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# Nuclear Waste Assessment System for Technical Evaluation (NUWASTE)

Presented to:
**Swedish National Council for Nuclear Waste**

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**Nuclear Waste – Burden or Benefit**

**November 8, 2012**

**Stockholm, Sweden**

# Topics

- NUWASTE Overview
  - Objective
  - Principles
  - Structure
- Differences Between US and Swedish Programs
- Swedish Evaluation
  - Scenarios
  - Disposal container savings
  - Natural uranium savings
- Typical refueling requirements
- Summary of results
- Scenario 4.1 processing projection
- Observation

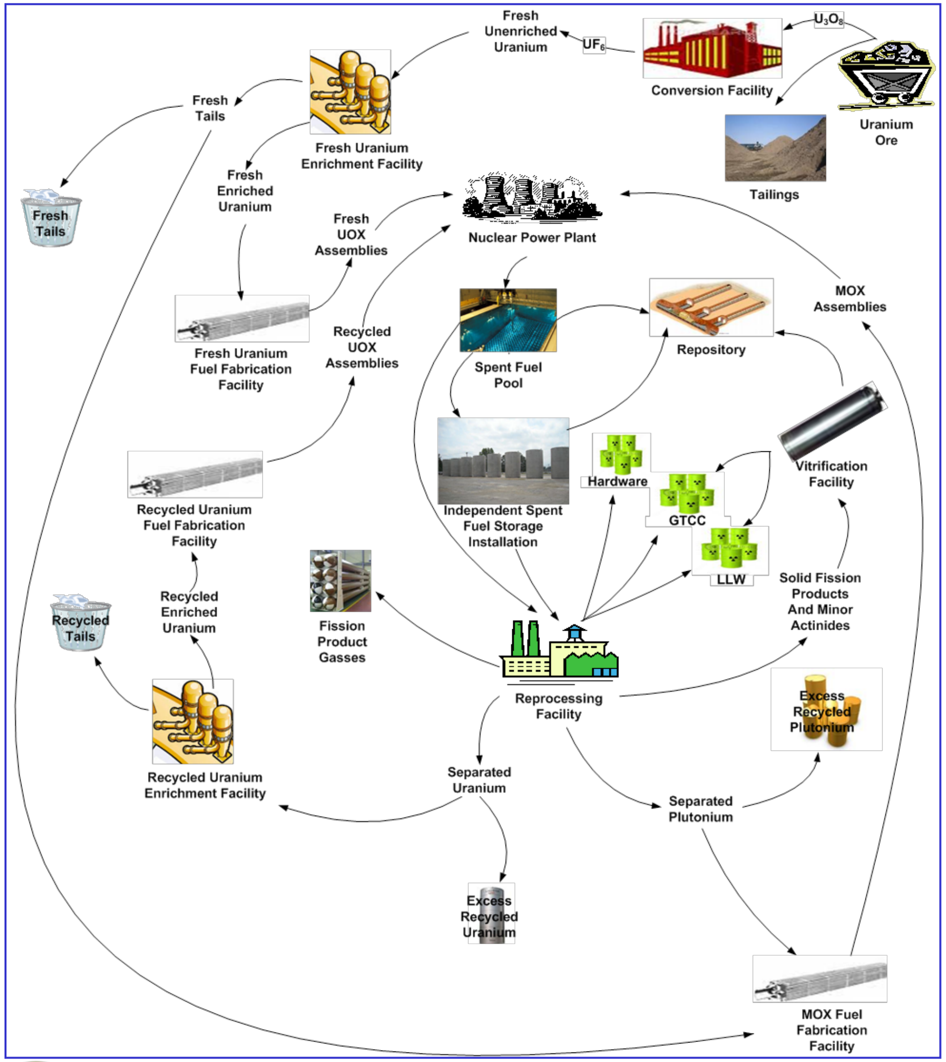
# NUWASTE Objectives

- Understand the impacts of potential fuel cycle initiatives on the generation and management of SNF, HLW and other radioactive waste streams.
- Create ability to vary system inputs to represent different initiatives that DOE may consider.
- Evaluate the impact on selected parameters, such as:
  - Number of surface dry storage casks required
  - Number of disposal waste packages required
  - Mass of natural uranium required
  - New waste streams
  - Proliferation risk
  - Facility utilization

# NUWASTE Principles

- Focused on present light water reactor and reprocessing technology (single recycle).
- Covers the full life cycle of US nuclear power production and waste disposition.
- Based on material balances of assemblies and masses.
- Built on fundamental physics concepts and methods.
- Utilizes data from open literature and DOE documents.
- Deterministic methodology that enables the user to explore the sensitivity to various inputs.

# NUWASTE Structure




Includes:

- 12 facilities
- 10 waste streams

Tracks:

- 65 individual isotopes
- Fresh uranium BWR & PWR assemblies
- Recycled uranium BWR and PWR assemblies
- PWR and BWR MOX assemblies
- Mass & assemblies reprocessed
- Mass & assemblies disposed
- Waste stream masses

# Differences between the US and Swedish Programs

US assumptions based on Yucca Mountain Program, Swedish Assumptions based on SKB Technical Report TR-10-13

- Storage methodology
  - USA – Dry storage systems as necessary based on fuel pool capacity
  - Sweden – Transferred to CLAB after 2 years out-of-reactor

| | Installed Nuclear Generation (GWe) | Inventory | | Disposal Container Capacity | | | Disposal Criteria |
|---|---|---|---|---|---|---|---|
| | | MT | Assemblies | BWR | PWR | HLW | |
| US | 100 | 170,000 | 575,000 | 44 | 21 | 6 | 2.3 KW/m |
| Sweden | 10 | 11,000 | 54,000 | 12 | 4 | 1 | 1.7 KW per container |

# Scenarios Evaluated

- Four datasets evaluated, each with 8 scenarios

| Dataset | Scenario | Waste Stream | Processing Capacity |
|---|---|---|---|
| 1 | 1.1 thru 1.8 | No Life Extension | 300 MT/year |
| 2 | 2.1 thru 2.8 | No Life Extension | 500 MT/year |
| 3 | 3.1 thru 3.8 | 10 Year Life Extension | 300 MT/year |
| 4 | 4.1 thru 4.8 | 10 Year Life Extension | 500 MT/year |

- Parameters evaluated
  - Disposal container savings
  - Natural uranium savings

# Scenarios Evaluated

Scenarios for Dataset 1 and Dataset 3 – 300 MTU/year transportation capacity

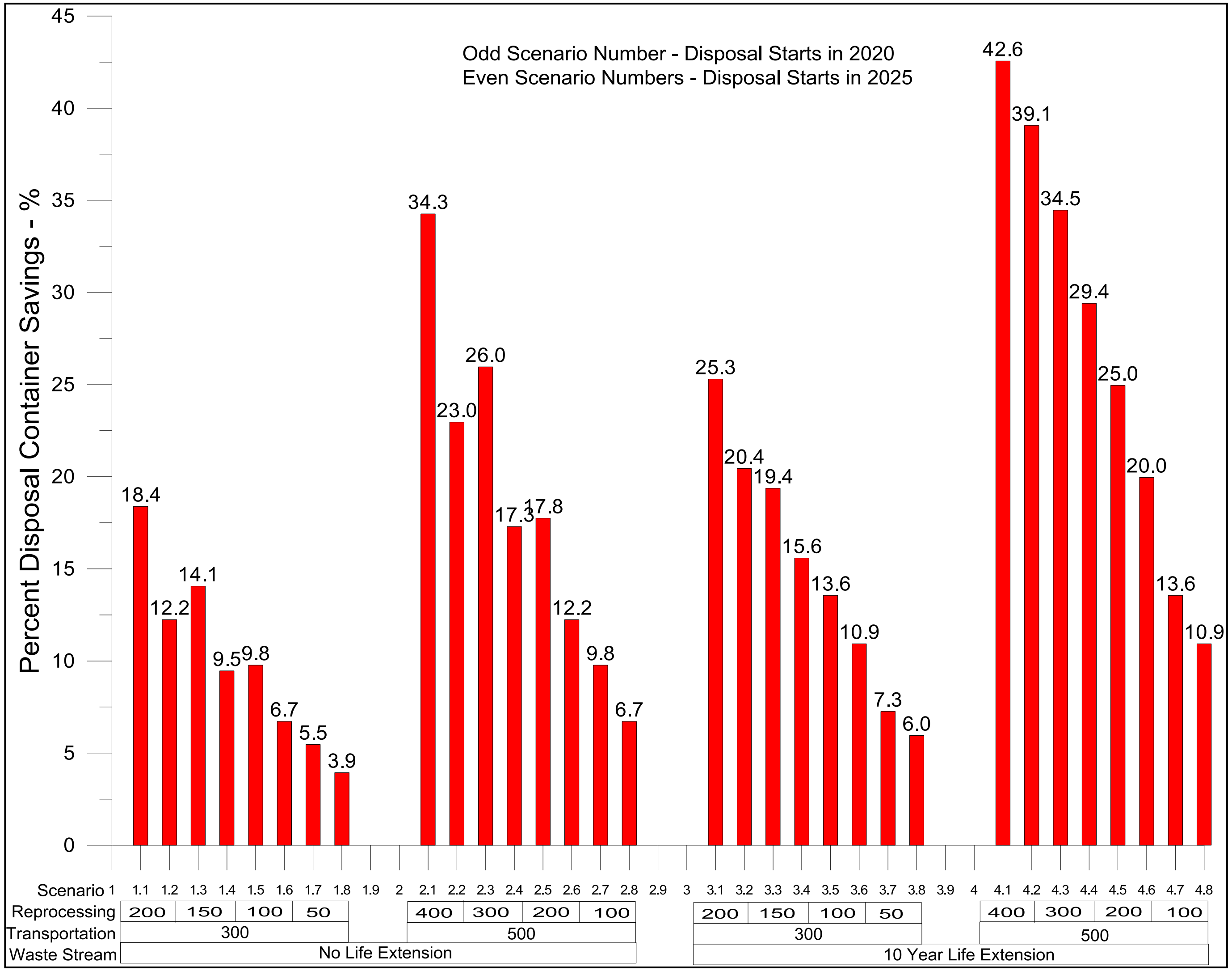
| Sequence No. | Disposal Start Year | Reprocessing | |
|---|---|---|---|
| | | Start Year | Capacity (MT) |
| 1 | 2023 | 2020 | 200 |
| 2 | | 2025 | |
| 3 | | 2020 | 150 |
| 4 | | 2025 | |
| 5 | | 2020 | 100 |
| 6 | | 2025 | |
| 7 | | 2020 | 50 |
| 8 | | 2025 | |

# Scenarios Evaluated

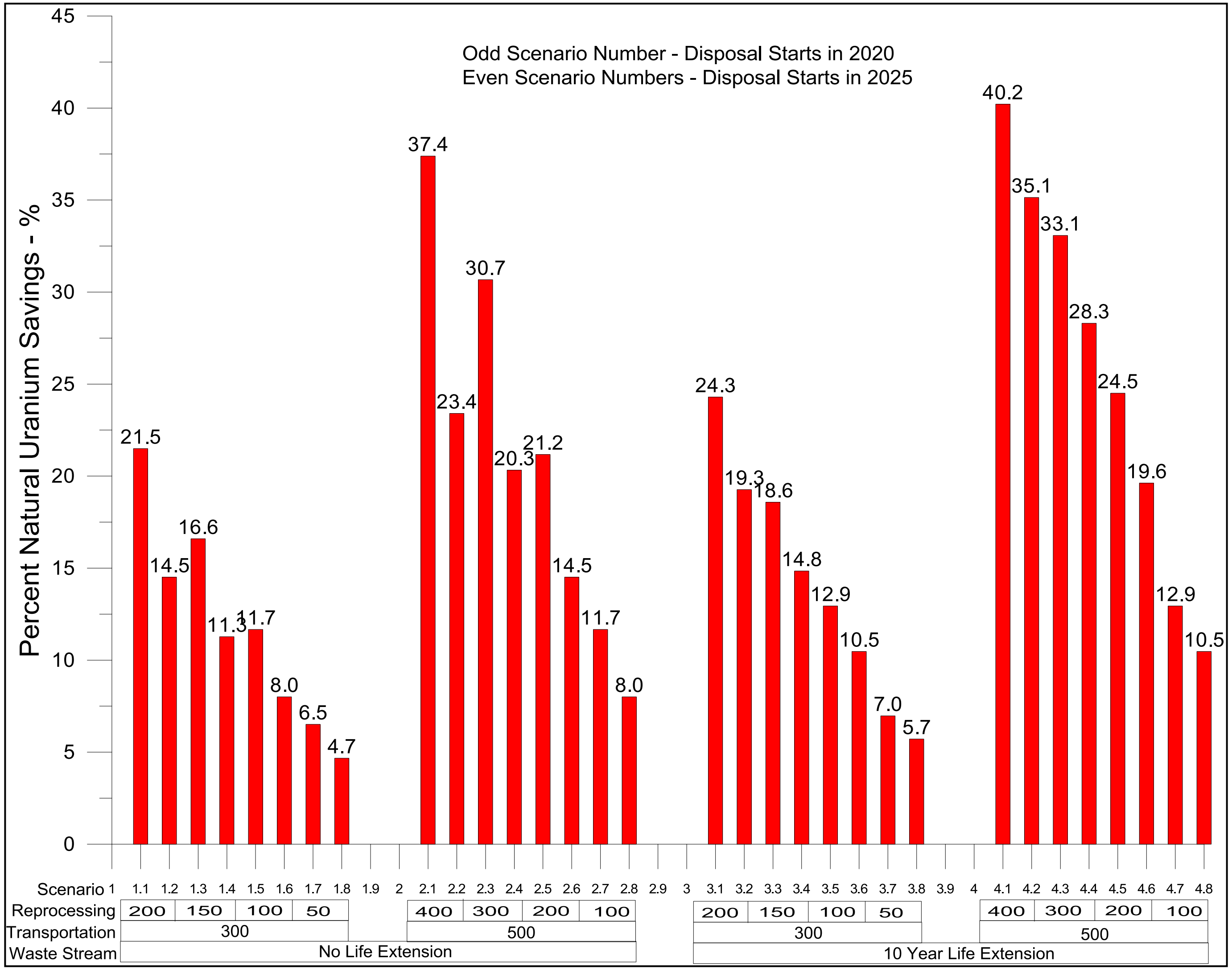
Scenarios for Dataset 2 and Dataset 4 – 500 MTU/year transportation capacity

| Sequence No. | Disposal Start Year | Reprocessing | |
|---|---|---|---|
| | | Start Year | Capacity (MT) |
| 1 | 2023 | 2020 | 400 |
| 2 | | 2025 | |
| 3 | | 2020 | 300 |
| 4 | | 2025 | |
| 5 | | 2020 | 200 |
| 6 | | 2025 | |
| 7 | | 2020 | 100 |
| 8 | | 2025 | |

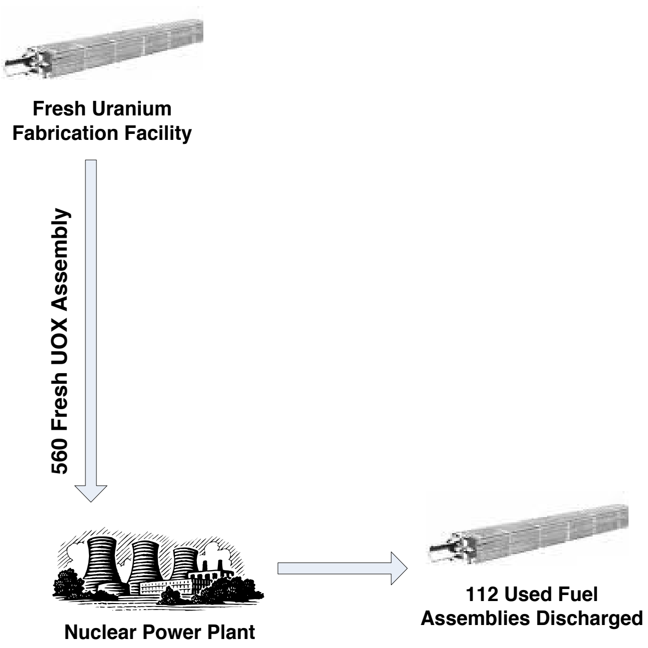
# Disposal Container Savings



# Natural Uranium Savings



# Typical Refueling Requirement – Fresh Uranium Fuel



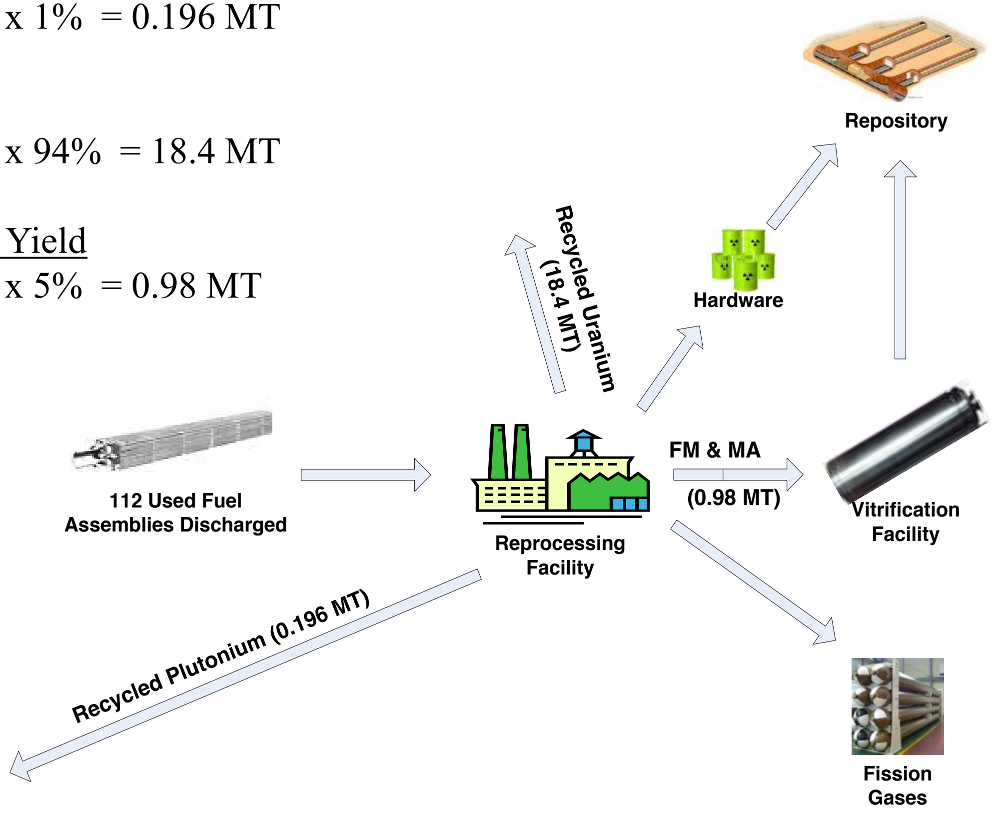

- BWR reactor core containing 560 fuel assemblies
- Average 20% assemblies discharges per year

# Typical Yields from Reprocessing

Plutonium Yield
112 assemblies x 0.175 MT/assembly x 1% = 0.196 MT

Uranium Yield
112 assemblies x 0.175 MT/assembly x 94% = 18.4 MT

Fission Products and Minor Actinides Yield
112 assemblies x 0.175 MT/assembly x 5% = 0.98 MT



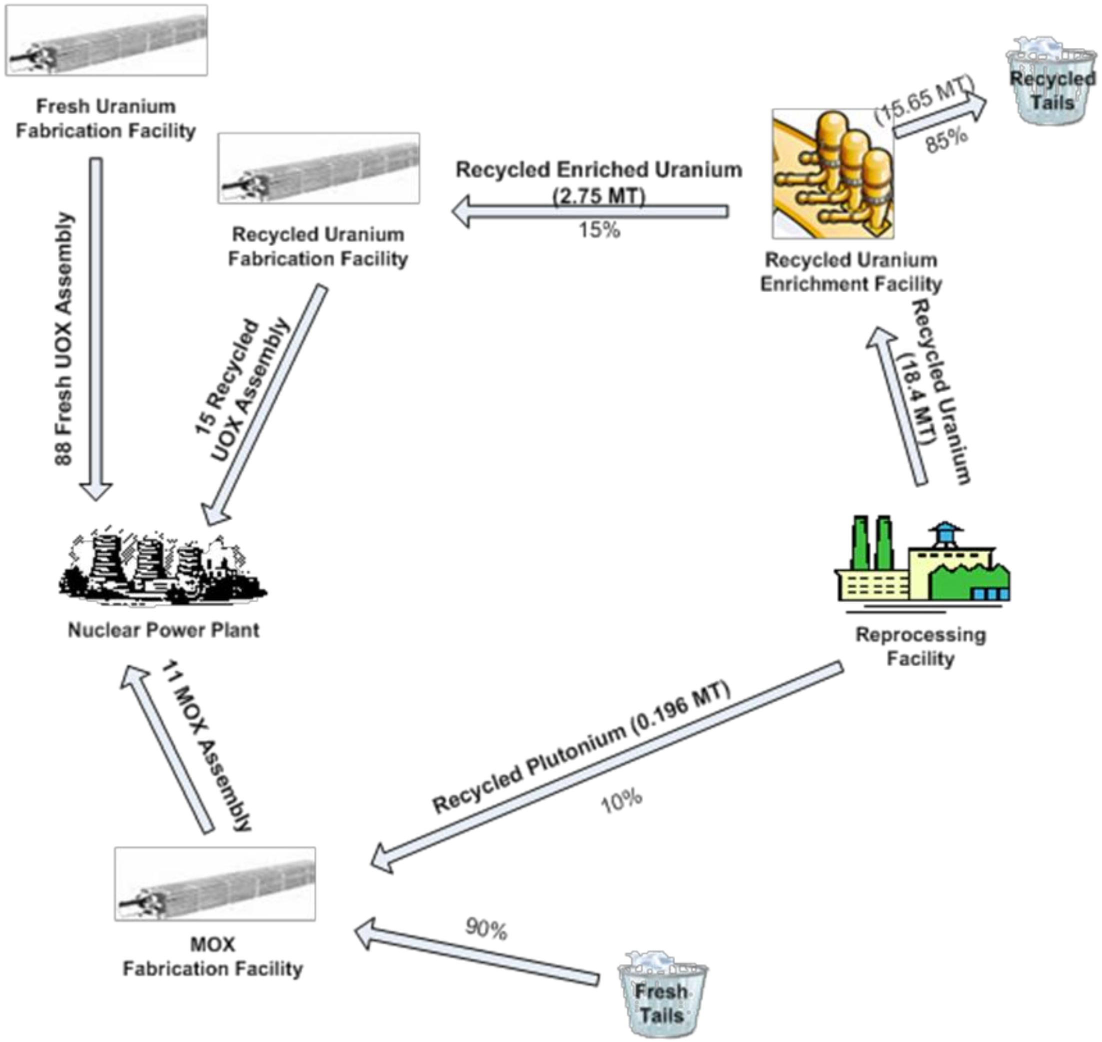
# Fresh and Recycled Fuel Fabricated

112 assemblies needed to refuel reactor

- 15 recycled UOX
- 11 MOX
- 86 fresh UOX

Reduction in fresh uranium required for a single year

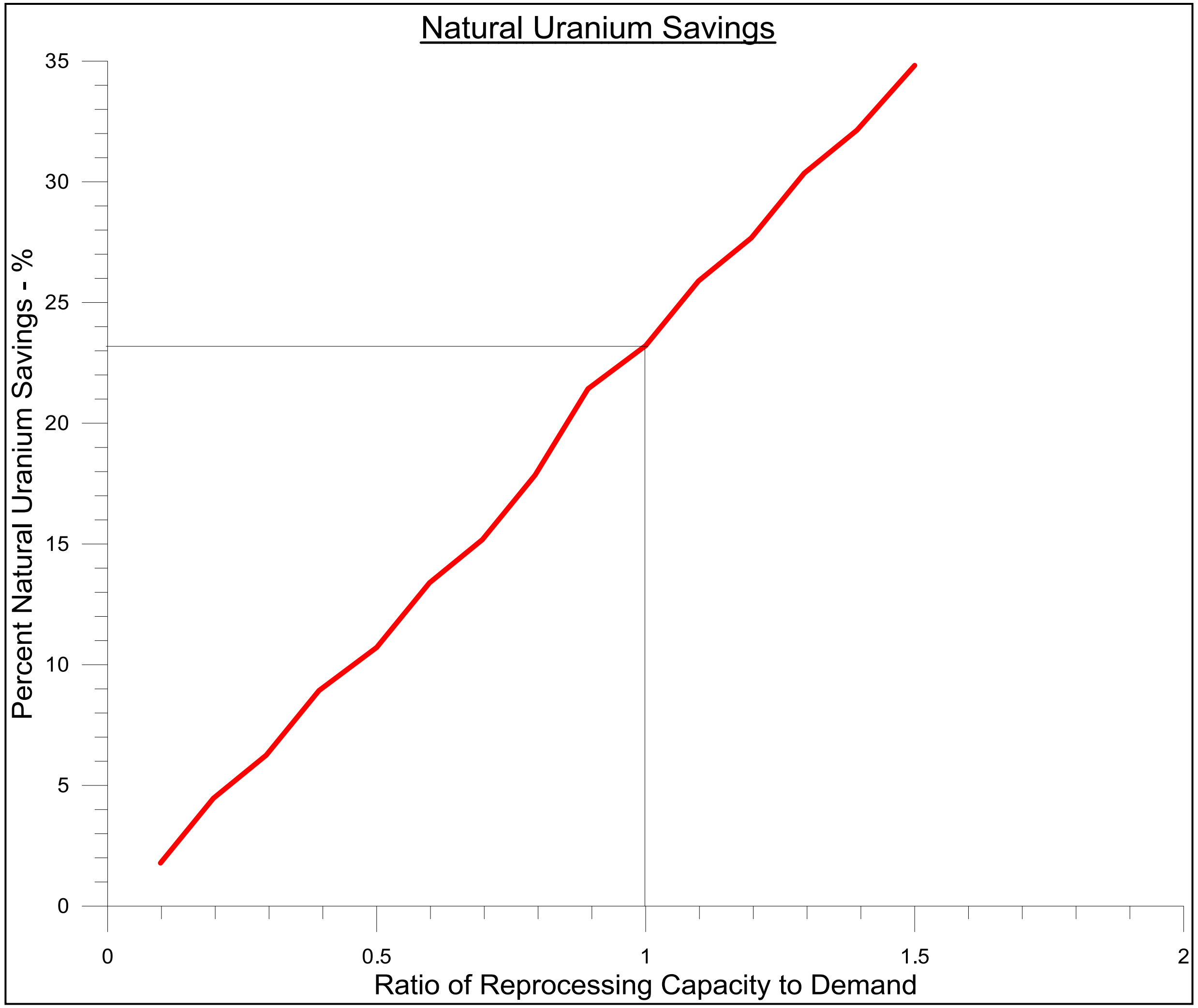
- (15+11)/112 = 23%



# Natural Uranium Saving

| A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Size | % Discharded Each Cycle | Number Discharged Assemblies (A x B) | % Discharged Assemblies Recycled | Number Recycled Assemblies (C x D) | MT per Assembly | MT Recycled Uranium (94%) (E x F x 0.94) | MT Enriched Recycled Uranium (15%) (G x 0.15) | Number Recycled UOX Assemblies (H/F) | MT Recycled Plutonium (1%) (E x F x 0.01) | Number Recycled MOX Assemblies (J/(F x 0.1) | Ratio of Reprocessing Capacity to Demand (E/C) | % Natural Uranium Savings (I + K)/C |
| 560 | 20% | 112 | 150% | 168 | 0.175 | 27.64 | 4.15 | 23 | 0.29 | 16 | 1.50 | 34.8% |
| 560 | 20% | 112 | 140% | 156 | 0.175 | 25.66 | 3.85 | 21 | 0.27 | 15 | 1.39 | 32.1% |
| 560 | 20% | 112 | 130% | 145 | 0.175 | 23.85 | 3.58 | 20 | 0.25 | 14 | 1.29 | 30.4% |
| 560 | 20% | 112 | 120% | 134 | 0.175 | 22.04 | 3.31 | 18 | 0.23 | 13 | 1.20 | 27.7% |
| 560 | 20% | 112 | 110% | 123 | 0.175 | 20.23 | 3.04 | 17 | 0.22 | 12 | 1.10 | 25.9% |
| **560** | **20%** | **112** | **100%** | **112** | **0.175** | **18.42** | **2.76** | **15** | **0.20** | **11** | **1.00** | **23.2%** |
| 560 | 20% | 112 | 90% | 100 | 0.175 | 16.45 | 2.47 | 14 | 0.18 | 10 | 0.89 | 21.4% |
| 560 | 20% | 112 | 80% | 89 | 0.175 | 14.64 | 2.20 | 12 | 0.16 | 8 | 0.79 | 17.9% |
| 560 | 20% | 112 | 70% | 78 | 0.175 | 12.83 | 1.92 | 10 | 0.14 | 7 | 0.70 | 15.2% |
| 560 | 20% | 112 | 60% | 67 | 0.175 | 11.02 | 1.65 | 9 | 0.12 | 6 | 0.60 | 13.4% |
| 560 | 20% | 112 | 50% | 56 | 0.175 | 9.21 | 1.38 | 7 | 0.10 | 5 | 0.50 | 10.7% |
| 560 | 20% | 112 | 40% | 44 | 0.175 | 7.24 | 1.09 | 6 | 0.08 | 4 | 0.39 | 8.9% |
| 560 | 20% | 112 | 30% | 33 | 0.175 | 5.43 | 0.81 | 4 | 0.06 | 3 | 0.29 | 6.3% |
| 560 | 20% | 112 | 20% | 22 | 0.175 | 3.62 | 0.54 | 3 | 0.04 | 2 | 0.20 | 4.5% |
| 560 | 20% | 112 | 10% | 11 | 0.175 | 1.81 | 0.27 | 1 | 0.02 | 1 | 0.10 | 1.8% |

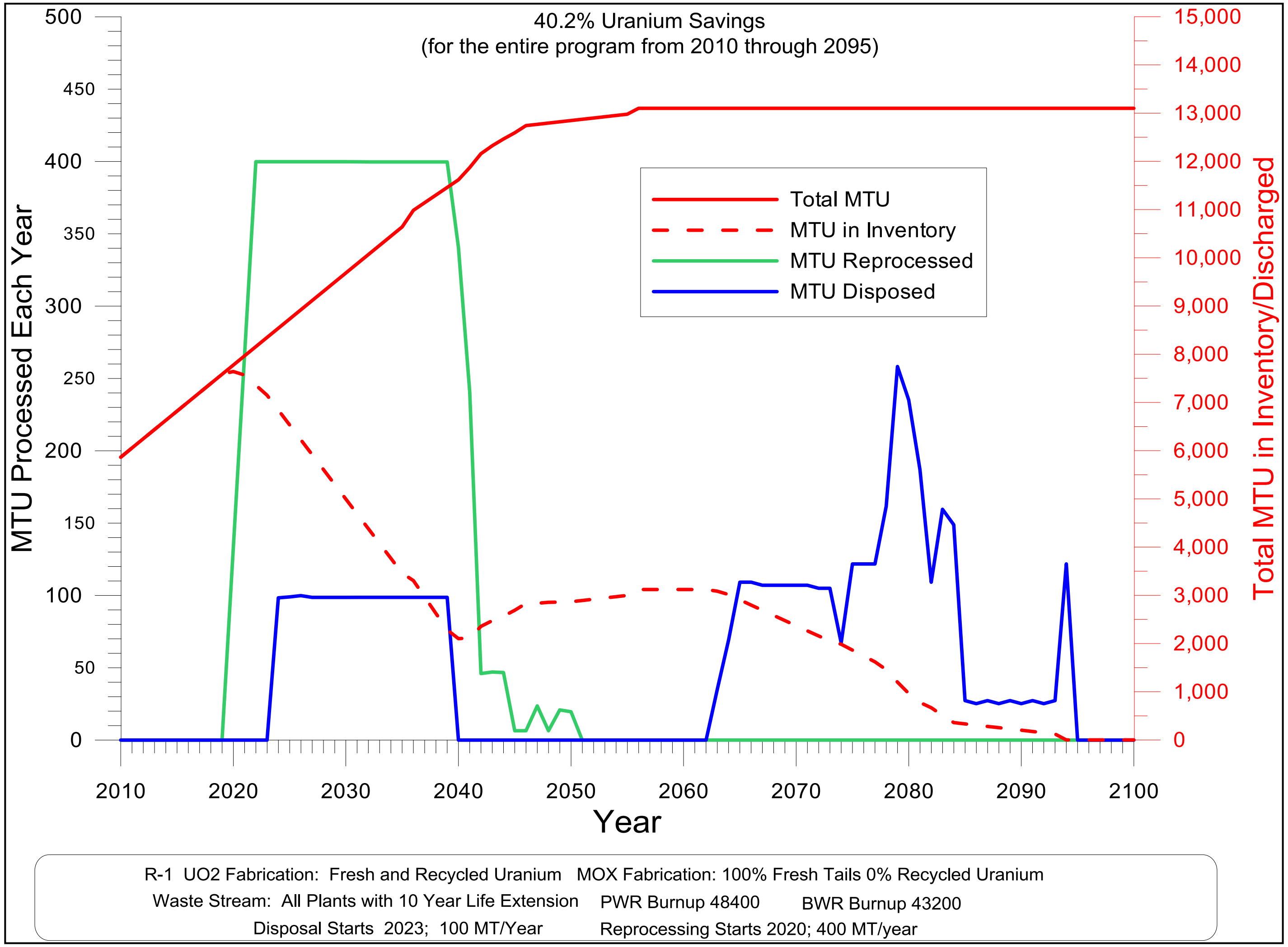
# Natural Uranium Saving



# Summary of Disposal Container and Natural Uranium Savings

| DataSet | Waste Stream | Disposal Start | Transportation Capacity (MT/year) | Reprocessing Start | Reprocessing Capacity (MT/year) | Disposal Container Savings (%) | Natural Uranium Savings (%) |
|---|---|---|---|---|---|---|---|
| 1.1 | No Life Extension | 2023 | 300 | 2020 | 200 | 18.39 | 21.50 |
| 1.2 | | 2023 | | 2025 | 200 | 12.25 | 14.51 |
| 1.3 | | 2023 | | 2020 | 150 | 14.06 | 16.59 |
| 1.4 | | 2023 | | 2025 | 150 | 9.47 | 11.28 |
| 1.5 | | 2023 | | 2020 | 100 | 9.77 | 11.67 |
| 1.6 | | 2023 | | 2025 | 100 | 6.72 | 8.01 |
| 1.7 | | 2023 | | 2020 | 50 | 5.47 | 6.51 |
| 1.8 | | 2023 | | 2025 | 50 | 3.94 | 4.67 |
| 2.1 | | 2023 | 500 | 2020 | 400 | 34.27 | 37.39 |
| 2.2 | | 2023 | | 2025 | 400 | 22.97 | 23.41 |
| 2.3 | | 2023 | | 2020 | 300 | 25.96 | 30.67 |
| 2.4 | | 2023 | | 2025 | 300 | 17.30 | 20.33 |
| 2.5 | | 2023 | | 2020 | 200 | 17.75 | 21.17 |
| 2.6 | | 2023 | | 2025 | 200 | 12.25 | 14.51 |
| 2.7 | | 2023 | | 2020 | 100 | 9.77 | 11.67 |
| 2.8 | | 2023 | | 2025 | 100 | 6.72 | 8.01 |
| 3.1 | 10 Year Life Extension | 2023 | 300 | 2020 | 200 | 25.30 | 24.29 |
| 3.2 | | 2023 | | 2025 | 200 | 20.44 | 19.27 |
| 3.3 | | 2023 | | 2020 | 150 | 19.37 | 18.58 |
| 3.4 | | 2023 | | 2025 | 150 | 15.59 | 14.85 |
| 3.5 | | 2023 | | 2020 | 100 | 13.56 | 12.94 |
| 3.6 | | 2023 | | 2025 | 100 | 10.94 | 10.47 |
| 3.7 | | 2023 | | 2020 | 50 | 7.26 | 6.97 |
| 3.8 | | 2023 | | 2025 | 50 | 5.96 | 5.72 |
| 4.1 | | 2023 | 500 | 2020 | 400 | 42.56 | 40.21 |
| 4.2 | | 2023 | | 2025 | 400 | 39.06 | 35.14 |
| 4.3 | | 2023 | | 2020 | 300 | 34.47 | 33.08 |
| 4.4 | | 2023 | | 2025 | 300 | 29.41 | 28.31 |
| 4.5 | | 2023 | | 2020 | 200 | 24.96 | 24.51 |
| 4.6 | | 2023 | | 2025 | 200 | 19.96 | 19.62 |
| 4.7 | | 2023 | | 2020 | 100 | 13.56 | 12.94 |
| 4.8 | | 2023 | | 2025 | 100 | 10.94 | 10.47 |

# Scenario 4.1 Processing Projection



# Observations

- There is no optimum scenario:
  - Optimization depends on which parameters are important.
  - Conflicting parameters exist (maximizing uranium savings would result in increased cost).
- Uranium savings depends on:
  - Reactor operating Lifetimes.
  - Reprocessing capacity.
  - Reprocessing operating period.
  - Number of assemblies disposed prior to completing reprocessing (assemblies available for reprocessing).
  - New assembly demand.
- Facility capacity utilization depends on timing and capacity of facilities.