Criteria to Compare HEU and LEU Systems

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Symposium
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About the Science and Technology Policy Institute (STPI)

- Federally Funded Research and Development Center (FFRDC) created by Congress
- Provides scientific and technical analysis to the Office of Science and Technology Policy (OSTP) and other Executive Branch Departments and Agencies
- Works primarily for the U.S. Federal government
- Non-advocacy, unbiased, and objective
- Rigorous and data-driven
Context

• No existing U.S. policy that prescribes enrichment levels for space nuclear reactors
• There are existing U.S. programs regarding reducing the use of HEU in civilian research reactors
• Space systems face unique operating requirements and conditions
• Decision regarding whether to use HEU or LEU should consider several criteria beyond performance, proliferation being one
  ➢ No comprehensive studies that make the comparison on all dimensions
Assessment Criteria

• Performance: mass, complexity, lifetime
• Safety: launch and re-entry accidents
• Security: proliferation concerns
• Timeliness: meeting demand timelines
• Cost: system, fuel, security, launch, insurance, bureaucracy
• Other: sustainability, applications to other markets, commercial availability
Assessment Factors

- **Performance**
  - **Specific power**: LEU typically results in higher mass

- **Safety**
  - **Power scalability**: HEU better for low power environments

- **Security**
  - **Reliability and technical risk**: Comparable LEU systems are more complicated

- **Timeliness**

- **Cost**

- **Other**
  - **Other factors**: Length of operational capability; development risk (nuclear system and complementary systems); extensibility; operability
Assessment Factors

- Performance
- Safety
- Security
- Timeliness
- Cost
- Other

**Launch Safety:** More challenging to avoid inadvertent critically with LEU
  - Moderated reactors on submersion accidents
  - Less design space for accident mitigation

**Other factors:** Risk of and from re-entry; Operational safety (health risk, environmental contamination risk)
Assessment Factors

• Safety
• Security
• Performance
• Timeliness
• Cost
• Strategy
• Political

**Time to performance system:** HEU system closer to launch readiness

**Coordination time** (launch approval, interagency, international): Using HEU may require increased interagency coordination and lead-time
Assessment Factors

• Performance

• Safety

• Security

• Timeliness

• Cost

• Other

**Security:** Higher security costs for HEU

**Launch costs:** Higher launch mass for LEU

**Certification and other approvals:** HEU will likely have higher approval costs

**Other factors:** Cost of R&D (includes testing requirements); nuclear system; fuel complementary systems; launch ready system; insurance/indemnification; and logistical and infrastructure costs
Launch Approval Process Covers All Space Nuclear Systems

• Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems, issued August of 2019

• The highest reviewed category, Tier III, of systems includes systems with criticality potential that utilize any fuel other than LEU

• Tier III requires presidential approval of the launch
Summary

• Some analyses and trade studies have been done but they only address parts of the trade-space
• Not all criteria are equally important
• The devil is in the details
  – Performance tradeoffs vary drastically based on power levels and reactor design
  – Harder to engineer systems for LEU for missions and safety criteria
  – Many of the costs are already considered or baked into mission decisions
BACKUP
Factors Required for Assessment

- Performance
- Safety
- Security
- Timeliness
- Cost
- Other

**Availability of fuel:** HEU has more established fuel lines than HALEU

**Political risk:** HEU programs could be cancelled for that reason

**Commercial Availability:** LEU makes it easier to share more of the mission with private partners can go under cost

Other factors: Sustainability, level of bureaucracy, applications to other markets (military, power, niche commercial)