Understanding Material Flows, Facilities Needs in Time and Space

PRESENTED AT THE NUCLEAR INTEGRATION PROJECT WORKSHOP

"THE BACK-END: HEALING THE ACHILLES HEEL OF THE NUCLEAR RENAISSANCE"

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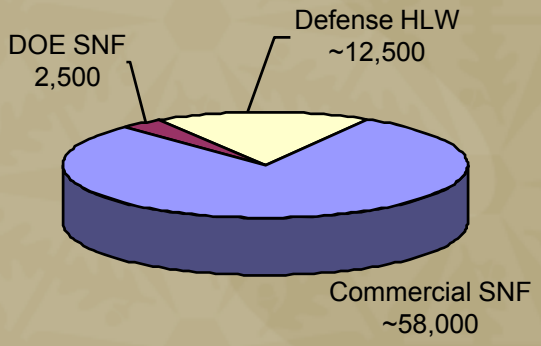
Presentation Outline

- The Base Case (No Expansion)
  - Yucca Mountain and WIPP
- Fuel Cycle Options Considered
  - Once-through, partially-, and fully-closed
- Assumptions Made
- Comparison of Fuel Cycle Options
- Conclusions

Current SNF/HLW Disposal Masses (MTiHM)

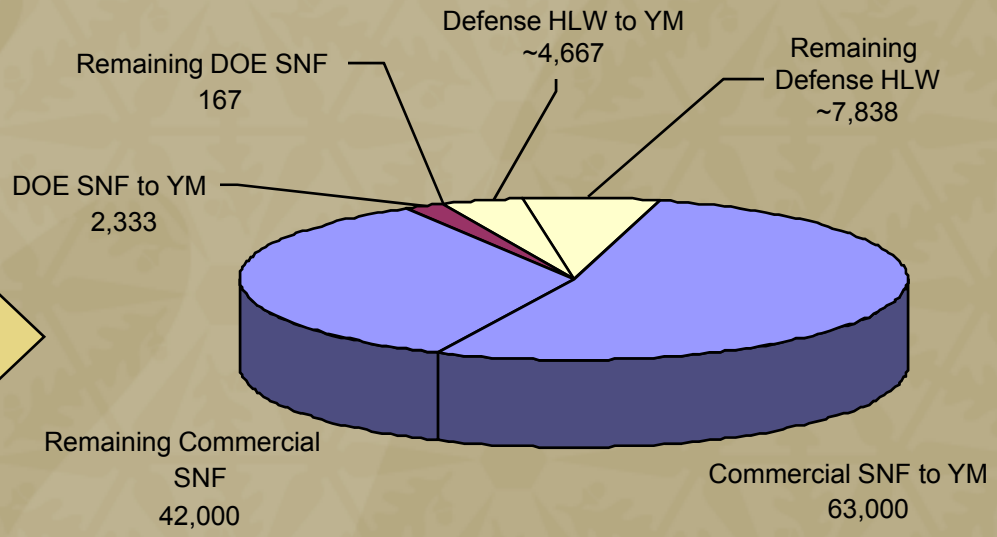


Total: ~73,000 MTiHM

Base Case

2017+

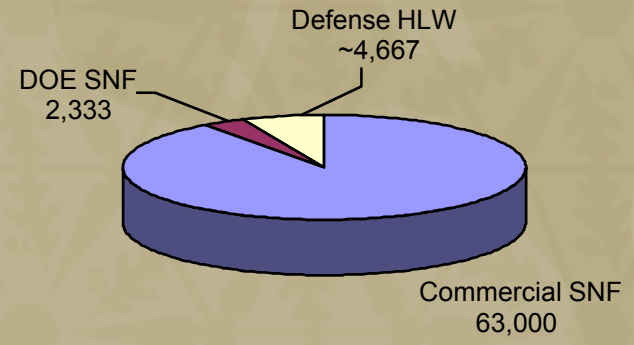
Projected SNF/HLW Disposal Masses (MTiHM)

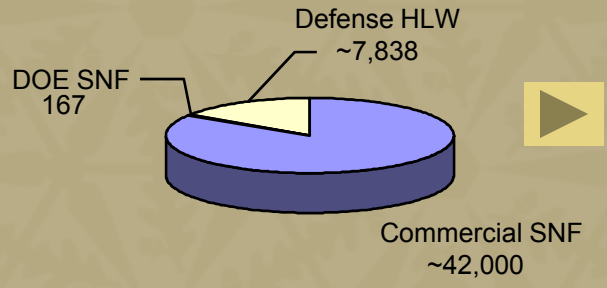


Total: 120,000 MTiHM

YM Proposal (70,000 MTiHM)

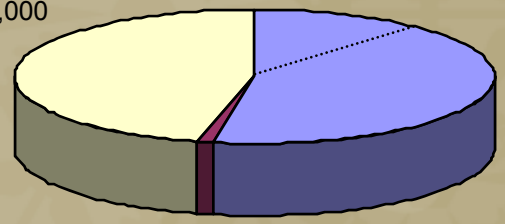
Post-YM SNF/HLW





Source: YM FEIS (2002)

Current TRU Waste Volumes (m^3)

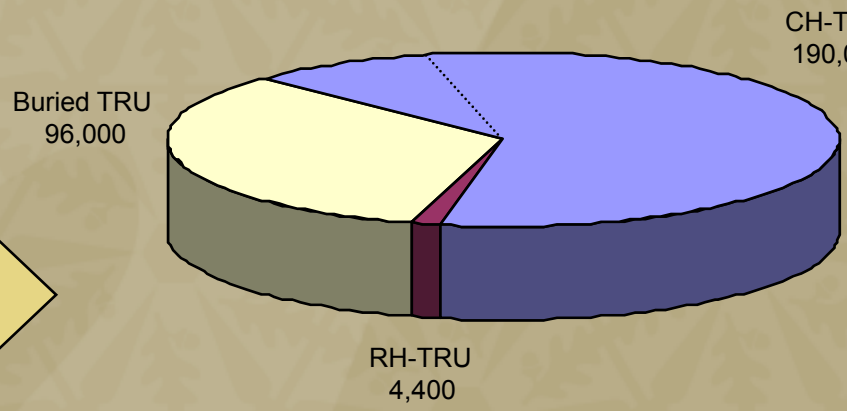


Total: 210,000 m^3

NTWMP

1999

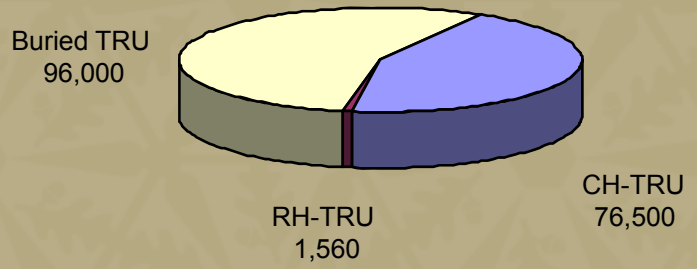
Projected TRU Waste Volumes (m^3)



Total: 290,000 m^3

NTWMP, Rev. 3 (2002)
CH-TRU: 113,500 m^3
RH-TRU: 2,840 m^3

Post-2034 TRU Waste

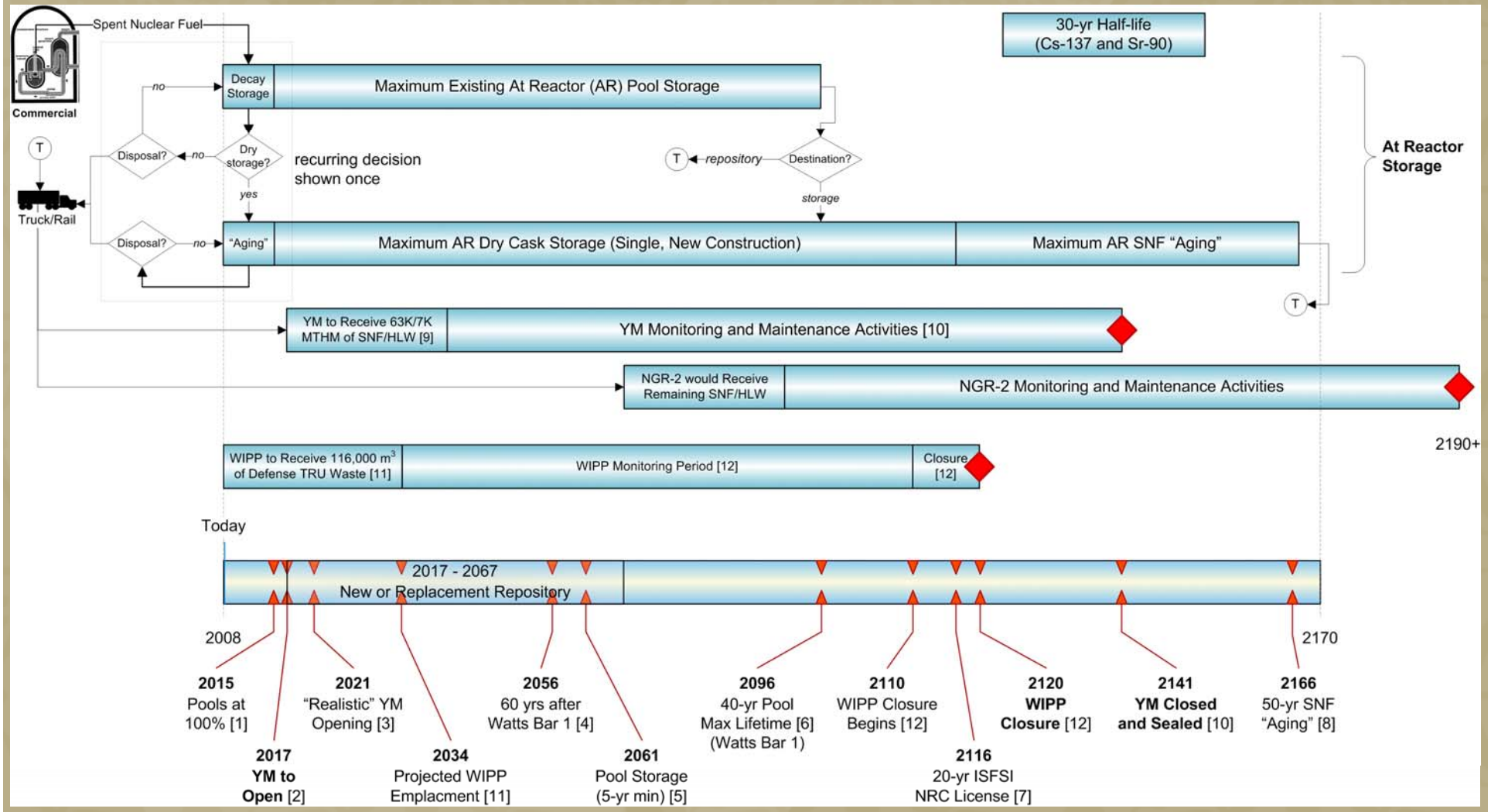


Source: YM FEIS (2002)

Current Snapshot of Situation

- **Where does that leave SNF and HLW?**
  - SNF and HLW will remain at the original sites
  - SNF alone will soon exceed YM *legal* capacity
  - No clear path for disposal of "all" SNF/HLW/TRU
- **Substantial and growing SNF liability costs**
  - TVA awarded $34.9M in 2006—61 lawsuits pending
- **Federal interim storage placed on hold**
  - Establish process for taking Federal title of SNF?
- **What are the SNF/HLW options?**
  - "… choice is not whether to put the waste in a repository or leave it …. choice is how and when to remove spent fuel … and where to put [it] … to assure safety and security." NAS (2001)

Proposed Waste Management Timing

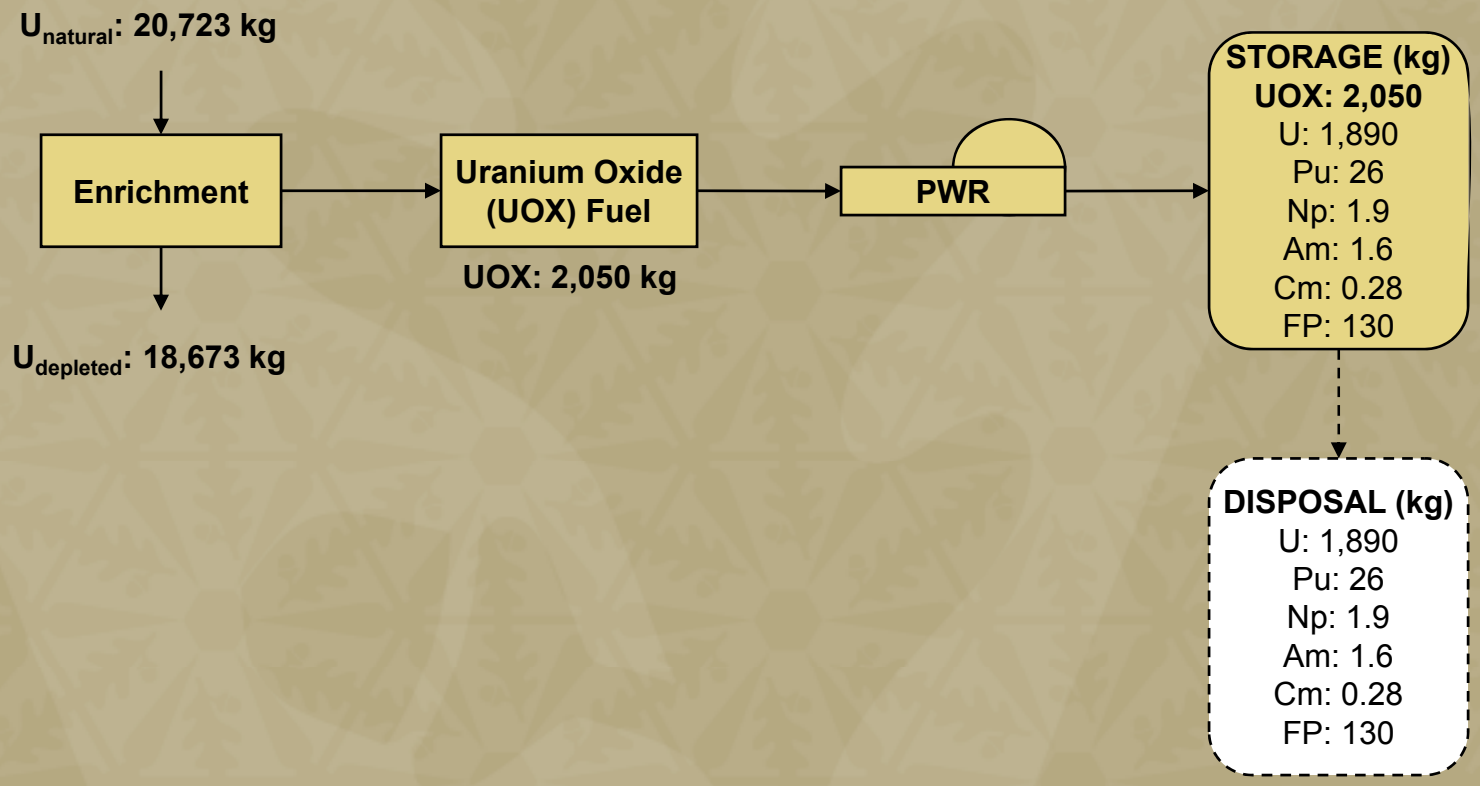


Fuel-Cycle Options Considered

- **Current industrial technology and extensions**
  - Base: Once-through fuel cycle (all use UOX fuel)
  - Conventional reprocessing (PUREX: Pu → MOX)
- **Partially-closed fuel cycles**
  - Pu burning in LWR's only (PUREX)
  - Pu, Am burning in LWR's
- **Fully-closed fuel cycles**
  - TRU burning in Fast Reactors (UREX+PYRO)

Source: NEA (2006)

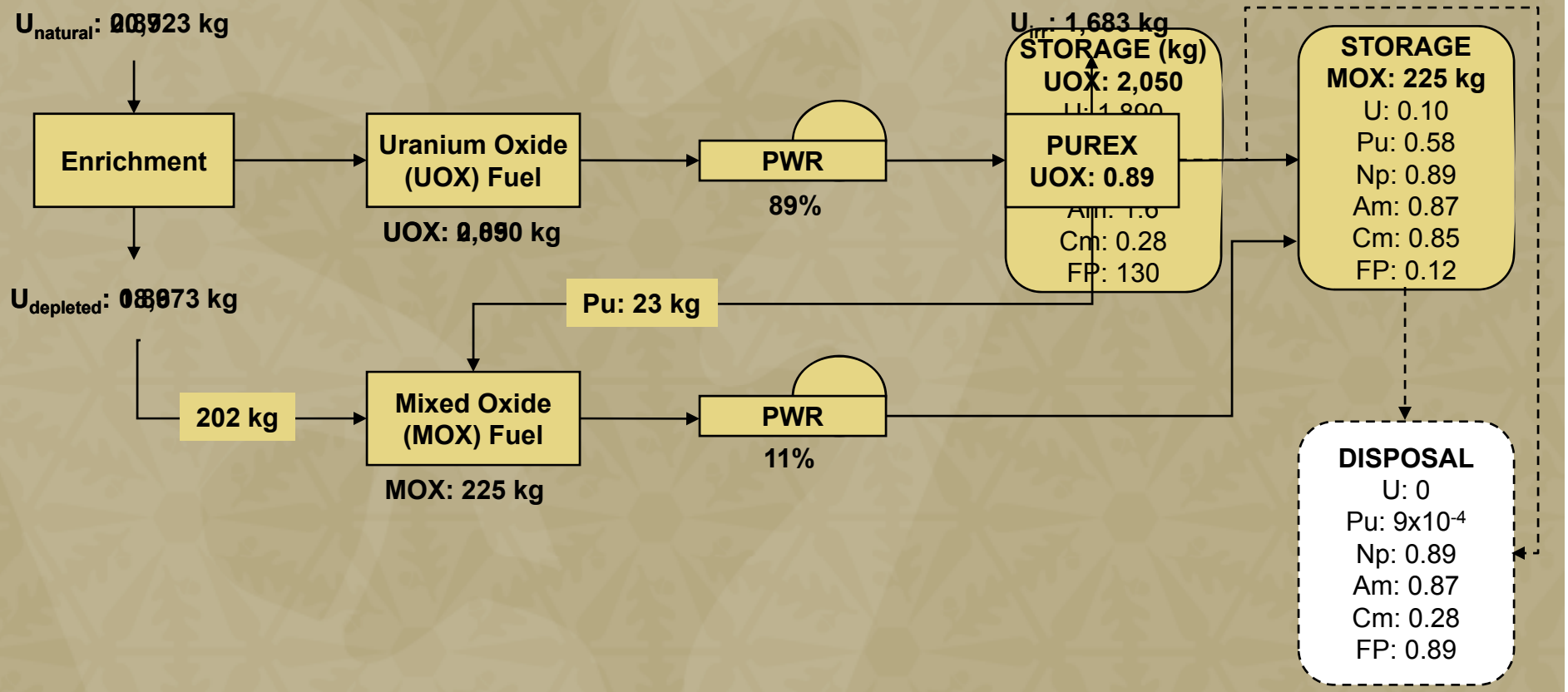
Fuel Cycles Considered
Base Case—No Reprocessing or MOX



Basis: kg/TWhe

Source: NEA (2006)

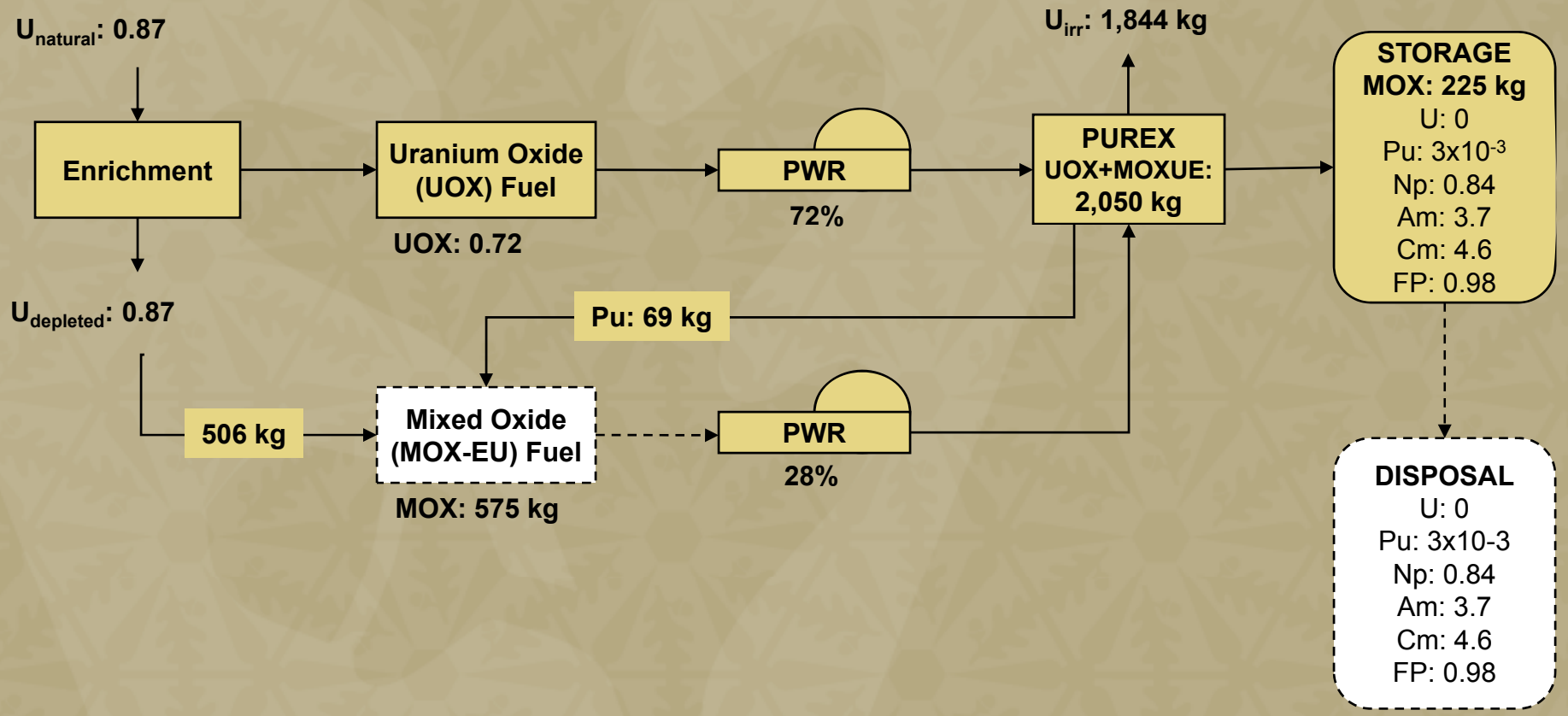
Fuel Cycles Considered
Open—Pu Once (PUREX) and MOX



Basis: kg/TWhe

Source: NEA (2006)

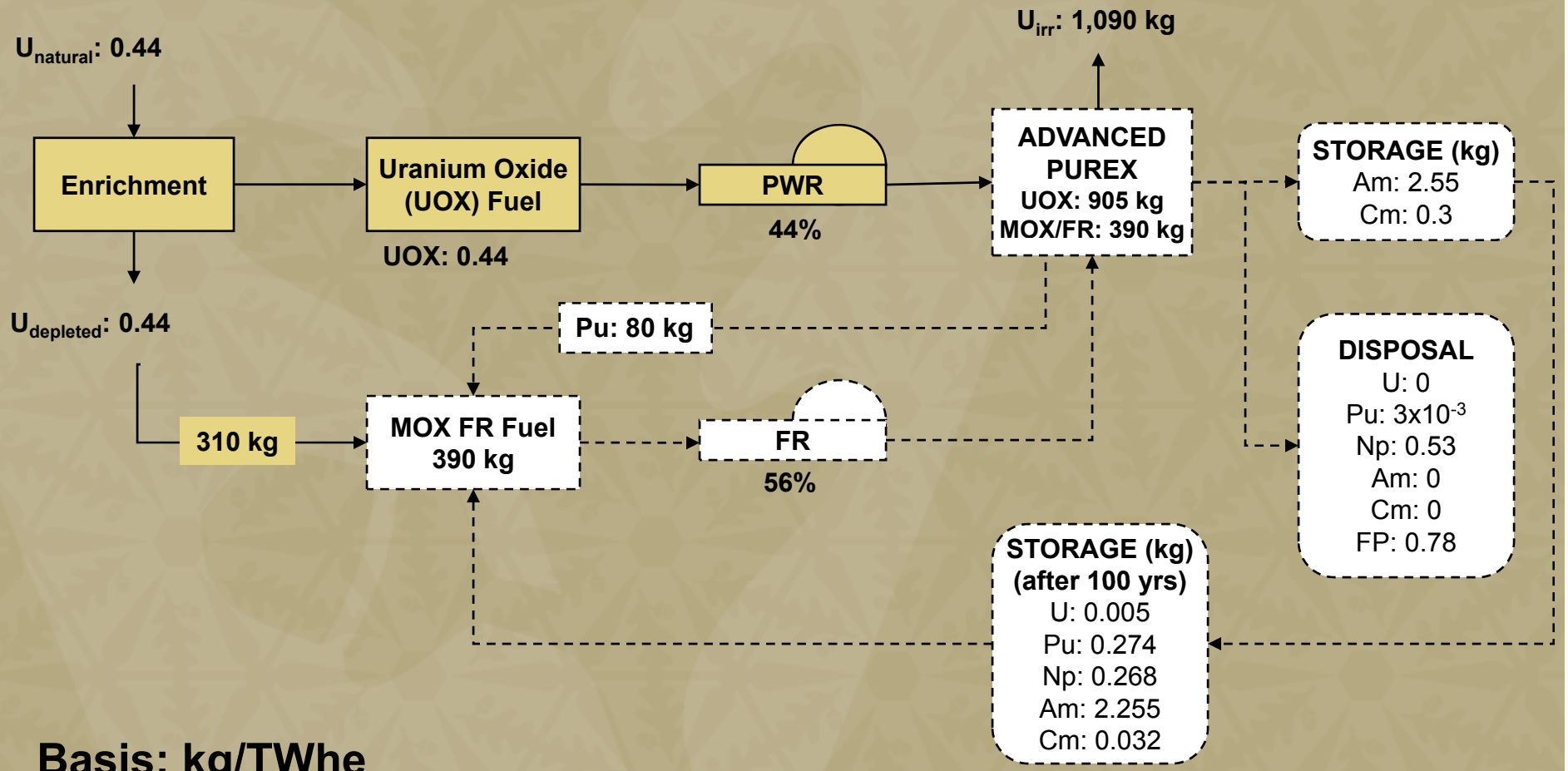
Fuel Cycles Considered
Partially-closed—Pu Recycling in PWRs



Basis: kg/TWhe

Source: NEA (2006)

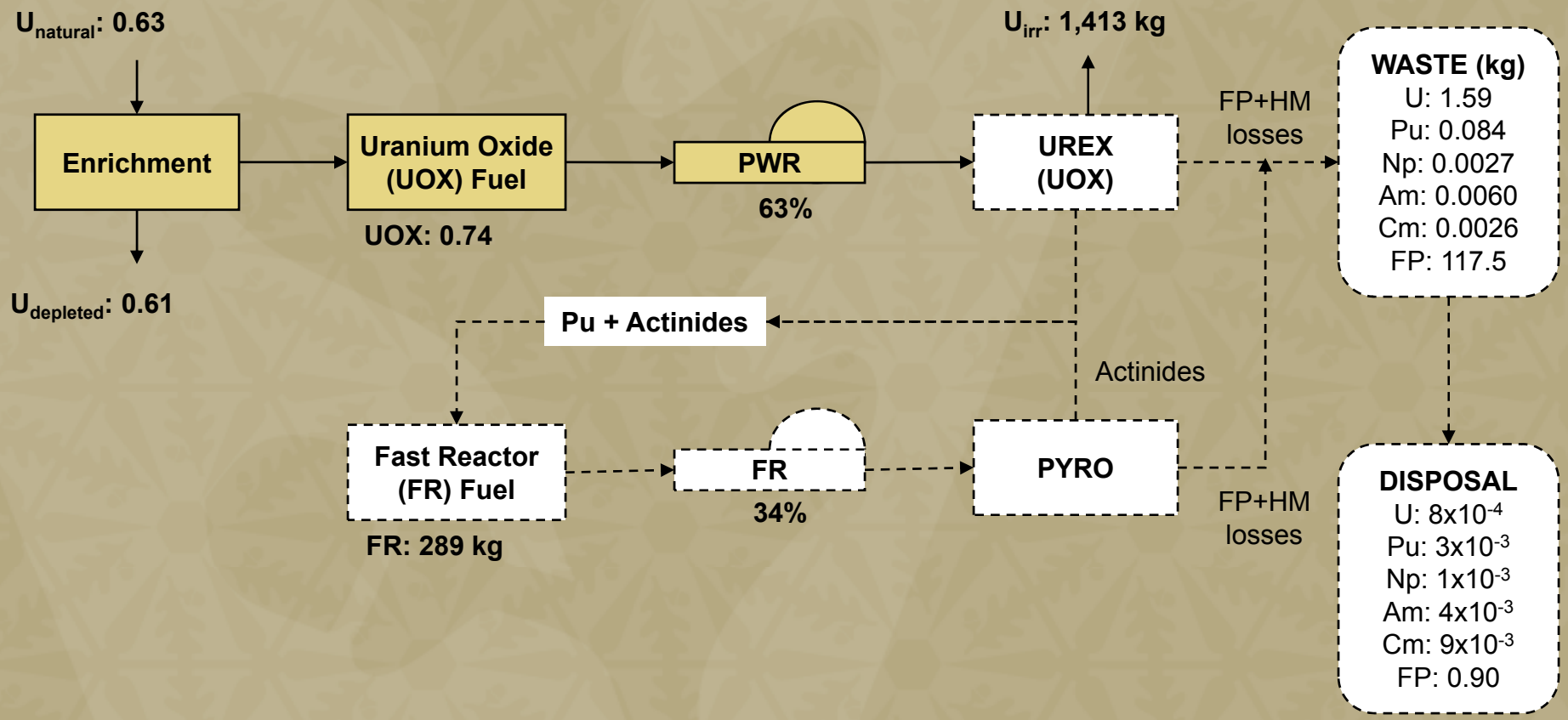
Fuel Cycles Considered
Partially-closed—Advanced PUREX



Basis: kg/TWhe

Source: NEA (2006)

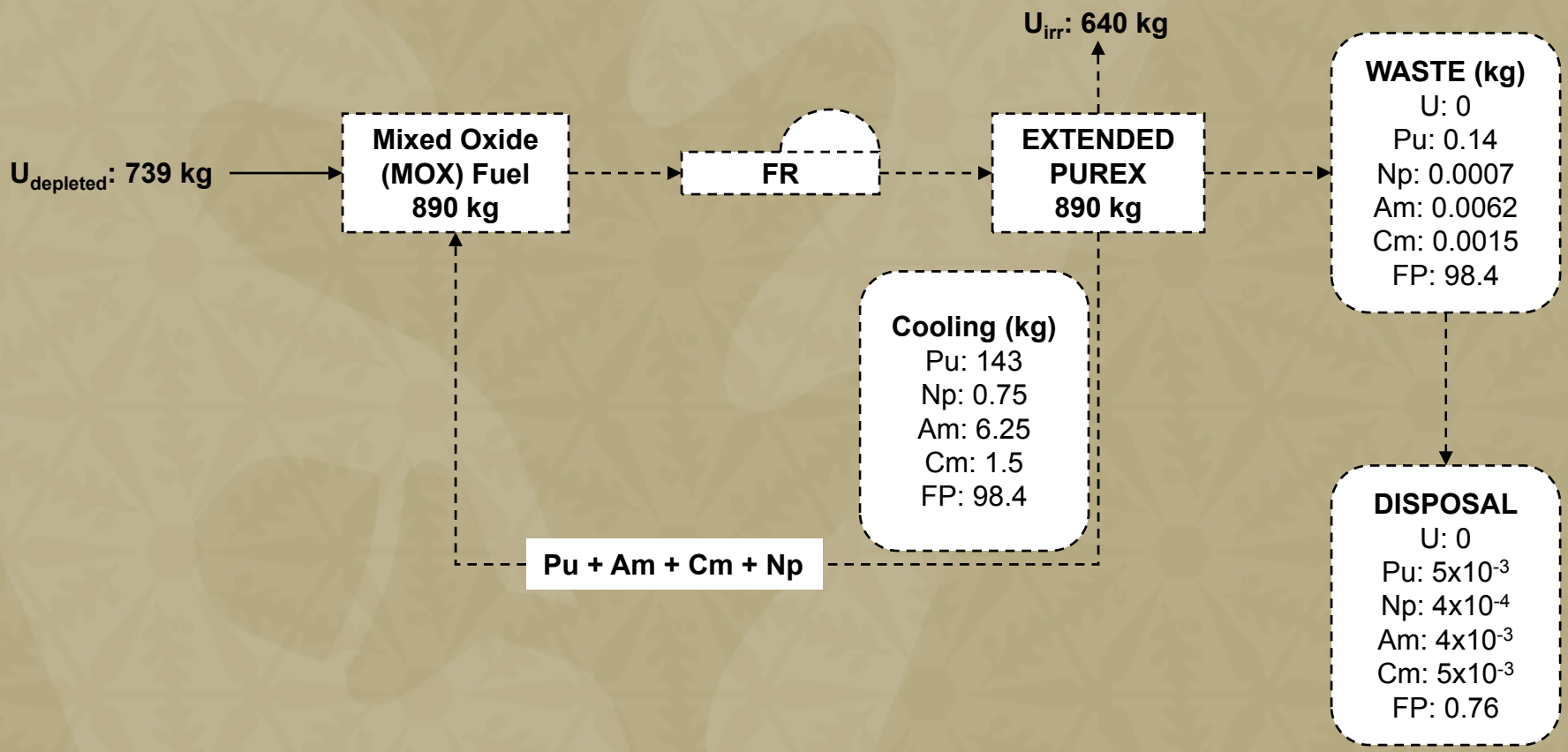
Fuel Cycles Considered
Closed—TRU Burning in FR



Basis: kg/TWhe

Source: NEA (2006)

Fuel Cycles Considered
Fully-closed—TRU Burning in FR



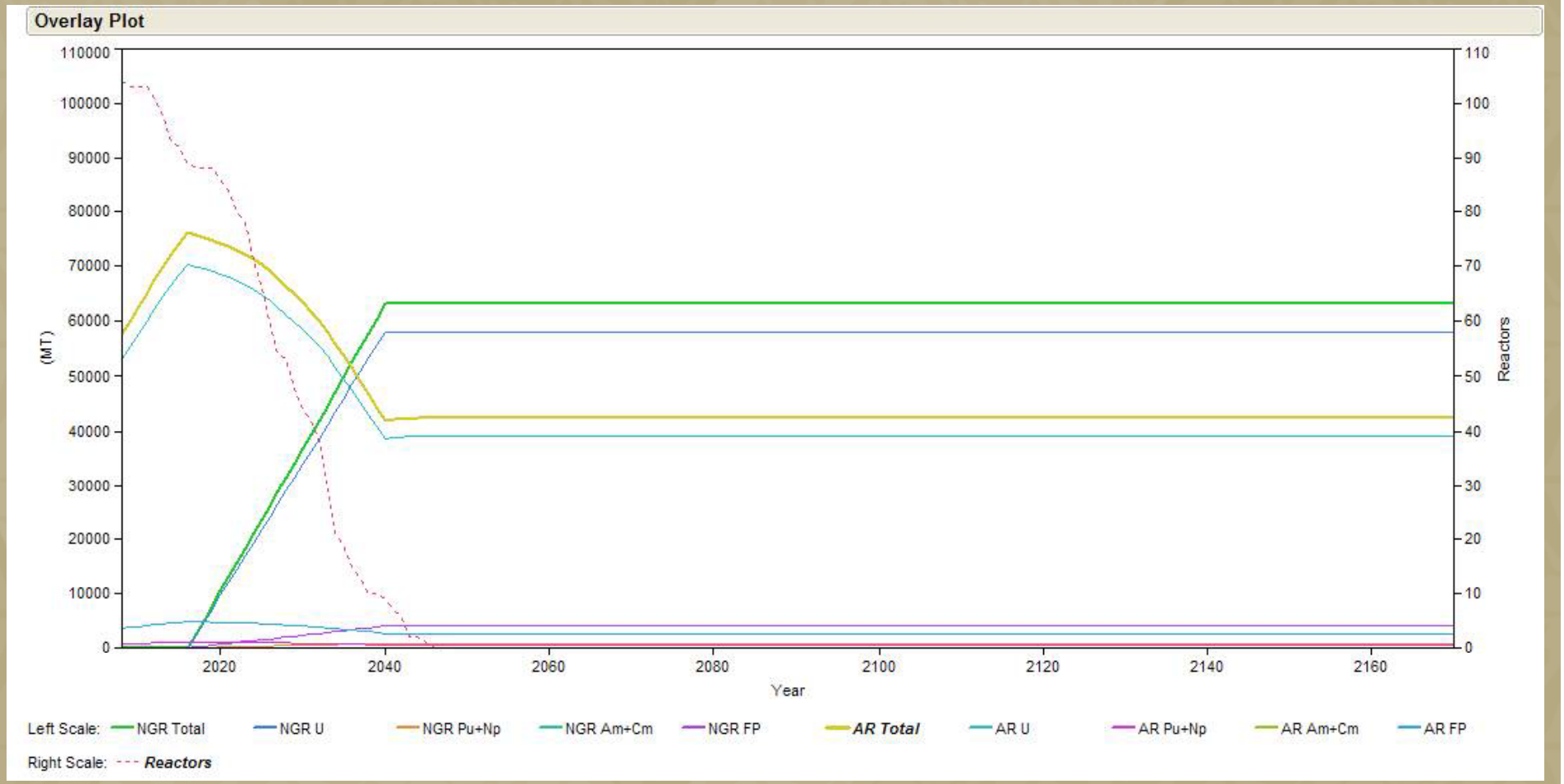
Basis: kg/TWhe

Source: NEA (2006)

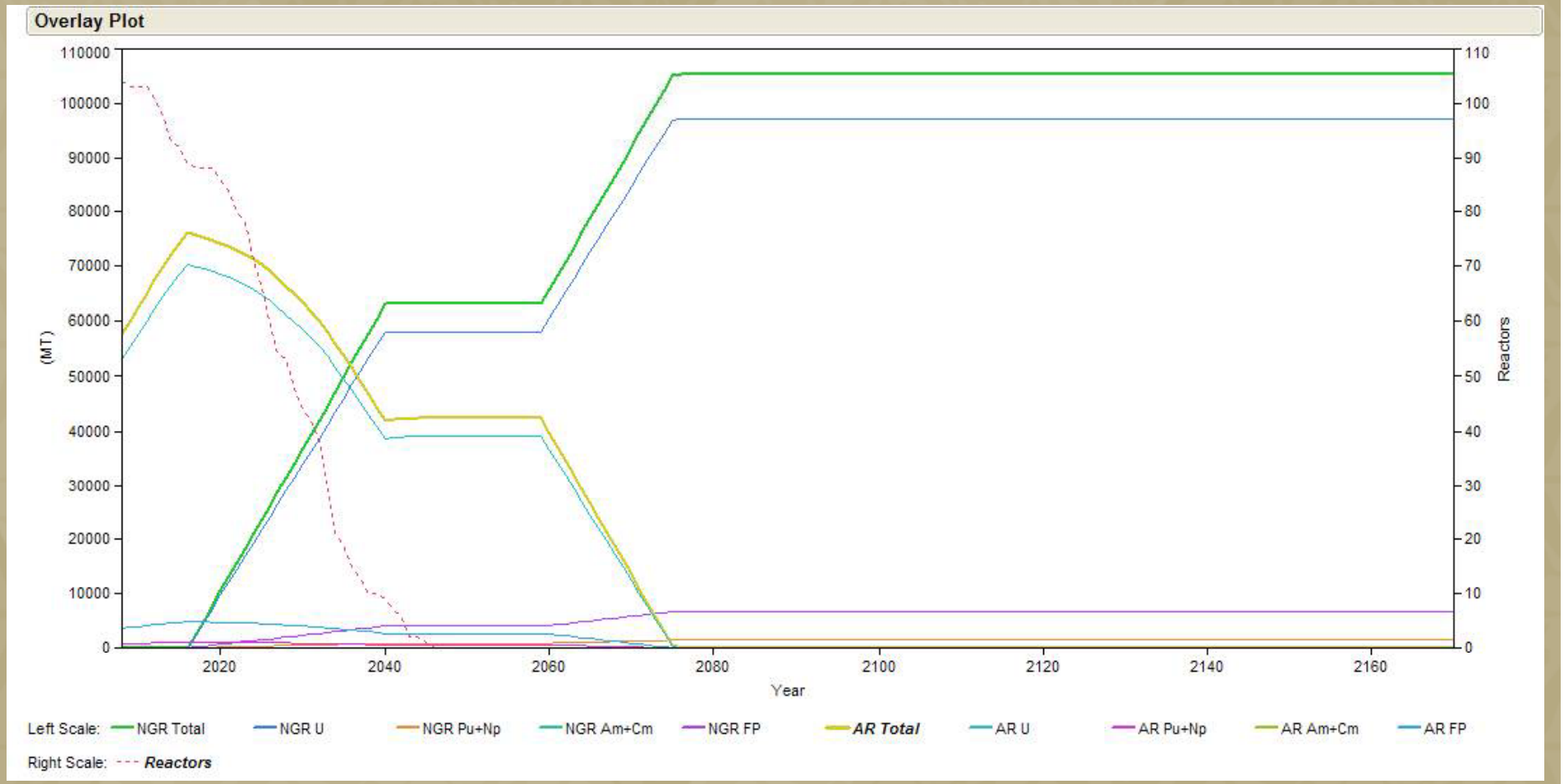
Fuel-Cycle Analysis and Assumptions

- "Base" case
  - 104 LWRs (equivalent) with no replacement
  - Conventional reprocessing (PUREX: Pu → MOX)
  - Impacts of YM and Second NGR (2X)
- Annual increase (EIA 2%)
  - No reprocessing versus once-through (MOX)
  - Impact of Second NGR (2X)
  - Impact of TRU burning (50 yrs + 2 NGRs)
- Other assumptions
  - Steady-state P&T values used (NEA 2006)
  - No decay correction
  - No change in waste classification

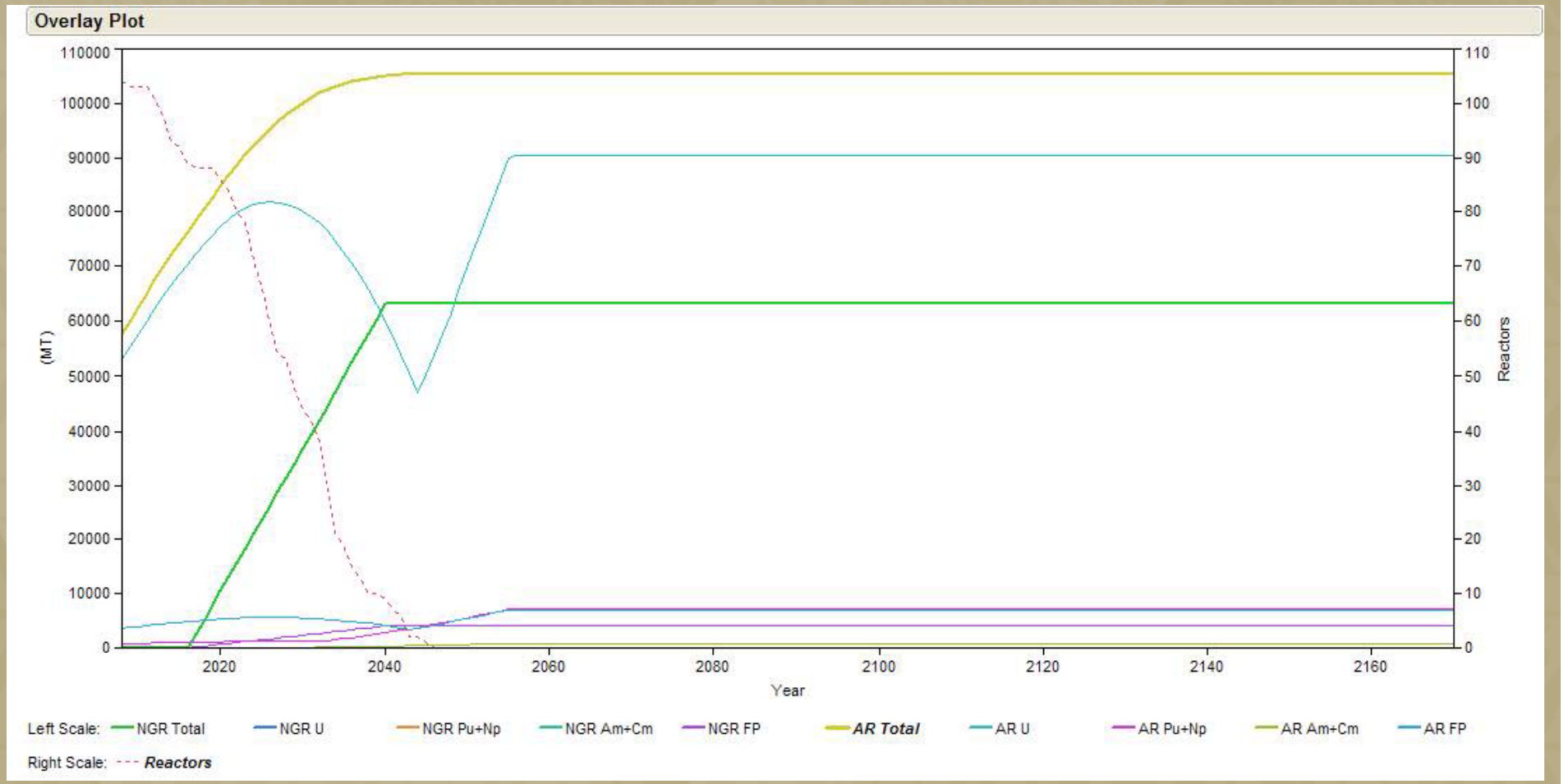
Base Case—No Reprocessing or MOX



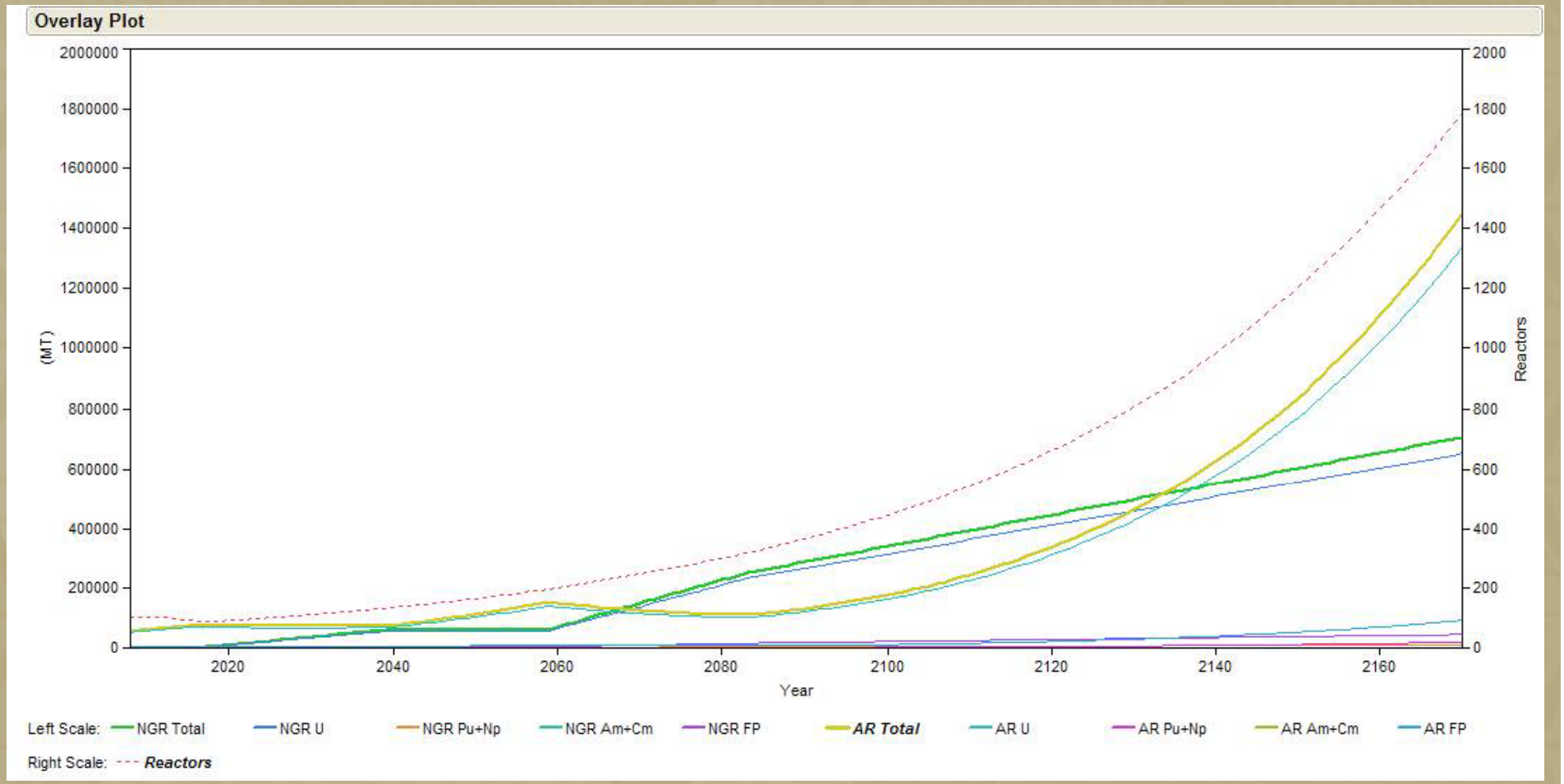
Base Case—Second NGR (50 years)



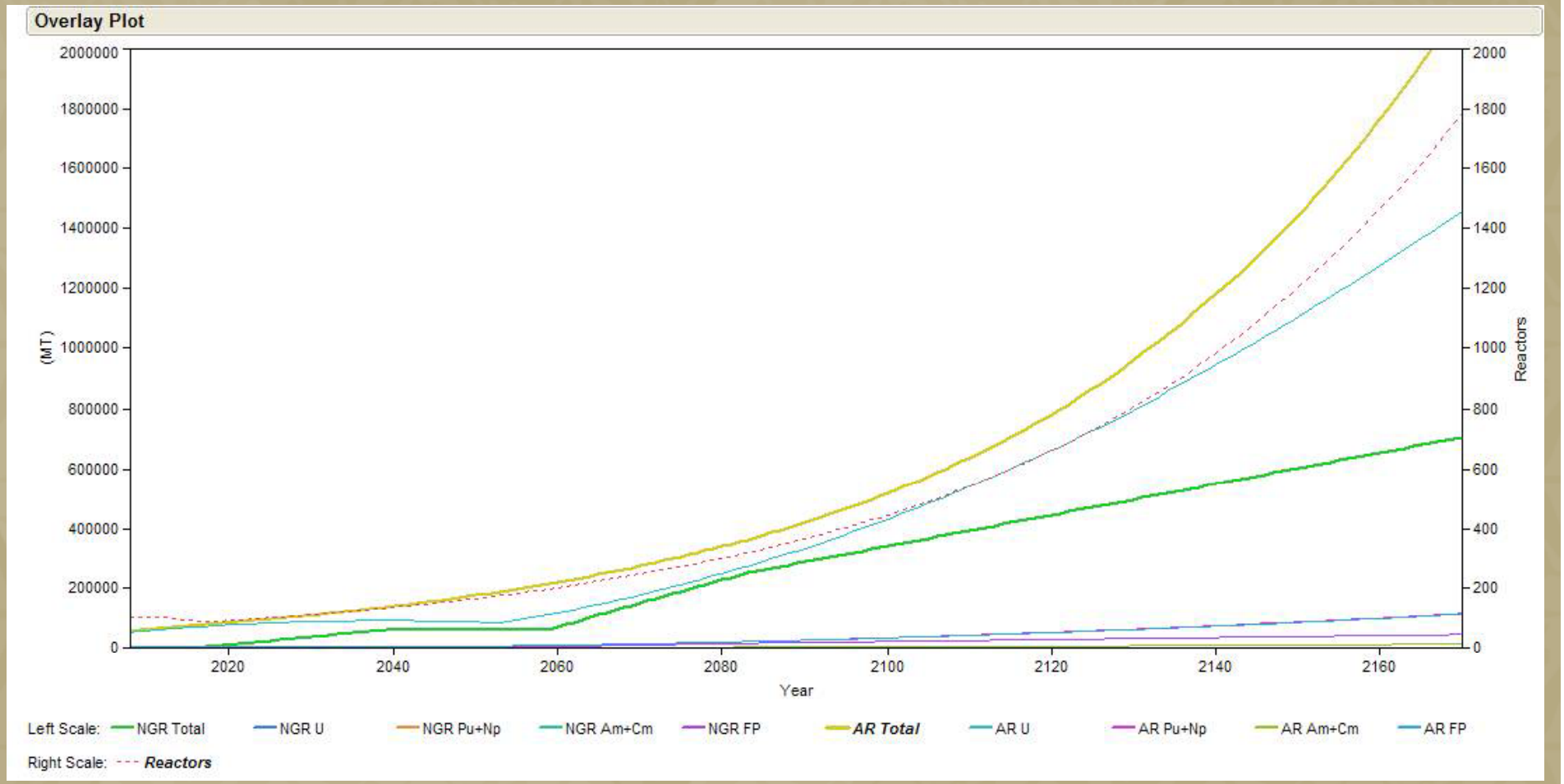
Open—Pu Once (PUREX) and MOX



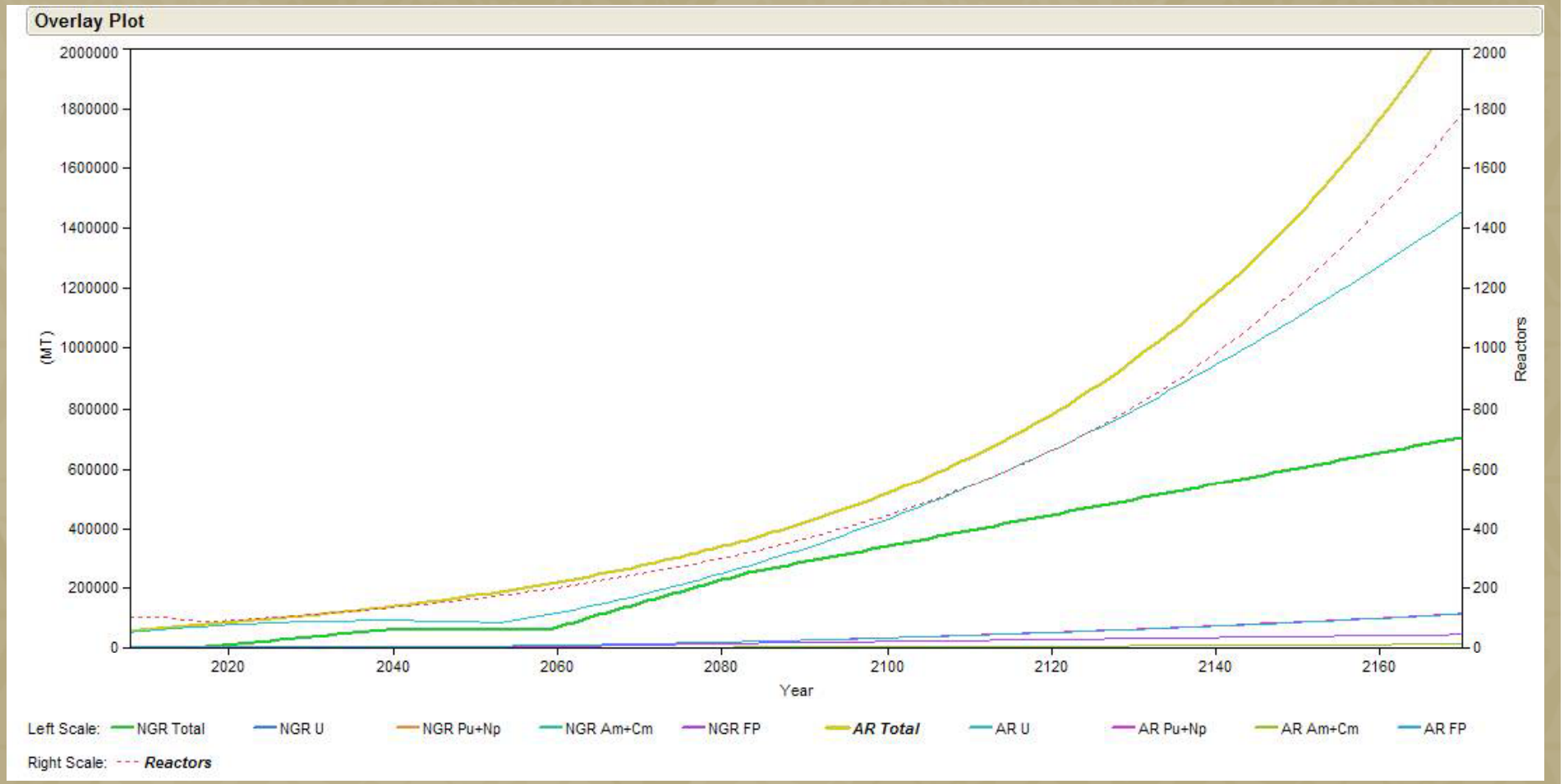
Base Case—2% Annual Increase/2nd NGR



Open—2% Annual Increase/2nd NGR



TRU Burning—2% Annual Increase/2nd NGR



Fuel-Cycle Analysis

- "Base" case
  - Second repository needed (but why hurry)
- Significant increase in reactor capacity
  - Additional and increased rate repository needed (might want to hurry a bit)
  - Beneficial to impose a waste-based capacity
  - Even if fuel cycle closed, significant actions are needed in the interim (MOX)
  - Issues will tend to be exacerbated with larger increases in reactor capacity

Supporting Overheads

NGR Background Information

Proposed Yucca Mountain (YM) Repository

- ***Max. Legal Capacity*: 70,000 MTiHM (NWPA)**

subsection (e)(2). The Commission decision approving the first such application shall prohibit the emplacement in the first repository of a quantity of spent fuel containing in excess of 70,000 metric tons of heavy metal or a quantity of solidified high-level radioactive waste resulting from the reprocessing of such a quantity of spent fuel until such time as a second repository is in operation. In the event that a monitored retrievable

- ***Proposed Action* from YM FEIS (2002) includes**
  - ★ Commercial SNF: 63,000 MTiHM (60% of projected total)
  - ★ DOE SNF: 2,333 MTiHM (93% of projected total)
  - ★ Defense HLW: 4,667 MT[i]HM (37% of projected total) ↔ 8,315 canisters (↔ ~5 m^3 waste glass/MT[i]HM)
  - ★ 24 years assumed for emplacement of SNF and HLW
  - ★ Closure complete 90-320 years after emplacement ends
- **2017 YM Projected Opening (2021+ more likely)**

SNF and Defense HLW Inventories

- **Current SNF and Defense HLW Inventories**
  - Commercial SNF: ~58,000 MTiHM (~2,000 MT/yr)
  - DOE SNF: 2,500 MTiHM
  - Defense HLW: ~12,505 MT[i]HM (12,280 canisters)
    - ★ ~1,200 MT[i]HM (~2,100 canisters) produced to date
- **Projected Future Total Inventories (Base Case)**
  - Commercial SNF: 105,000 MTiHM (40+ years)
  - DOE SNF: 2,500 MTiHM (Negligible change)
  - Defense HLW: ~12,505 MT[i]HM (30+ years)
- **Currently stored at reactor or treatment sites**
- **Proposed for disposal in Yucca Mountain (YM)**

Source: YM FEIS (2002)

Proposed Action at Yucca Mountain

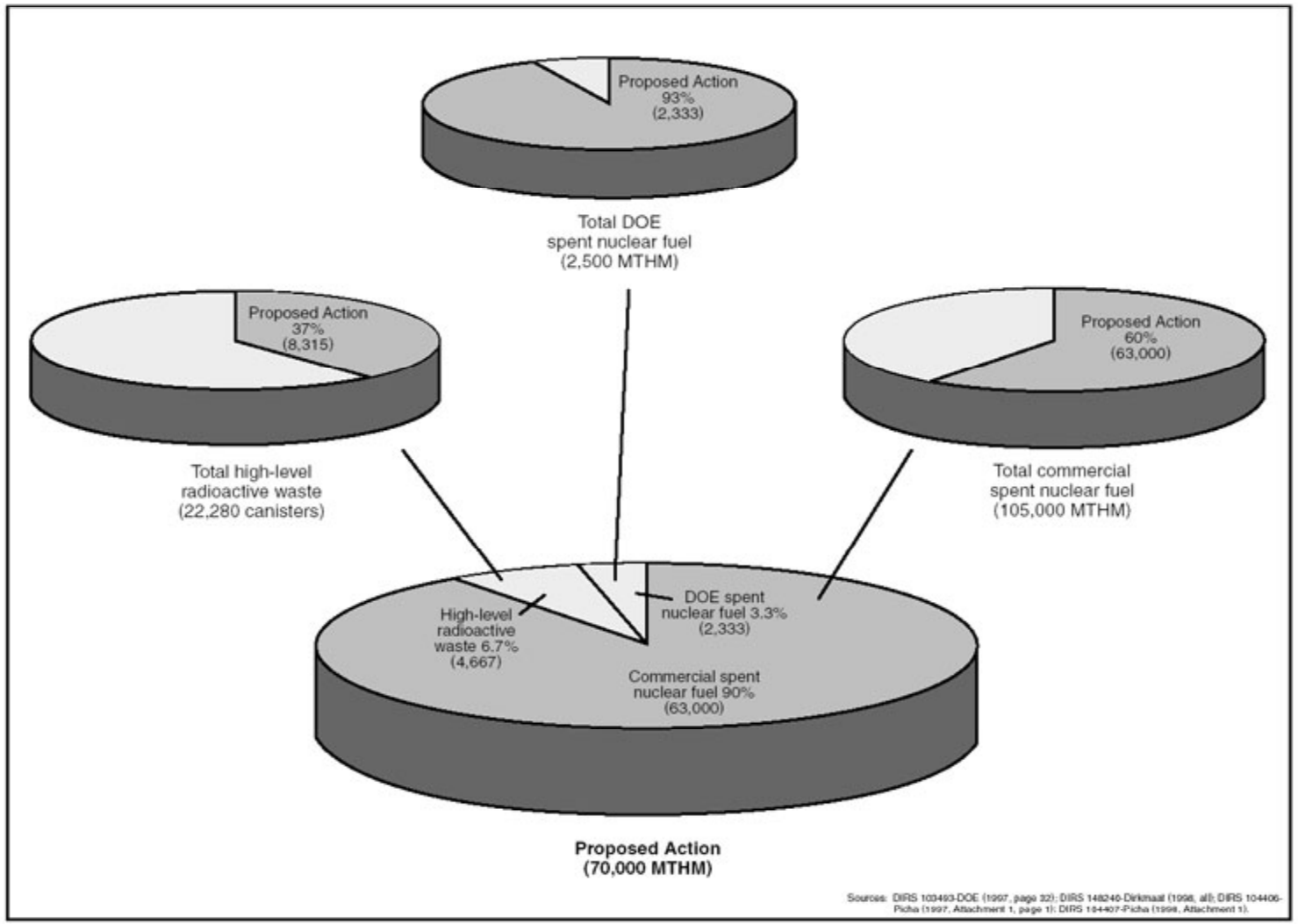
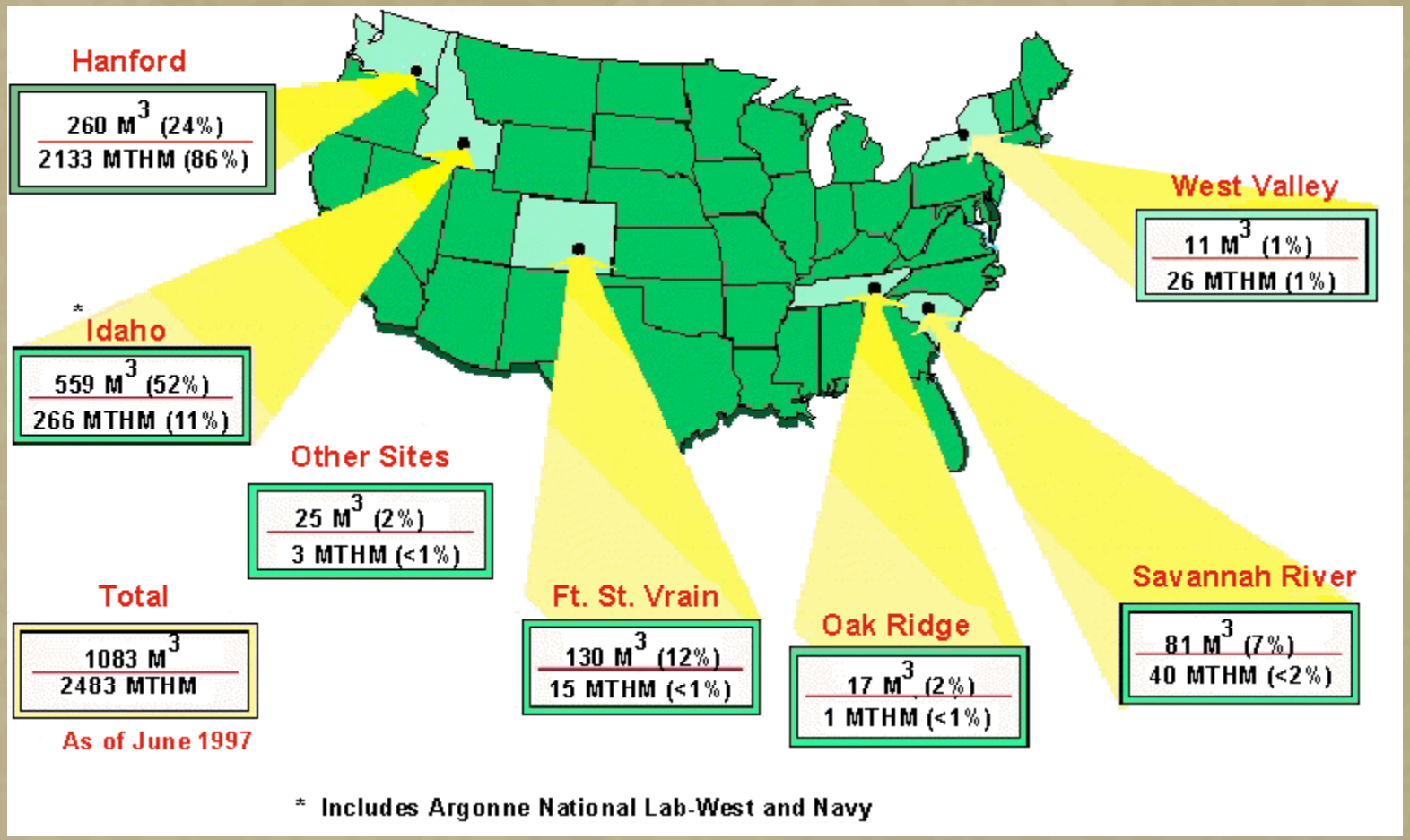


Figure A-2. Proposed Action spent nuclear fuel and high-level radioactive waste inventory.

Source: USDOE (2002) YM FEIS

DOE SNF Inventory: Locations and Amounts



Source: http://nsnfp.inel.gov/programdocuments/strategicplan/fullstrategicplan.asp

NGR Background Information (Cont'd)

Second National Geologic Repository (NGR)

- **NWPA (1982) called for two geologic repositories**
  - ★ YM selected as sole site for evaluation in 1986
  - ★ Second repository indefinitely suspended in 1986
- **Subsequent Amendments to NWPA (2004)**
  - ★ … report … on or after January 2007, but not later than January 2010, on the *need* for a second repository
- **Second repository will be needed unless NWPA amended and P&T employed**
  - ★ *Legal capacity based on spent fuel not waste* (NWPA)
- **Potential Impacts on Waste Management**
  - ★ P&T option including fuel and waste form development
  - ★ Classification of wastes resulting from P&T processes

WIPP Background Information

Waste Isolation Pilot Plant (WIPP)

- ***Max. Legal Capacity*: 175,600 m^3 and $5.1x10^6$ Ci of Defense TRU waste (WIPP LWA)**
  - ★ Limit of 7,080 m^3 RH-TRU Waste (DOE/NM Agreement)
  - ★ Permit issued in 1999 for mixed TRU wastes (NM)
- ***Planned* WIPP Disposal Volume: 116,100 m^3**
  - ★ *Received:* CH-TRU: 50,000 m^3 and some RH-TRU
  - ★ *Planned*: CH-TRU: 113,500 m^3 and RH-TRU: 2,840 m^3
  - ★ Approximately 60K m^3 projected to not be used (by 2034)
  - ★ Example: 8,315 [DWPF] canisters → ~23K m^3 glass
- **Received first shipment in 1999—to cease emplacement in 2034**
  - ★ Proposed 35-yr operations and ~100-yr monitoring

Source: NTWMP, Rev. 3 (2002)

Transuranic (TRU) Waste Inventories

- *Current* TRU Waste Inventories (2002)
  - CH-TRU (200 mrem/hr at surface): 110,000 m^3
    - ~30,000 m^3 of this is buried waste at INL
  - RH-TRU: 2,800 m^3
  - Buried TRU: 126,000 m^3 (Peterson, et al. 2002)
- Projected *Total* TRU Waste Inventories
  - CH-TRU: 190,000 m^3
  - RH-TRU: 4,400 m^3
- Large uncertainties in TRU waste volumes
  - *Current* INL TRU: 60K m^3 to 100K m^3 to 210K+ m^3
- Currently stored across DOE Complex
- Much of TRU waste intended for disposal in the Waste Isolation Pilot Plant (WIPP)

Source: NTWMP, Rev. 3 (2002)

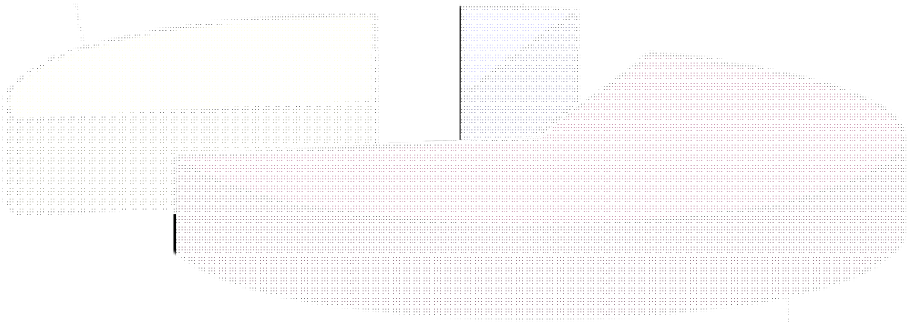
WIPP Background Information (Cont'd)

What to do if or when WIPP closes in 2034?

- **Should we care about WIPP and how much?**
  - ★ *Pro*: No capacity limitation for Defense HLW (not TRU)
  - ★ *Con*: Defense TRU waste only at this time (and *specifically bans* emplacement of SNF and HLW)
  - ★ *Pro*: Reclassification of Hanford (HLW) to TRU wastes
  - ★ *Con*: Public reaction to reclassification and WIR decision
  - ★ *Pros*: "Self-sealing" and low permeability
  - ★ *Cons*: Probability of human intrusion and "retrievability"
  - ★ *Result*: No clear decision appears possible
- **Should something be done before 2034? And, if so, when?**
- **Can something be done that includes WIPP?**

TRU Waste Managed by DOE

- Prohibited from WIPP disposal or generated after end of operational life
- Prohibited by legislation or non-defense
- Facility will be reevaluated for feasibility
- Overarching concern is to ensure a disposal path

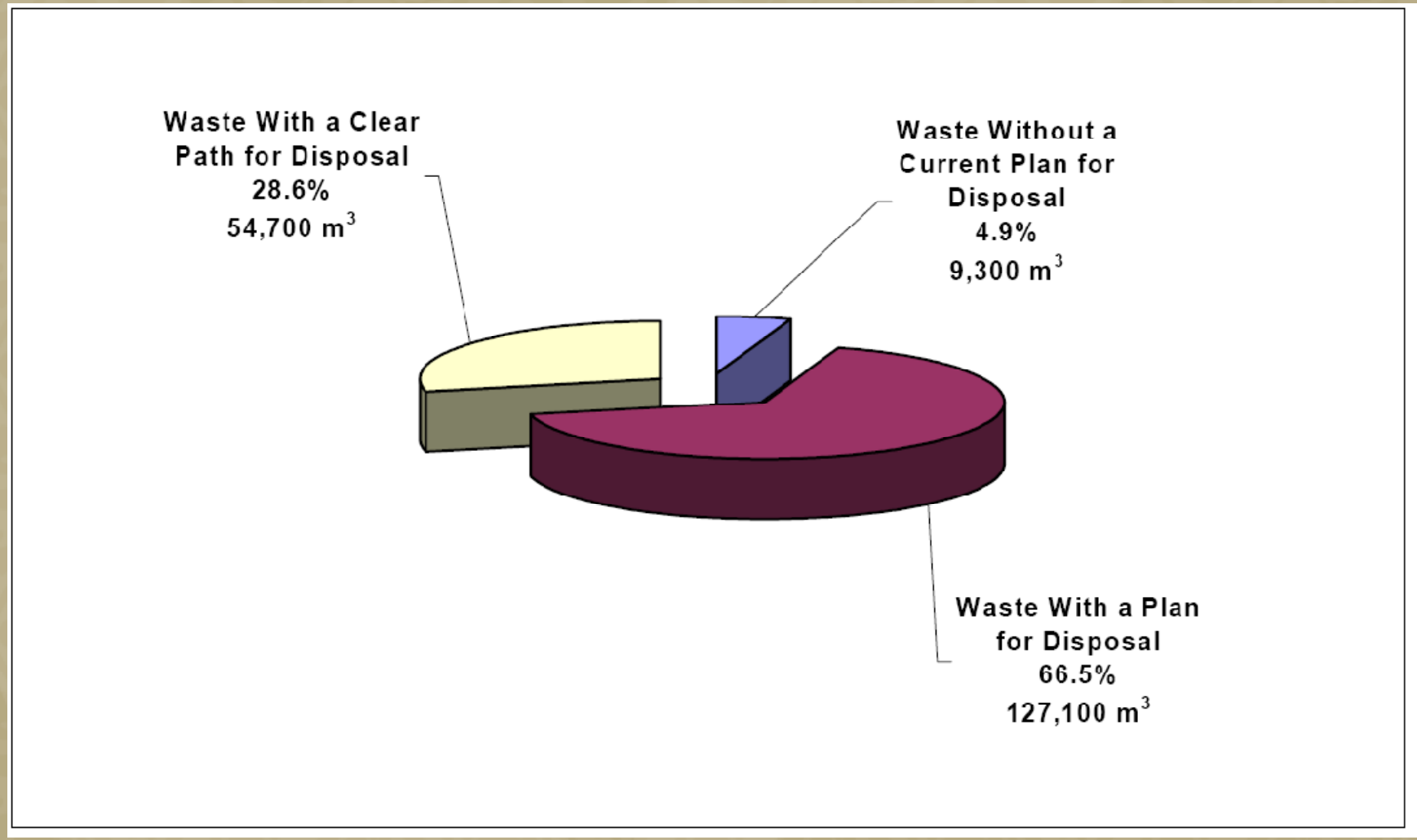


- Readily certified
- Infrastructure in place
- Defense-generated TRU waste that
- Conforms to WIPP WAC and HWFP

- Need that must be fulfilled prior to certification for disposal
- Include infrastructure, technology needs, and regulatory issues
- DOE has plans in place for required infrastructure, technologies, and regulatory change

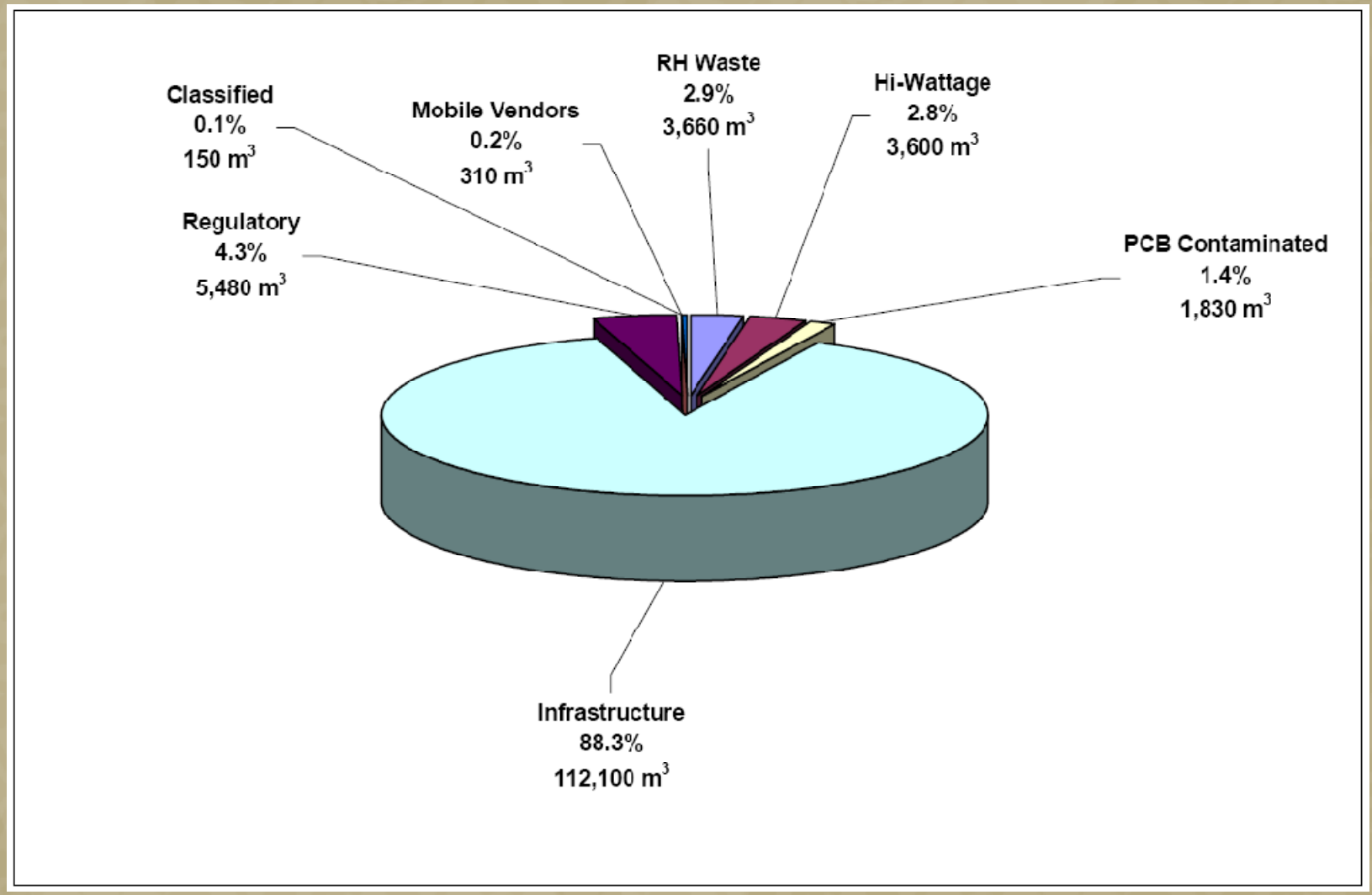
Source: NTWMP, Rev. 3 (2002)

TRU Wastes Managed by DOE



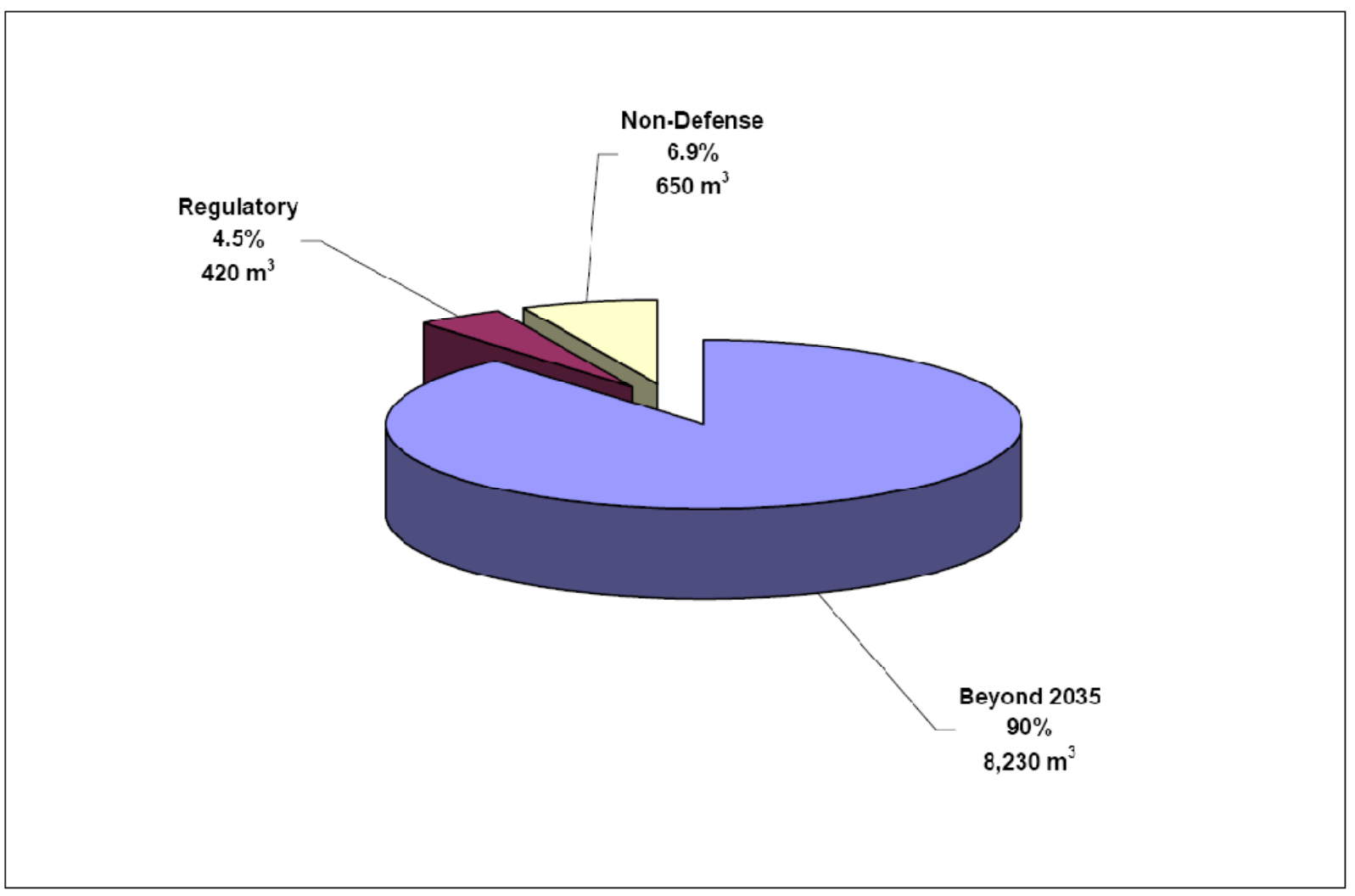
Source: NTWMP, Rev. 3 (2002)

Wastes with a Plan for Disposal



Source: NTWMP, Rev. 3 (2002)

TRU Wastes not Acceptable for WIPP



Source: NTWMP, Rev. 3 (2002)