B&W Medical Isotope Production System

NRC Meeting 11/17/08

Non-Proprietary Slides

Discussion Topics and Purpose

- System Overview
- Licensing Proposal
- Waste Proposal
- Purpose: Discuss B&W recommendation to assure NRC has a clear understanding of our thought process

MIPS System Overview

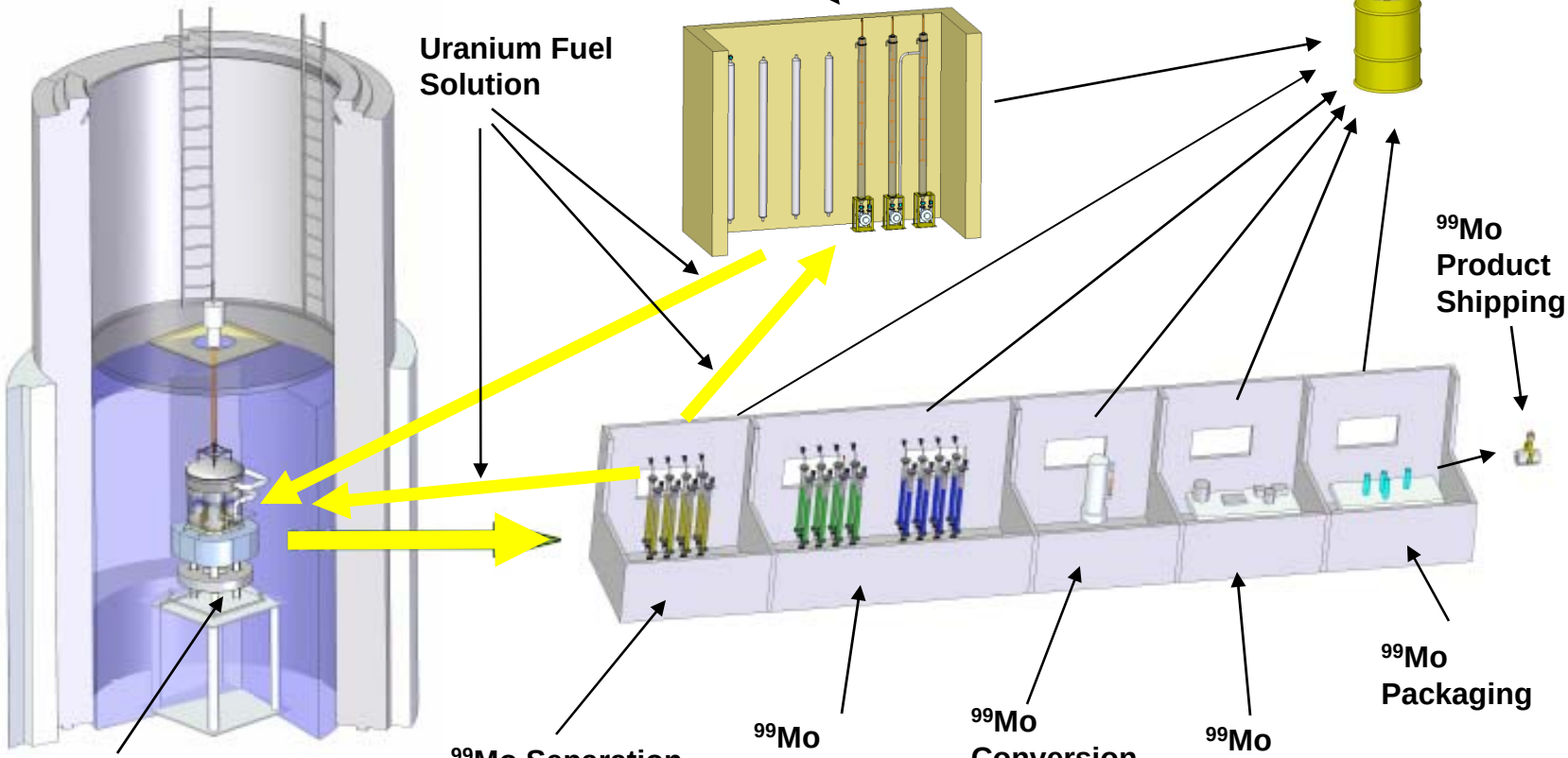
- **Reactor**
  - **Aqueous Homogeneous Reactor (AHR) Modules**
  - **Less than 20% Enriched (LEU) Solution**
  - **800kW Reactor System**
- **Processing and Support Facilities**
  - **99Mo Extraction and Certification Hot Cells**
  - **Laboratory**
  - **Shipping/receiving**
  - **Uranium Fuel Clean-up**
  - **Waste management**

Designs Options Being Considered

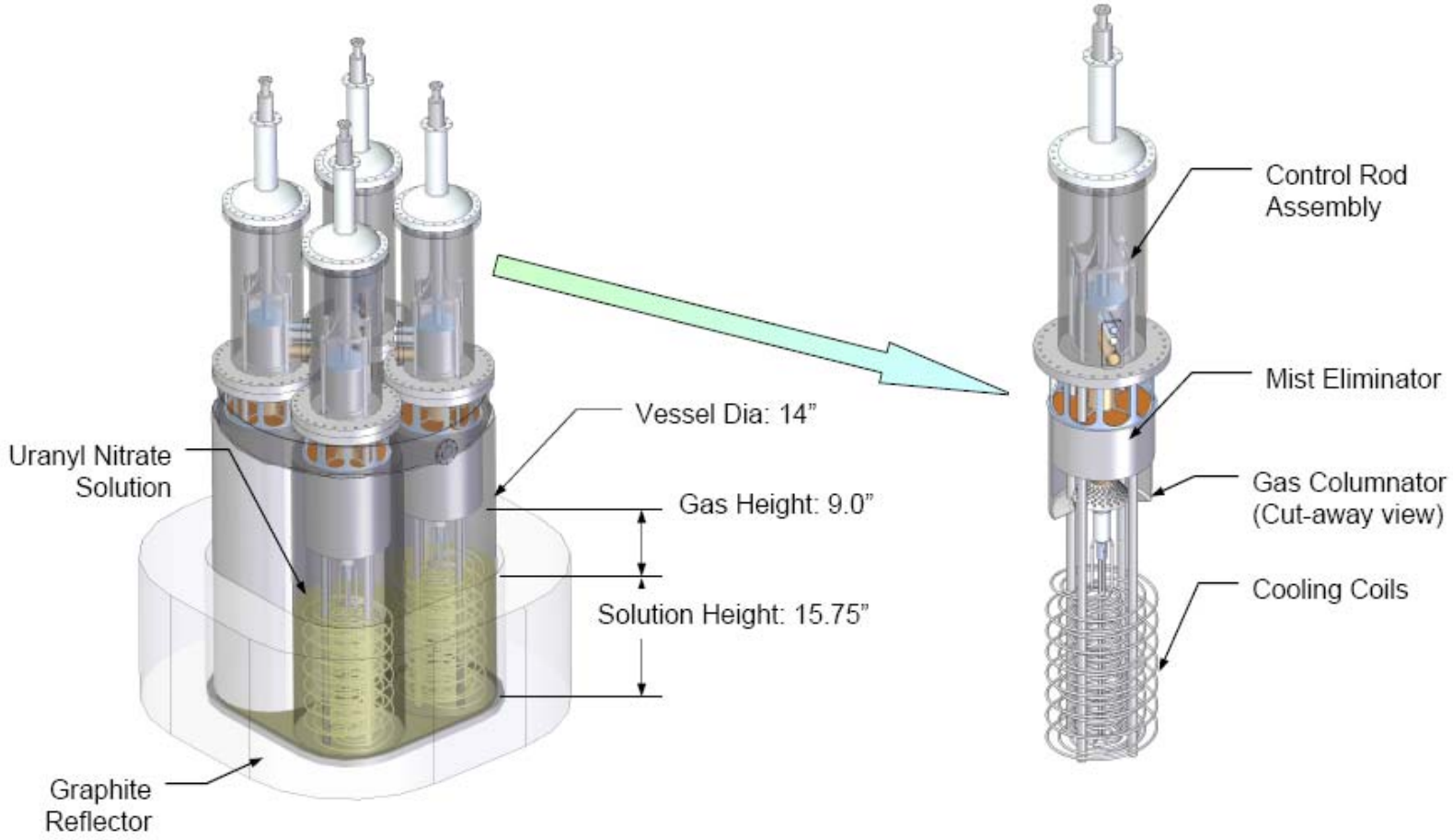
- Modular Reactor System based on ^{99}Mo delivery requirements and existing reactor experience
  - 200 kW reactor with 50kW modules with up to 4 reactors for a total of 800 kW MIPS
  - Single 200 kW reactor without modules with up to 4 reactors for a total of 800 kW MIPS
- Option 1: Underwater reactor system with water serving as shielding
- Option 2: Dry system in hot cells with concrete serving as shielding

Current Conceptual Design

Underwater configuration shown. Also considering a dry system in a cell.



200kW design with 50kW modules



Reactor Attributes 200 kW

Parameter	Value
U-235 Enrichment	~19.75 wt.%
Fuel Concentration	~ 250 gmU/liter
Chemical Form	$UO_2(NO_3)_2$ solution
Solution pH	~ 1.0
Solution Volume	~130 liters
Average Thermal Flux	~ 10^{12} n/cm^2-sec
Total Length of Cooling Coils	~340 ft.
Total Radiolytic Gas Flow	~41 liters/min
Solution Temperature	~ 80^{o}C (176^{o}F)
Core Dome Pressure	Slightly Below Atmospheric
Production of ^{99}Mo/cycle/per Reactor	1100 6-day Ci Pre-Calibrated

MIPS Reactor Design Characteristics

- **Low solution temperature, Power Density and pressure Minimizes Safety Risks**
- **Large Negative Coefficients of Reactivity Results in Self-Limiting Excursions Providing Inherent Nuclear safety**
- **Reactivity Control Provided by Internal Control Rods**
- **Radial Graphite Reflector Used to Optimize Core Flux profile**

MIPS Reactor Design Characteristics

- **Fuel Solution Heat Removal Provided by Internal Cooling Coils**
- **Large Pool Volume Provides Passive Residual Heat Removal Capacity (underwater design)**
- **Radiolytic Gases Diluted by Air Flow to Prevent Flammable Mixture**

Licensing Approach

- Single License Under 10CFR50
- Determination MIPS is not Production Facility
- Licensing as Non-power Reactor
- Reactor License Classification

Single License Under 10CFR50

- Options Considered
  - 1. Single Part 50 license that covers all facilities
  - 2. [ ]
  - 3. License reactor only under 10CFR50 and a new part 70 license for the separation facilities
- Proposed Approach
  - Option 1 single license for all facilities

Single License Under 10CFR50

- Reasons for Option 1 Single License
  - Integral facility sharing components (e.g. confinement, emergency power, etc.)
  - Difficult to draw a bright line separating the two licenses
  - Business arrangements not related to SNM-42
  - If a hearing is requested, all issues can be readily addressed in one proceeding
  - Single regulator if Virginia becomes an Agreement State

MIPS is Not a Production Facility

- Atomic Energy Act Definition
  - Significant SNM production
- 10CFR50 Definition
  - Pu or U-233 formation
  - plutonium separation
  - facility for processing irradiated material defined by fission product concentrations
- MIPS meets criteria 3 of 10CFR50 however does not meet intent of Atomic Energy Act
- Under 10CFR50 this is Utilization Facility

MIPS is Not a Production Facility

- Although MIPS meets criteria 3 of 10CFR50, it is clear that it is not designed or could be modified to produce a significant amount of SNM. Therefore, MIPS should only be classified as a utilization facility with a single 10CFR Part 50 license
- There will be no difference in the licensing requirements under single 10CFR50 license if it is not classified as a production facility, but it will eliminate any confusion for members of the public or Congressional oversight committees
- Even if MIPS were classified as a production facility, it need not be labeled as one since it is meeting the same requirements as a utilization facility

Licensing as Non-power Reactor

- **Definitions**
  - 10CFR50: Non-power Reactor defined as R&D (MIPS not R&D)
  - 10CFR100: Power Reactor defined to produce electrical or heat energy (MIPS not Power Reactor)
  - 10CFR50 Testing Facility defined as R&D if less than certain power levels (MIPS not Testing facility, however it is below power thresholds)
  - While MIPS fits no existing **defined** reactor type, it is a non-power reactor

Requested Action

- NRC conclude that MIPS will be handled as a non-power and NUREG 1537 will be used by the NRC staff for license reviews

Licensing as Non-power Reactor

- Technical Basis and Merit
  - MIPS is clearly a low power facility that is below the power level criteria of a reactor that is a testing facility
  - NUREG 1537 recognizes non-power reactor might not be for R&D
  - MIPS does not pose risks of a power reactor
  - NUREG 1537 provides a framework to apply risk-informed decisions to assure appropriate safety and safeguards to protect public health and safety

Reactor License Classification

- Class 104 License
  - Medical Therapy (MIPS not used directly in medical therapy although it directly supports medical diagnostic procedures that support medical therapy)
  - Research and Development (MIPS does not meet the 50% cost of owning and operating facility criteria for R&D)
- Class 103 License
  - Commercial and industrial facilities not meeting R&D financial criteria

Reactor License Classification

Class 103 License

- Commercial and industrial facilities not meeting R&D financial criteria

- Recommendation/Request
  - NRC conclude that MIPS will have a Class 103 license but use the non-power reactor licensing guidance in NUREG 1537 for the licensing reviews

Licensing Approach

- Questions or discussion before proceeding to waste discussion

Waste Considerations

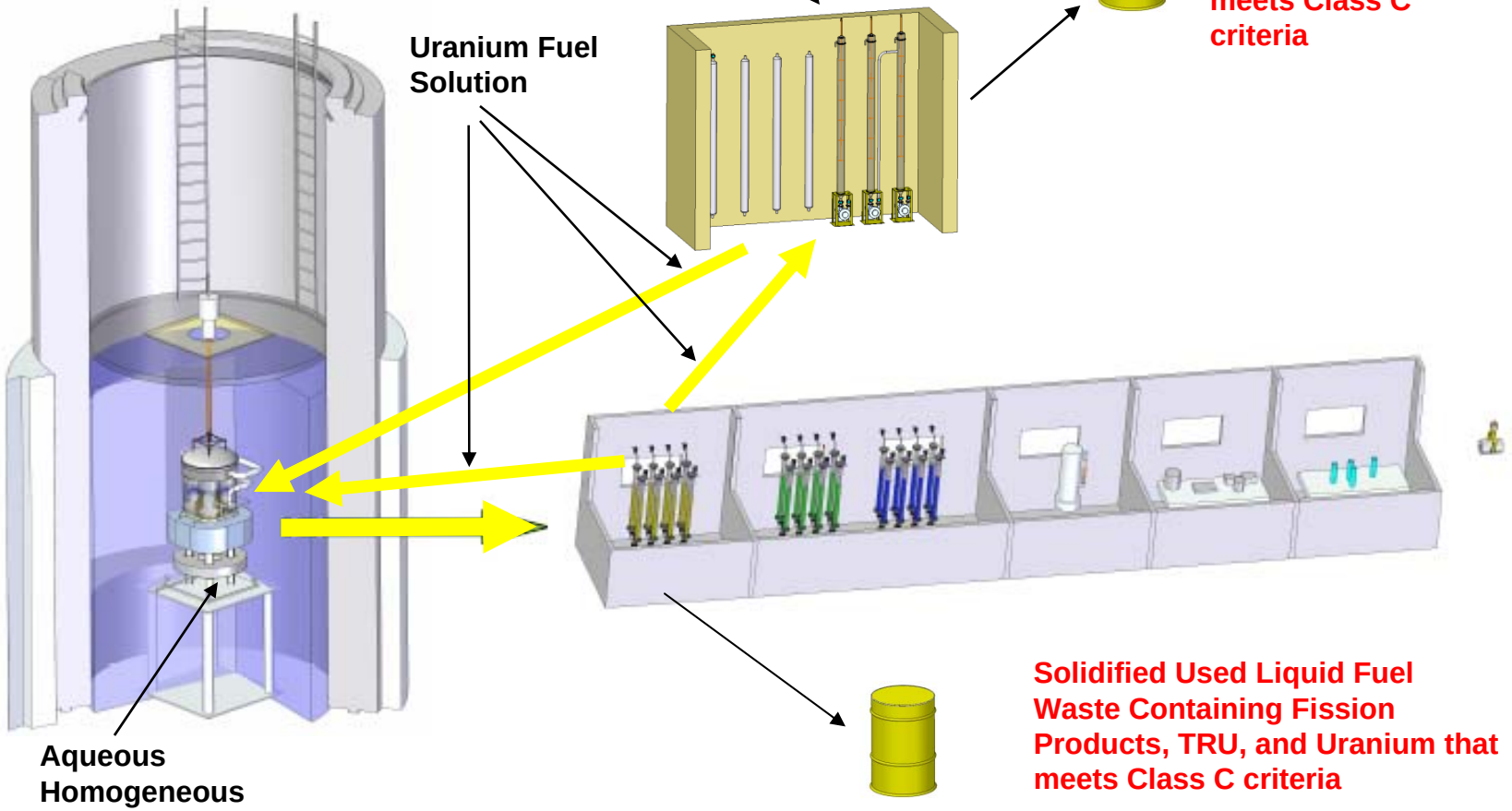
- Used Liquid Fuel Waste (ULFW)
  - This will be generated at end of useful liquid fuel “load” life after many cycles of ^{99}Mo extraction. A fuel “load” is expected to last years.
- Fuel Cleanup Liquid Waste (FCLW)
  - This waste will be generated periodically as the liquid fuel “load” needs to be cleaned to remove fission products that, if allowed to build in over many cycles, could create quality or efficiency problems with ^{99}Mo extraction. Frequency of cleanup is being determined through development.

Current Conceptual Design

Underwater configuration shown. Also considering a dry system in a cell.

Periodic Uranium Fuel Cleanup

Uranium Fuel Solution

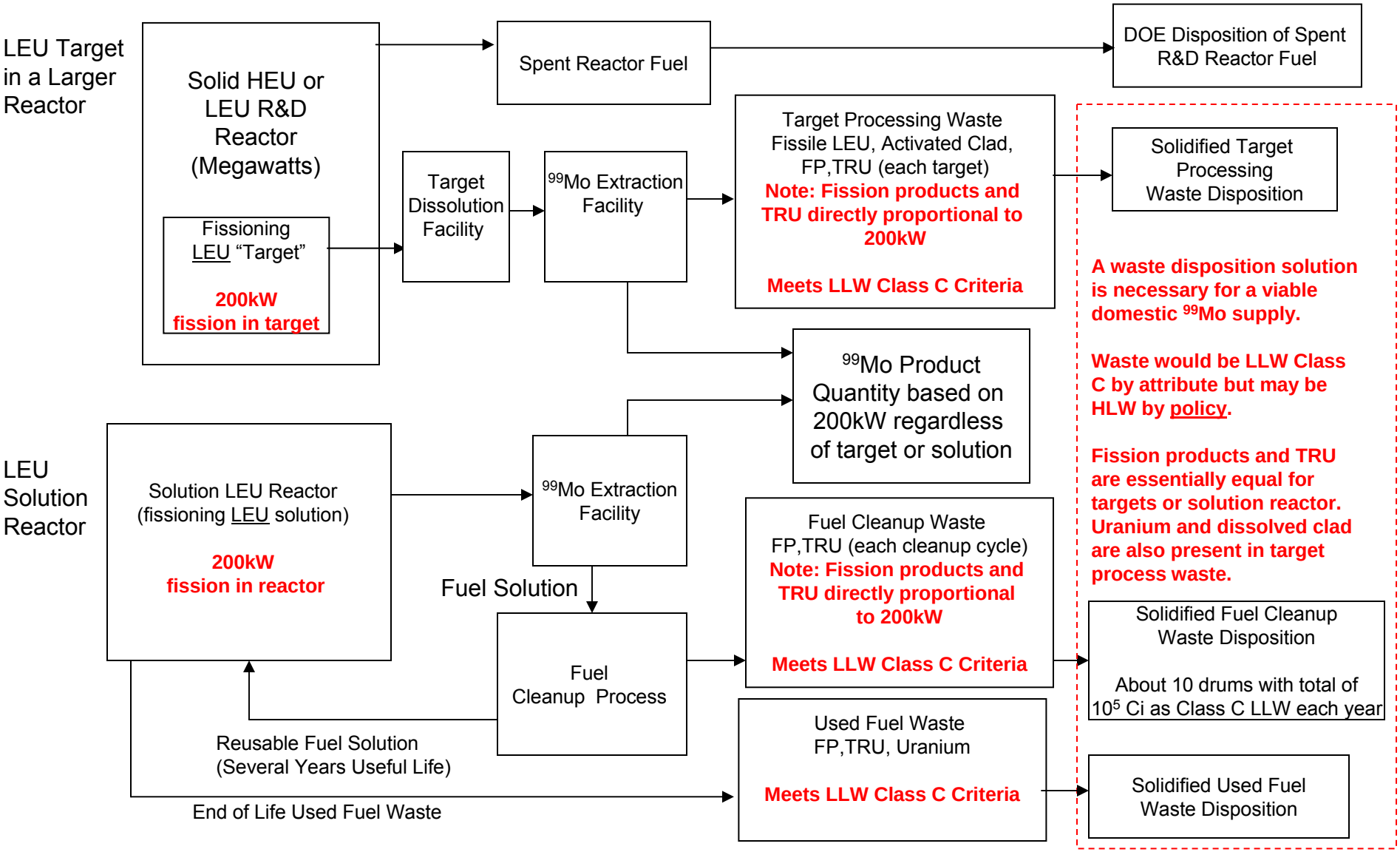


Solidified Fuel Cleanup Liquid Waste containing fission products and TRU that meets Class C criteria

Aqueous Homogeneous Reactor(s) (Approx. 800 kW total)

Solidified Used Liquid Fuel Waste Containing Fission Products, TRU, and Uranium that meets Class C criteria

HLW Policy Issue for Target or Solution ^{99}Mo Production in US



Waste Considerations

Why is this important?

- Timing to complete application
- corporate risk of proceeding without clear disposal
- HLW disposal cost unknown
- Legislative clarification options could take years to achieve given the focus of the new administrations to address the economy, tax cuts, job stimulus, and war issues
- For DOE to take title of fuel also likely to require legislation and await the transition to the new administration
- DOE's willingness and ability to accept additional HLW unclear

Waste Legislation

- Marine Protection Act 1972
  - First statutory definition of HLW
  - HLW for purposes of ocean disposal is
    - Aqueous reprocessing waste from first solvent extraction system
    - Irradiated fuel from nuclear power reactors
- Prior to 1978 spent fuel considered LLW
  - Spent fuel disposed of as LLW at West Valley &Hanford
  - No knowledge of NRC/AEC treating ULF as HLW
- LLWPA 1980
  - LLW defined as not being HLW, TRU waste, spent fuel or 11e.(2)

Waste Legislation

- NWPA 1982 –
  - HLW is

(A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and

(B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation.

- LLW is not HLW, spent fuel, TRU, or 11e(2) or other material NRC determines to be LLW
  - Spent fuel is fuel withdrawn from reactor not separated by reprocessing

- Issue is whether MIPS waste is “highly radioactive” or “spent fuel”

Used Liquid Fuel (ULF)

Is ULF HLW as used in the NWPA?

- NWPA focused on solid fuel rods - concern was primarily power reactor fuel rods
- NWPA focused on disposal issues with solid spent fuel because of its high radioactivity – needed permanent isolation - deep geological disposal
- Legislative history instructive by its silence on ULF
- No evidence that any legislator knew of ULF
- Not many in NRC likely knew of ULF
- Plain meaning of spent fuel is irradiated solid fuel rods
- ULFW is not within plain meaning of spent fuel
- Terms “spent fuel” & “fuel” ambiguous as whether includes ULFW

Used Liquid Fuel (ULF)

- Given lack of knowledge of the existence of aqueous fuel, room to interpret meaning of the term “spent fuel”
  - No legislative intent found to include within spent fuel ULF that is not so “highly radioactive” needing permanent isolation - deep geological disposal
  - Unlike solid spent fuel, ULF meets Class C concentrations suitable for near surface disposal under Part 61 levels prima facie evidence that not so highly radioactive needing permanent isolation - deep geological disposal
- With ambiguity as to meaning, room for NRC to derive appropriate interpretation of “fuel” and “spent fuel” consistent with statutory intent
- DOJ with NRC and DOE concurring used the lack of highly radioactive argument to support its position that waste incidental to reprocessing is not HLW.

- Requested Action: NRC conclude that ULF is neither HLW nor spent fuel within meaning of NWPA based on the legislative history focus on solid rods, absence of liquid fuel discussion, and lack of sufficient radioactivity warranting permanent isolation - deep geological disposal

Fuel Cleanup Liquid Waste (FCLW) from MIPS

- Same considerations as with ULF
- Radionuclides and fission products within FCLW similar to targets radiated in a reactor to generate Mo99
- Cintichem targets disposed of as LLW at Barnwell
- DOE EIS in 1995 treated targets as LLW

- Requested Action: NRC conclude that FCLW is neither HLW nor spent fuel within meaning of NWPA based on the legislative history focus on solid rods, absence of liquid fuel discussion, and lack of sufficient radioactivity warranting permanent isolation - deep geological disposal

Waste

- Questions or discussion regarding waste

Summary

- Based on our analysis, we believe we have proposed reasonable positions on these issues
- Disposition of these issues is important to understand the path forward and factor into schedules and business plans
- We are very pleased that NRC is actively reviewing our recommendation