U.S. Department of ENERGY

National Nuclear Security Administration

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Global Threat Reduction Initiative

HEU Minimization Challenges

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GTRI – Global Threat Reduction Initiative

DOE STRATEGIC GOAL 2.2

Prevent the acquisition of nuclear and radiological materials for use in weapons of mass destruction and other acts of terrorism

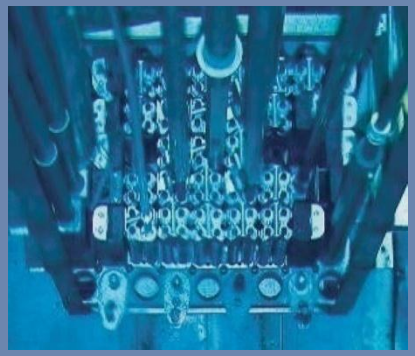
GTRI MISSION

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

GTRI is:

- A part of President Obama's comprehensive strategy to prevent nuclear terrorism; and
- The key organization responsible for implementing the U.S. HEU minimization policy.

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; and

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-Conversion Program

- The program to convert research reactors from the use of highly enriched uranium (HEU) to low enriched uranium (LEU) started under the U.S. Department of Energy (DOE) with the RERTR (Reduced Enrichment for Research and Test Reactors) in 1978

- RERTR became an international program, establishing multiple collaborations leading to LEU fuel development and reactor conversion to LEU fuels

- In 2004 the DOE's National Nuclear Security Administration (NNSA) established the Global Threat Reduction Initiative (GTRI) that incorporated the reactor conversion program as one of the main pillars for HEU minimization
  - 39 Research reactors had converted to LEU by 2004
    - 11 of these reactors were in the U.S. and the remaining 28 were in foreign countries
  - GTRI has accelerated the program to minimize HEU utilization in civil application
  - 77 research reactors have converted to date or have shutdown before conversion
    - 20 of these reactors were in the U.S. and the remaining 57 were in foreign countries

GTRI-Conversion Program Implementation

- Develop or identify an alternative LEU fuel assembly with a service lifetime at least similar to that of the HEU fuel assembly
  - LEU fuel provides a similar service lifetime as the HEU fuel
  - There is no significant penalty in reactor performance – ensure that the ability to perform its scientific mission is not significantly impacted
  - Safety criteria are satisfied
- Ensure that conversion can be achieved without requiring major changes in reactor structures or equipment
- Determine, as possible, that the overall costs associated with the conversion do not increase significantly the annual operating costs
- Remaining research reactors becoming increasingly challenging:
  - Higher density fuels; fuels of unique design
  - Possible reactor modifications may be necessary for some facilities

Technical and Economic Challenges
Maintaining Performance and Missions

- Reactors of a similar type and performance to those that converted before may not need a formal feasibility study, as conversion potential can be assessed by comparison with those already converted

- For most of the reactors remaining in operation with HEU fuel, a dedicated study is necessary to determine if conversion can be accomplished without a significant impact on performance and maintaining the ability to perform their scientific mission.

- These dedicated studies are referred to as Feasibility Studies.

- Economic impact studies may be required beyond the technical feasibility to determine the overall impact and acceptability of the conversion.

Technical and Economic Challenges (cont'd)
Conversion Analysis

- FEASIBILITY STUDIES to determine suitable LEU fuel assembly designs:
  - Design fuel assemblies using qualified LEU fuels **and fuels under development**
  - Compare reactor performance with HEU and LEU fuels; Calculate key safety parameters
  - High Performance, High Flux reactors and some with special missions may further require optimizing the fuel design and possibly facility specific mitigation measures to be able to maintain their scientific mission without a significant impact on performance
- OPERATIONAL AND SAFETY ANALYSES to show:
  - Transition from HEU to LEU fuel can be done safely and without interrupting normal operations
  - LEU reactor satisfies all safety requirements.
- Resolve REGULATORY ISSUES
  - Formulate safety requirements
  - Answering questions posed by regulatory bodies and their experts regarding the reactor's safety documentation **and possibly new fuels or fuel assembly designs**.
- Assess ECONOMIC IMPACT
  - Fuel or fuel assembly qualification
  - Conversion mode – gradual conversion or full core replacement
  - Potential facility modifications required for conversion

Conversion Challenges of US-supplied Reactors

- Domestic U.S. reactors that remain operating with HEU fuels
  - High Flux (High Performance) reactors
  - Reactors with unique fuel design
- Foreign research reactors
  - High Flux reactors
  - Reactors for which an acceptable fuel is available but with special requirements
  - Reactors with unique fuel design
  - Critical assemblies with unique fuel design
- Costs of conversion and operating the reactors after conversion to LEU fuel is an important consideration and it is being addressed
  - LEU fuel cycle costs – new fabrication methods, fuel costs
  - Fuel consumption
  - Experiment performance impact
  - Security, transportation impacts, HEU availability

U.S. High Performance Reactors

Reactor	HEU Core Power	Primary Uses	*Regulator*
MITR Massachusetts Institute of Technology	**5 MW** (6 MW planned)	**Mixed**	***NRC Regulated***
MURR University of Missouri	**10 MW**	**Isotope Production, Activation**	
NBSR National Institute of Standards and Technology	**20 MW**	**Beam Science**	
ATR (ATRC) Idaho National Laboratory	**100-250 MW** (ATRC 600 W)	**Fuel & Material Irradiation**	***DOE Regulated***
HFIR Oak Ridge National Laboratory	**85 MW**	**Beam Science & Isotope Production**	

U.S. High Performance Reactors (cont'd)

- Throughput is key issue for all of the U.S. High Performance Reactors
- Require very high density fuels able to withstand
  - High to very high heat flux (fission rate)
  - High burnup (fission density)
  - High to very high coolant flows (potential for hydrodynamic challenges)
  - GTRI is developing a high density fuel (U-Mo monolithic fuel) and engaging in a partnership with industry for establishment of a fabrication capability, as the fuel fabrication process is different from the current HEU fuels
    - U-Mo Monolithic fuel (U density up to ~17 g/cc.)

- Feasibility studies completed for these reactors
  - Conversion found feasible provided the completion of the qualification of the U-Mo fuel, which is under way
  - Mitigation actions being pursued to minimize the performance penalty and maintain their current mission and applications
    - Significant mitigations being pursued, including ex-core mitigations, a difference from prior conversions

Other Challenges

- Reactors for which an acceptable fuel is available but with special requirements
  - Conversion potential is not a technical issue
  - Discussions with operator and other stakeholder organizations to determine possibility for conversion, regulatory implications, fabrication of the fuel, etc.
- Reactors with unique fuel design
  - Conversion potential needs to be addressed on a case by case basis. Some of the facilities may have no potential for conversion to LEU fuel (fast critical assemblies, for example)
    - An LEU fuel may not be available to fulfill the mission of the reactor
    - A unique fuel development effort may be technically or economically unfeasible
  - Study other possibilities for minimizing HEU fuel utilization (options of last resort)
    - Assess possibility of changing facility mission such that it can be accomplished with LEU fuel or consider facility consolidation or shutdown if facility is underutilized or if facility can be consolidated with similar facilities
    - Reduce HEU enrichment; this may be technically feasible in some cases where LEU conversion is not.

      NOTE: Reduced HEU enrichment to above 20% is not considered HEU minimization under current accepted international norms or GTRI policy.

Other Challenges (cont'd)

- Commitment of Research or Government organizations
  - Operating organizations
    - Resistance to changes from well known conditions
    - Regulatory uncertainty
    - Potential impact on operations and mission
    - Resources to support conversion
  - Government organizations
    - Costs associated with conversion
    - Length of commitment, especially when new fuels must be developed or qualified
    - Age of facilities – investment in old facilities

- Economic impacts of conversion must be minimized, but cannot be considered in isolation from the gains obtained in threat reduction and increased global security
    - Costs of physical protection of nuclear facilities, for example, have been accepted
    - National and multinational commitments have historically allowed capital challenges to conversion to be overcome
    - Consideration of costs associated with a security event caused by failure to minimize HEU

Conclusions

- Reactors remaining to be converted are in general the most technically challenging
  - Solving technical challenges can result in economic challenges
- U.S. High Performance Research Reactors
  - Commitment to convert to LEU: extensive effort in fuel development and fabrication capability for U-Mo monolithic fuel to enable USHPRR reactor conversion
- Reactors with unique fuel design need to be addressed on a case by case basis to determine the technical options available
- Conversion and post-conversion operating costs are a factor that must be included in the decision to convert specific research reactors
  - Economic impact needs to account for potential differences in LEU fuel cycle costs
  - Conversion costs vs. threat reduction and increased security
- Other challenges include varying commitment of research and government organizations to HEU minimization, which is vital for the framework to overcome the technical and economic challenges

GTRI Program is committed to resolving the technical challenges involved in the conversions of the remaining U.S. HEU-fueled reactors. Internationally GTRI continues to engage reactor operators and government organizations to discuss the potential for conversion and to jointly overcome technical, economic, and other challenges

Thank you for your attention!