week
- Mo-99 is produced at only 5 processing facilities worldwide, in cooperation with 8 research reactor facilities
  - Processing facilities located in Canada (HEU), The Netherlands (HEU), Belgium (HEU), South Africa (HEU and LEU), and Australia (LEU)
  - Research reactors used for irradiation located in Canada, The Netherlands, Belgium, France, Poland, Czech Republic, South Africa, and Australia

Tc-99m generator and labeling kits



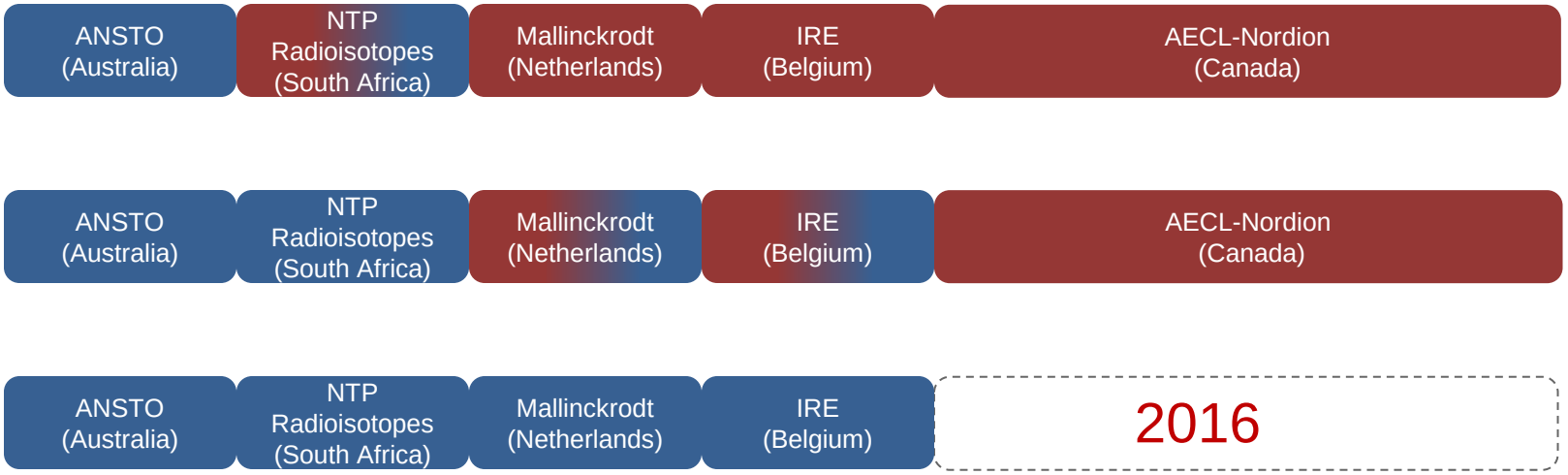
SAFARI-1 Reactor (South Africa)

GTRI & Mo-99

Transition to a Reliable Non-HEU-Based Mo-99 Supply

Global Mo-99 Market – Major Producers

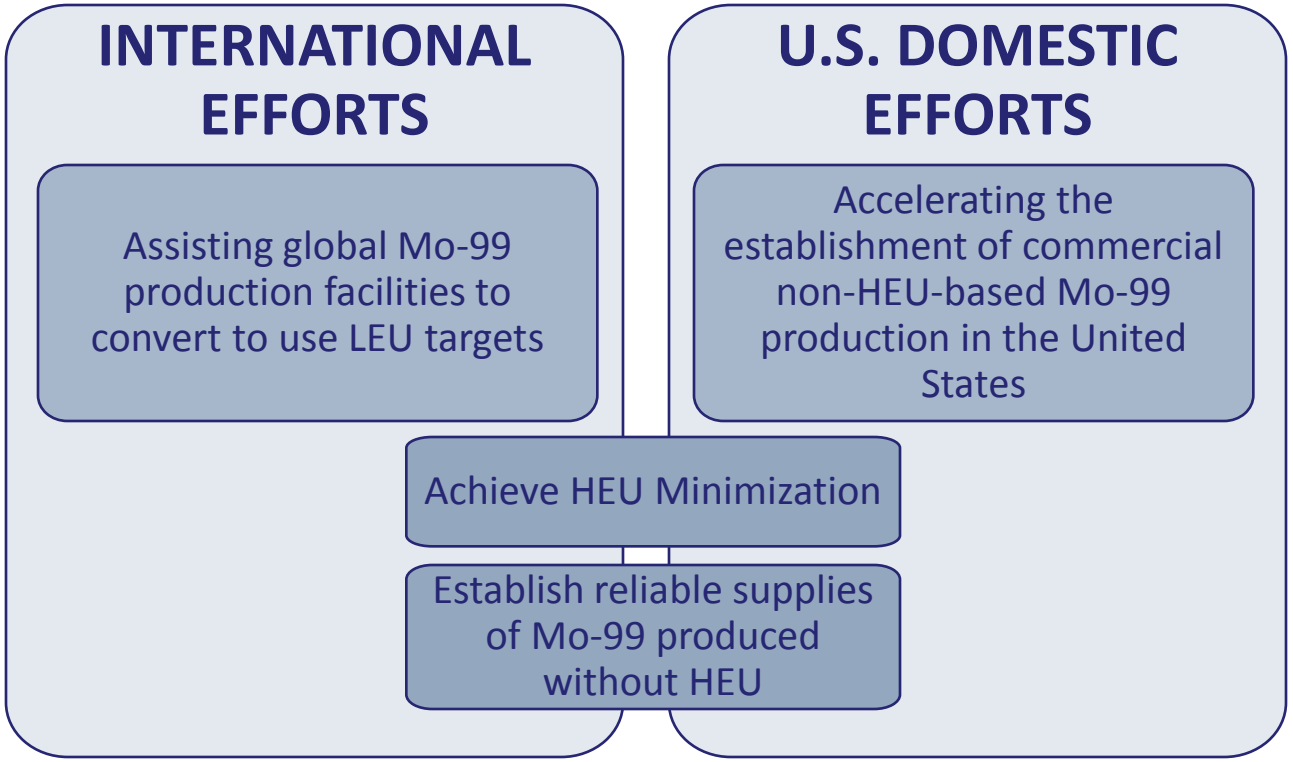
HEU | Non-HEU



U.S. Domestic Mo-99 Projects

GTRI & Mo-99
International & Domestic Balance

- Under its long-standing HEU minimization mission, GTRI provides assistance to research reactors and isotope production facilities to convert from the use of HEU to LEU.
- GTRI's mission includes accelerating the establishment of a reliable U.S. domestic supply of Mo-99 produced without the use of HEU.



GTRI & International Mo-99

Assisting Conversion from HEU Targets to LEU Targets

- **Four-party joint statement at the 2012 Nuclear Security Summit on the minimization of HEU and the reliable supply of medical radioisotopes**

  "…Belgium, the Netherlands, and France, in cooperation with the United States, reaffirm their determination to support conversion of European production industries to non-HEU-based processes by 2015….."

- **GTRI offers support to international Mo-99 producers to convert Mo-99 production from HEU targets to LEU targets**

  South Africa

  GTRI has provided NTP Radioisotopes in South Africa up to $25M in support to convert Mo-99 production from HEU targets to LEU targets by the end of 2015, and to address the HEU in Mo-99 waste residue.

  In June 2010 South Africa successfully achieved the first large-scale production of Mo-99 using LEU targets, and the first shipment of FDA-approved Mo-99 produced with LEU targets was received in the United States in December 2010.

  Belgium

  GTRI has contributed $4.8M towards the conversion of the IRE isotope production facility in Belgium from HEU targets to LEU targets for completion by the end of 2015.

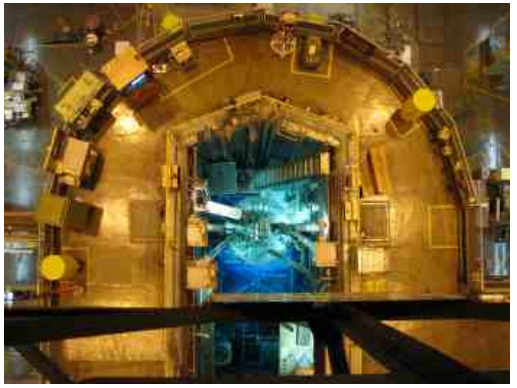
  The Netherlands

  Covidien is leading the conversion project to LEU targets by the end of 2015.

  Canada

  The NRU reactor in Canada is expected to cease isotope production in 2016.

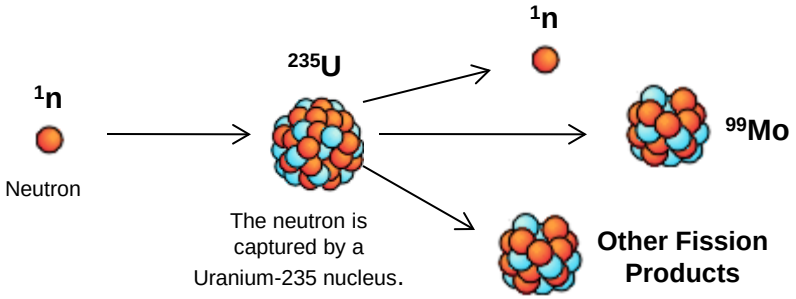
Nuclear Security Summit
Seoul 2012



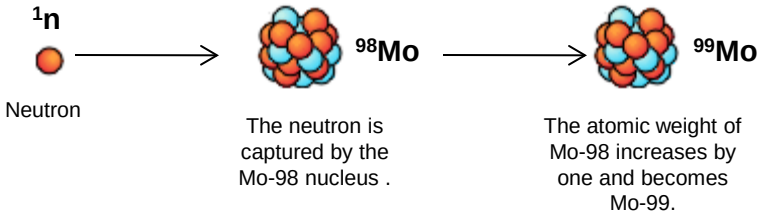
SAFARI-1 Reactor (South Africa)

GTRI and U.S. Domestic Mo-99:
Non-HEU Production Methods

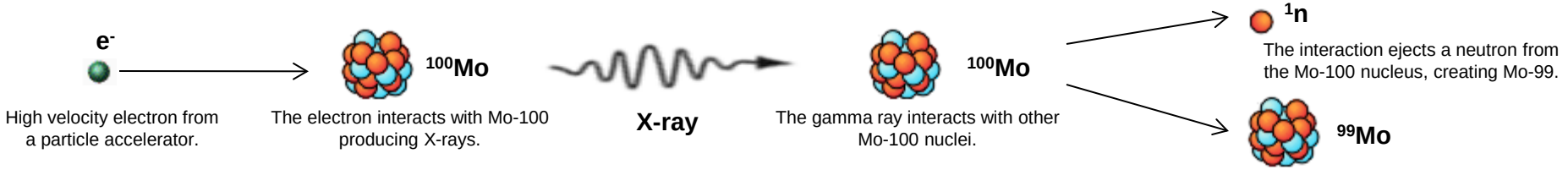
LEU Fission Based: ^{235}U (n,f)



Neutron Capture:(n,γ)



Accelerator Based: (γ,n)



GTRI and U.S. Domestic Mo-99
Cooperative Agreement Partners

Objective: To accelerate existing commercial projects to meet at least 100% of the U.S. demand of Mo-99 produced without HEU.

NorthStar Medical Radioisotopes, LLC

- NNSA has awarded a total of $25 million to NorthStar Medical Radioisotopes to pursue accelerator technology.

Morgridge Institute for Research/SHINE Medical Technologies

- NNSA has awarded a total of $10.7 million to Morgridge Institute for Research to pursue accelerator with LEU fission technology in cooperation with SHINE Medical Technologies.

Babcock and Wilcox (B&W):

- NNSA has awarded $9.1 million to B&W to pursue LEU solution reactor technology.

General Electric-Hitachi (GEH):

- NNSA awarded $2.3 million to General Electric-Hitachi to pursue neutron capture technology. *On February 7, 2012, GEH announced its business decision to suspend progress on the project indefinitely due to market conditions.*

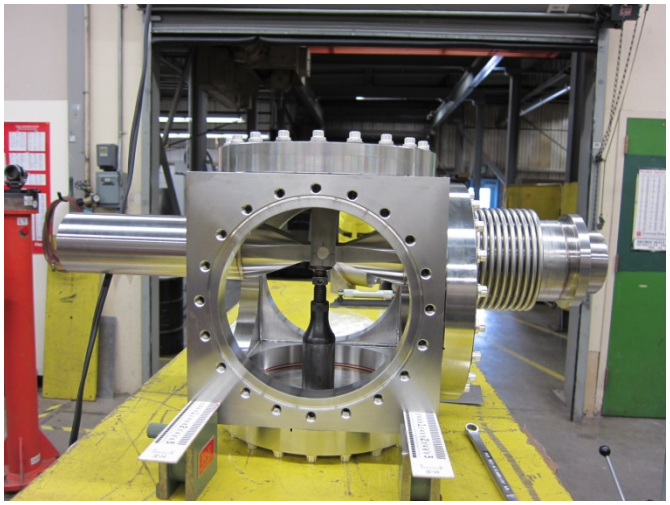
Each cooperative agreement is currently limited to $25M, under a 50% - 50% cost-share arrangement.

U.S. National Laboratories Support to Mo-99 Production

GTRI makes the expertise of the U.S. National Laboratories available to:

- Support technical development of each of the Mo-99 technical pathways
- Ensure the expertise at the national laboratories is available to support the acceleration of commercial projects using non-HEU technologies

All work packages funded by NNSA outside the cooperative agreement are open-sourced, non-proprietary, non-critical-path activities.



GTRI Supports Domestic and International Commitments to Eliminate the use of HEU in Isotope Production

The American Medical Isotopes Production Act of 2012 – January 2013

Intended to help establish a reliable domestic supply of Mo-99 produced without the use of HEU and includes a number of short, medium, and long-term actions.

U.S. Government Public Statement – June 2012

The White House Released a Fact Sheet announcing possible options to support the establishment of a reliable supply of molybdenum-99 produced without HEU.

Nuclear Security Summit – March 2012

"We encourage States to take measures to minimize the use of HEU, including through the conversion of reactors from highly enriched to low enriched uranium (LEU) fuel, where technically and economically feasible, taking into account the need for assured supplies of medical isotopes, and encourage States in a position to do so, by the end of 2013, to announce voluntary specific actions intended to minimize the use of HEU. We also encourage States to promote the use of LEU fuels and targets in commercial applications such as isotope production, and in this regard, welcome relevant international cooperation on high-density LEU fuel to support the conversion of research and test reactors.**"**

OECD-NEA Six Principles intended to strengthen the security of the global Mo-99 supply

One of the largest risks to the security of the global Mo-99 supply are the economic conditions of the Mo-99 marketplace. The current Mo-99 industry needs to transition to a full-cost-recovery, non-HEU-based industry in order to achieve a long-term, reliable supply of this important medical isotope. The High-level Group on the Security of Supply of Medical Radioisotopes (HLG-MR) has developed a cohesive, six principle policy approach to address supply chain issues in order to move towards a long-term, secure supply of Mo-99.