WM2009 CONFERENCE
Waste Management for the Nuclear Renaissance
March 1-5 2009, Phoenix, Arizona

New Policy Developments and Challenges for Radioactive Waste Management in South Africa

Session 03: 10h00-12h00: Monday, March 2, 2009

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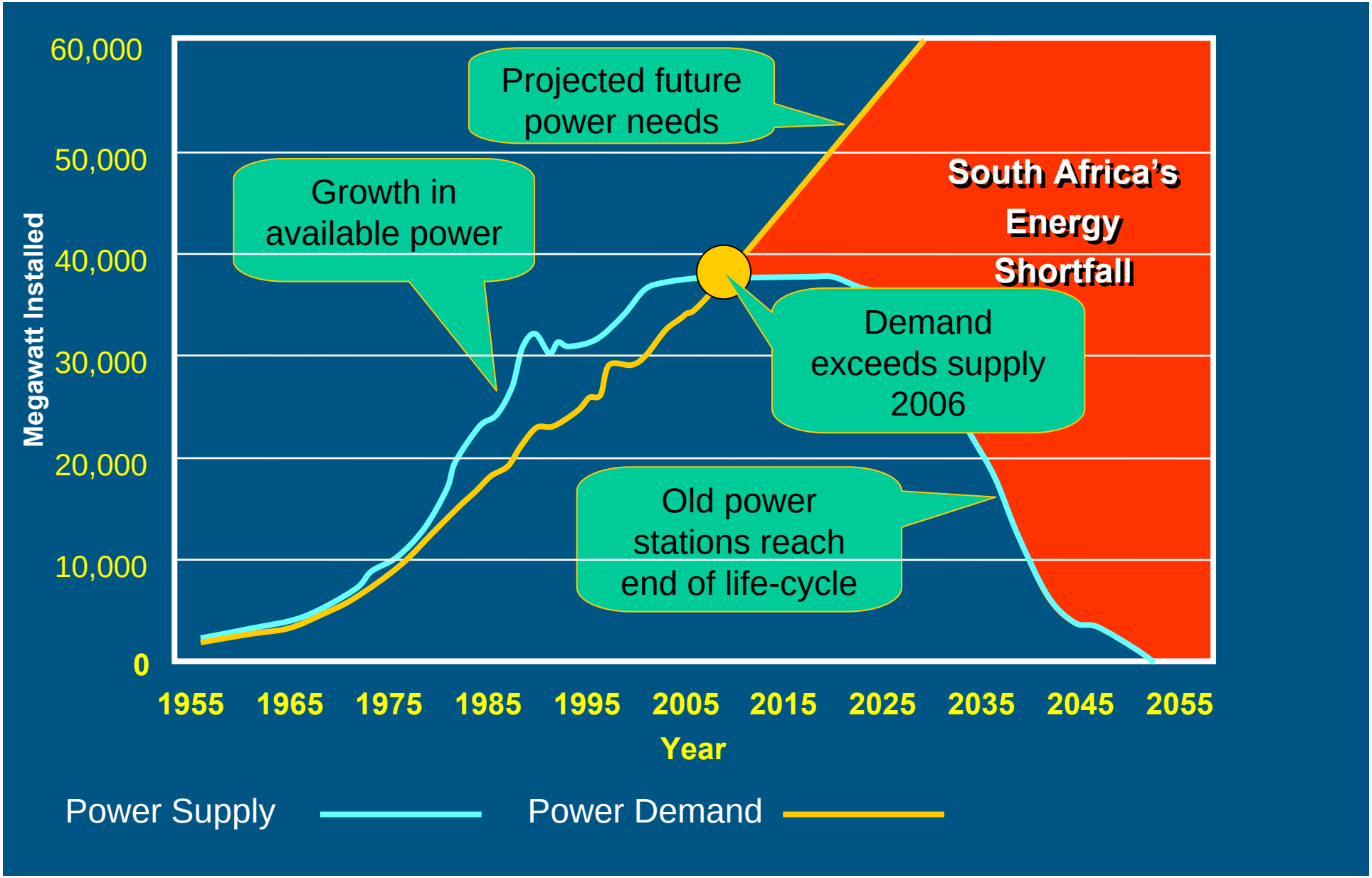
SA Needs power now



CHARACTERISTICS OF GEN III+ DESIGNS

- **Modular Construction**
- **Evolutionary Design**
- **Passive Safety Features**
- **Less Waste Generation**
- **Cost Effective**

Ten Nations Preparing Today for Tomorrow's Energy Needs

Generation IV: Nuclear Energy Systems Deployable no later than 2030 and offering significant advances in sustainability, safety and reliability, and economics

Generation I

Early Prototype Reactors

- Shippingport
- Dresden, Fermi I
- Magnox

Generation II

Commercial Power Reactors

- LWR-PWR, BWR
- CANDU
- VVER/RBMK

Generation III

Advanced LWRs

- ABWR
- System 80+
- AP600
- EPR

Near-Term Deployment

Generation III+ Evolutionary Designs Offering Improved Economics

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Generation IV

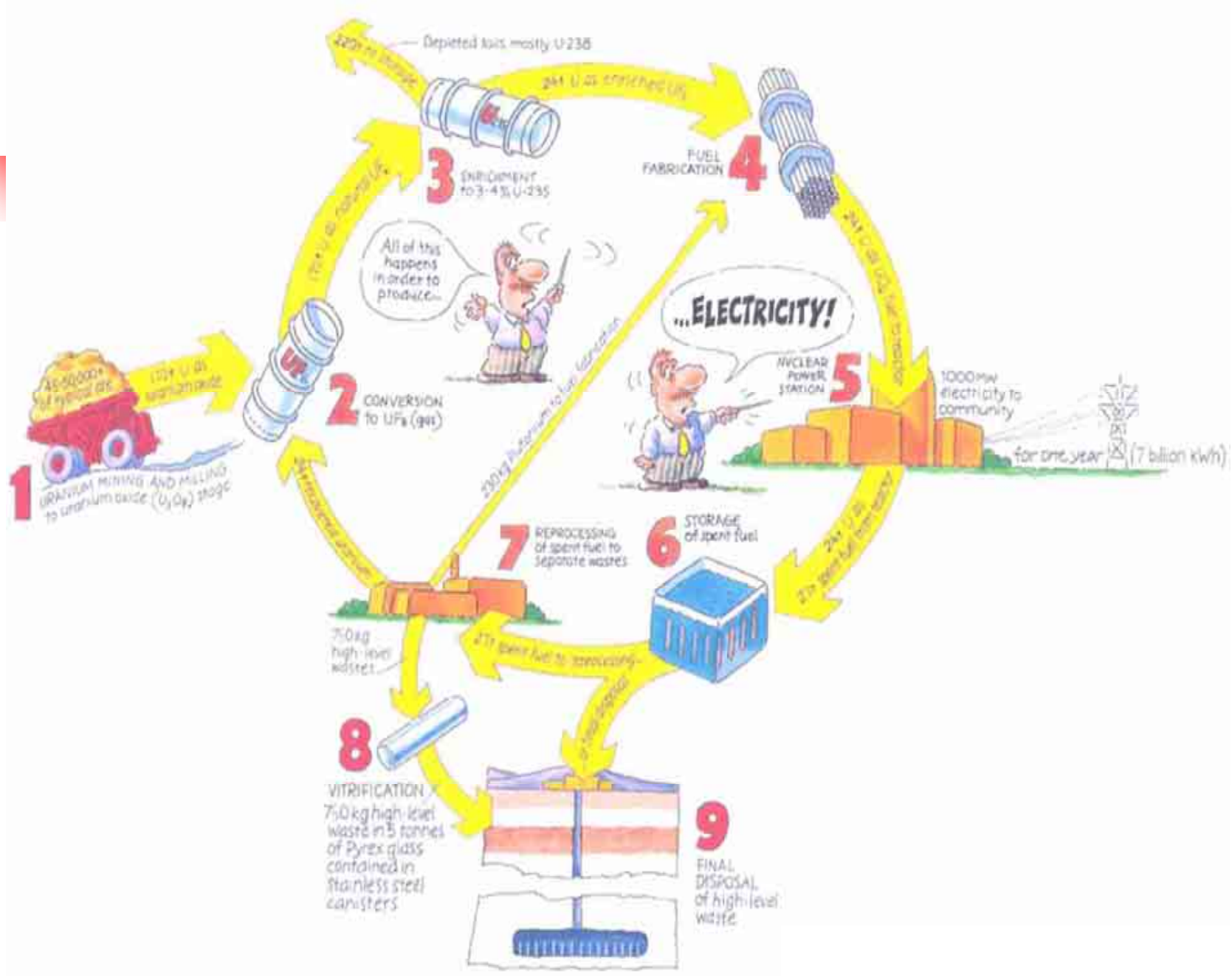
- Highly Economical
- Enhanced Safety
- Minimal Waste
- Proliferation Resistant

PRIMARY GOALS OF GEN IV REACTORS

- Improve Nuclear Safety
- Improve Proliferation Resistance
- Minimize Waste & Natural Resource Utilization
- Cost Reduction for Building & Operation

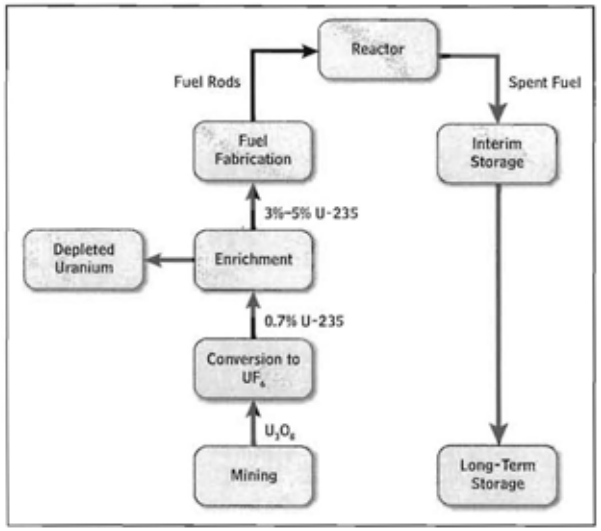
MAJOR MISSION INTERESTS FOR GEN IV REACTORS

- Electricity Generation
- Hydrogen Production and Other Process Heat Applications (Oil Sands, CTL, SMR, Desalination, etc)
- Actinide Management in High Level Waste

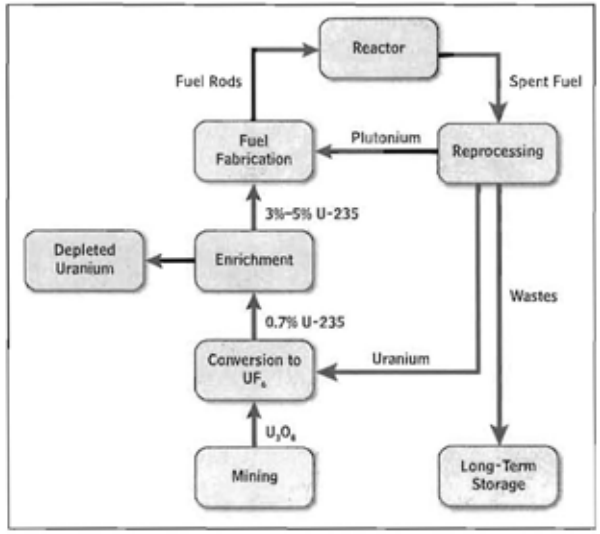

Depleted tails mostly U-238
220t to storage
1
URANIUM MINING AND MILLING to uranium oxide (U_3O_8) stage
45-50,000t ore yields 100t U as uranium oxide
2
CONVERSION to UF_6 (gas)
3
ENRICHMENT to 3-4% U-235
FUEL FABRICATION
4
5
NUCLEAR POWER STATION
1000MW electricity to community
for one year (7 billion kWh)
..ELECTRICITY!
All of this happens in order to produce...
6
STORAGE of spent fuel
7
REPROCESSING of spent fuel to separate wastes
750kg high-level waste
8
VITRIFICATION
750kg high-level waste in 3 tonnes of Pyrex glass contained in stainless steel canisters
9
FINAL DISPOSAL of high-level waste

Nuclear Fuel Cycles

Direct Disposal



Reprocessing



Source: Congressional Budget Office based on Ian Hore-Lacy, *Nuclear Energy in the 21st Century* (London: World Nuclear University Press, 2006).

Note: U_3O_8 = uranium oxide concentrate; UF_6 = uranium hexafloride; U-235 = uranium-235.

FISSION PRODUCTS:

Long-lived: I_{129}, Tc_{99}, Zr_{93}, Cs_{135}

Minor Actinides: Np, Am, Cm

Short-lived: Cs_{137}, Sr_{90}

PARTITIONING:

Chemical, Electrochemical Separation of

Long-lived from Short-lived fp's

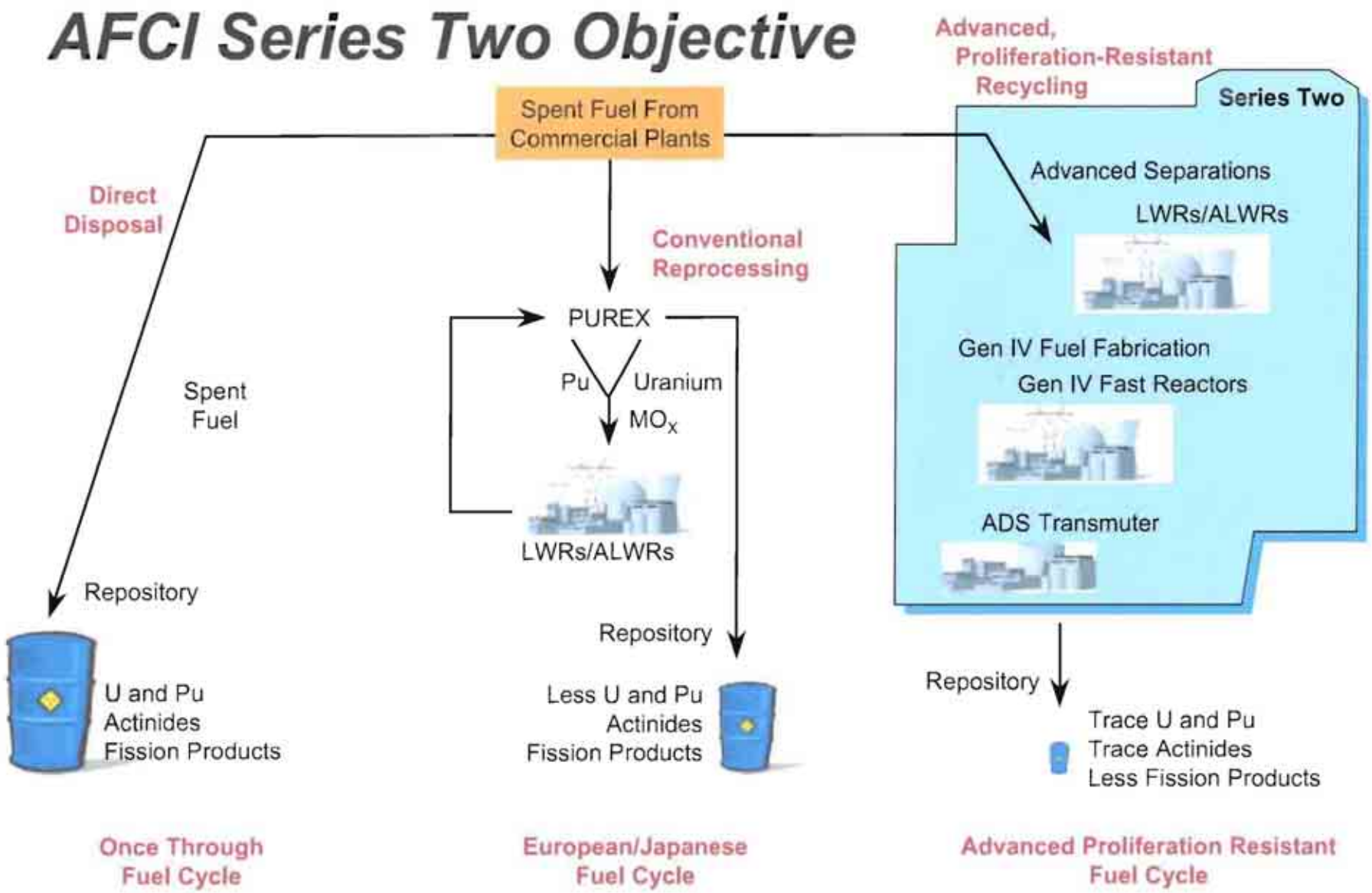
TRANSMUTATION:

Conversion using ADS, Fast reactors

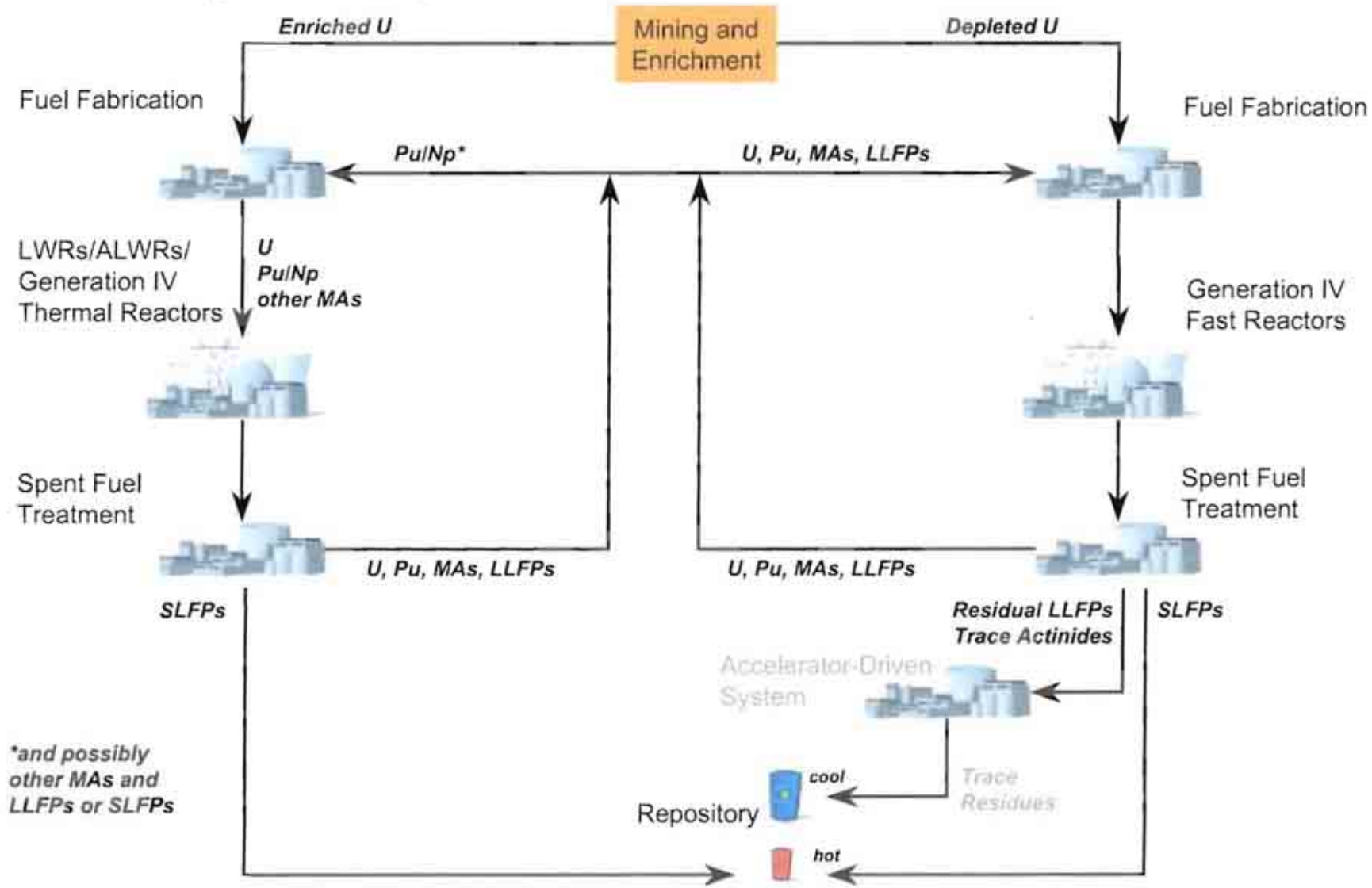
Radiotoxicity reduction: Np, Pu → short-lived fp's

I_{129} → stable, non-radioactive Xe

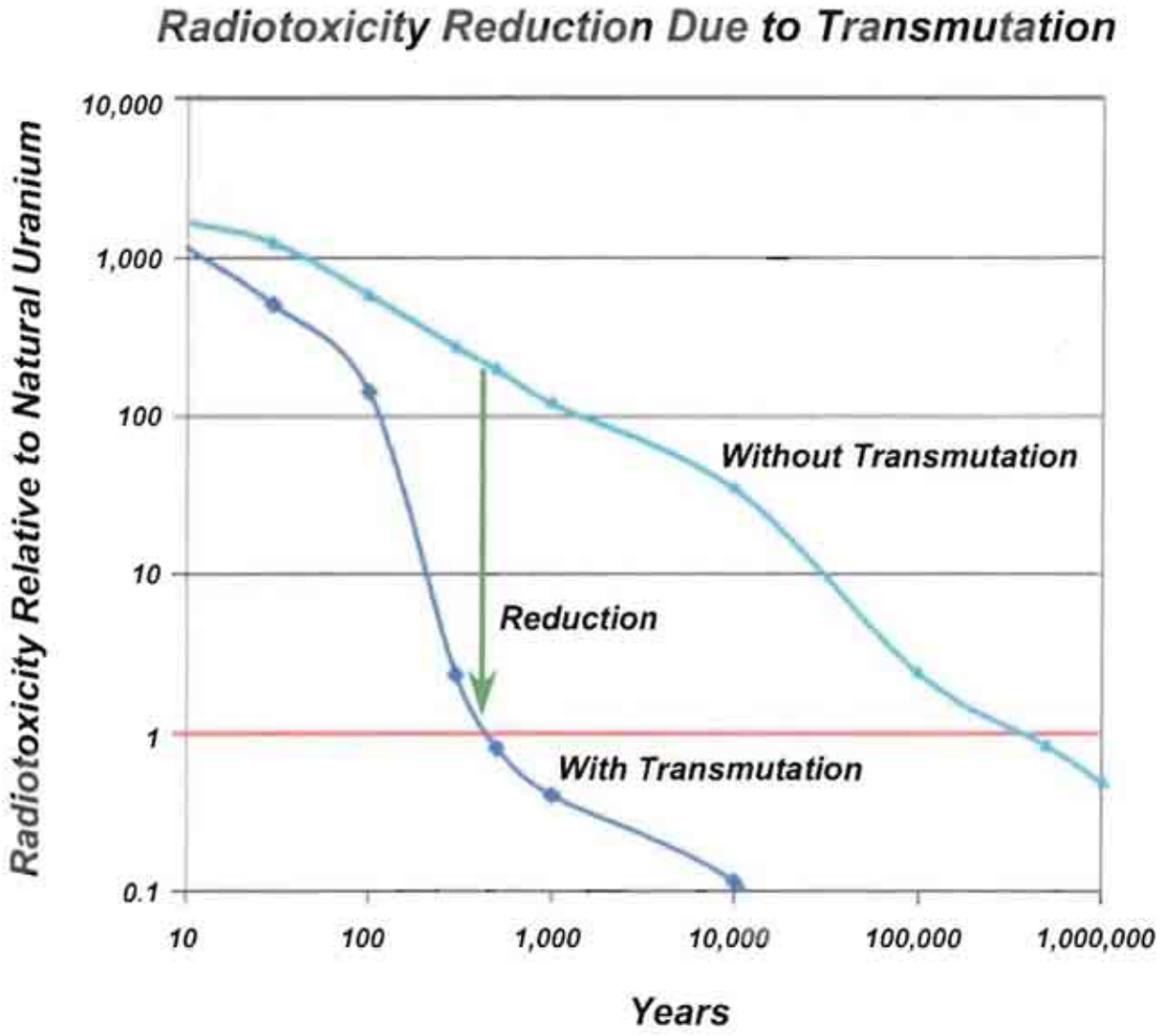
AFCI Series Two Objective



Fuel Cycle Options – Series Two



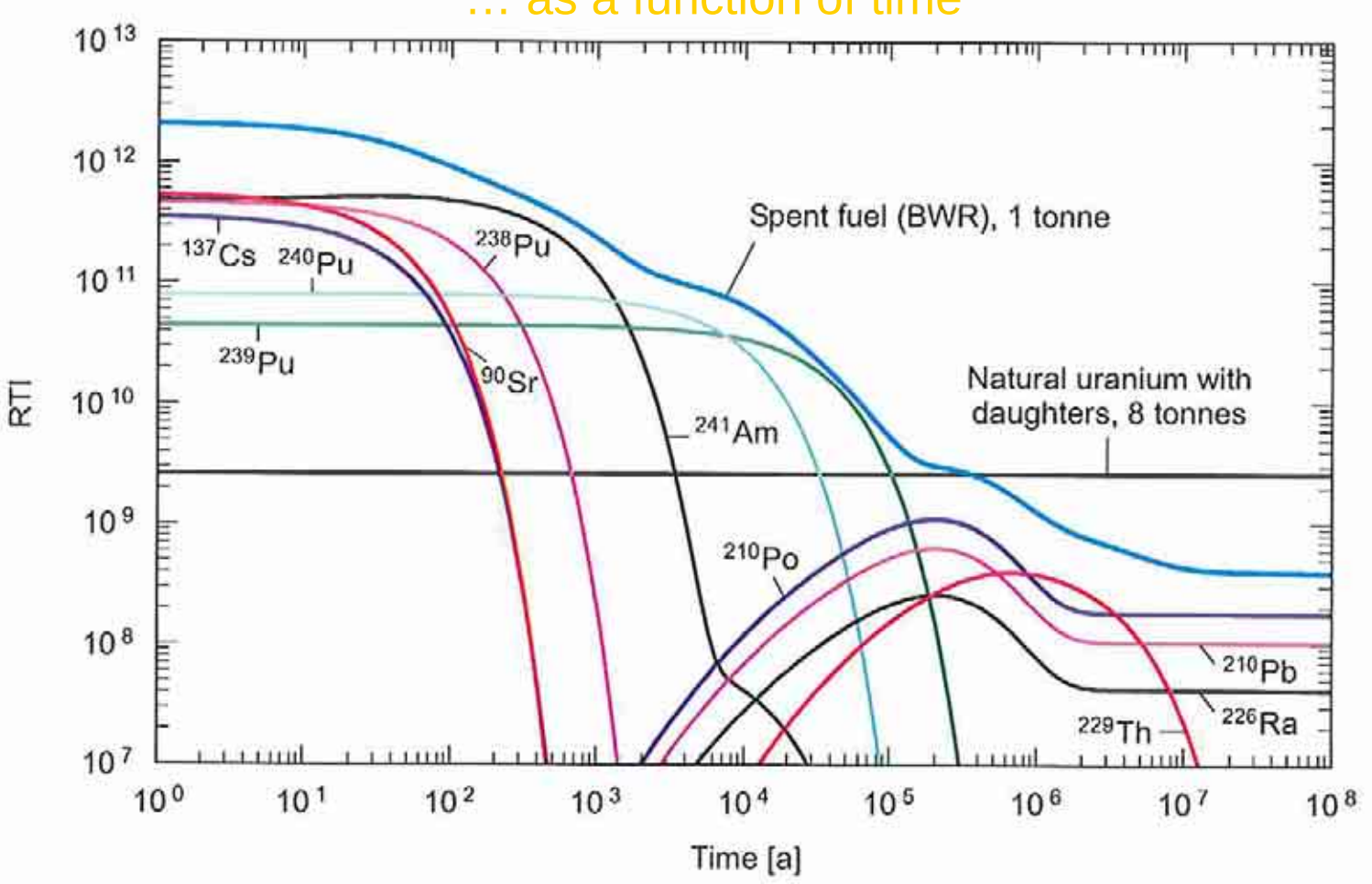
Benefit of Transmutation



Spent Fuel Characterisation

Radiotoxicity Index (RTI) of SF

… as a function of time

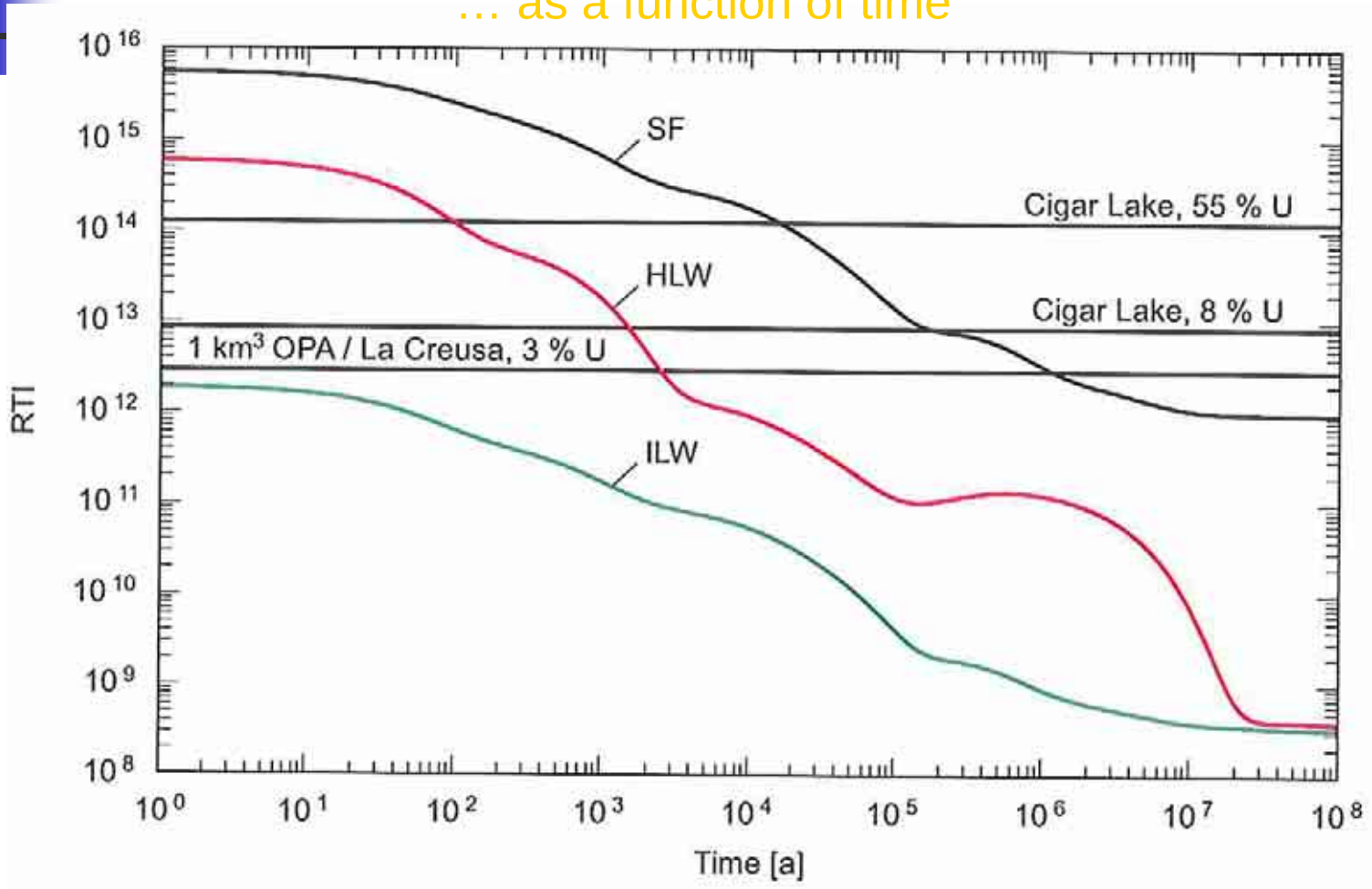


Source: Nagra, 2002

Spent Fuel Characterisation

Radiotoxicity Index (RTI) of SF, HLW and ILW

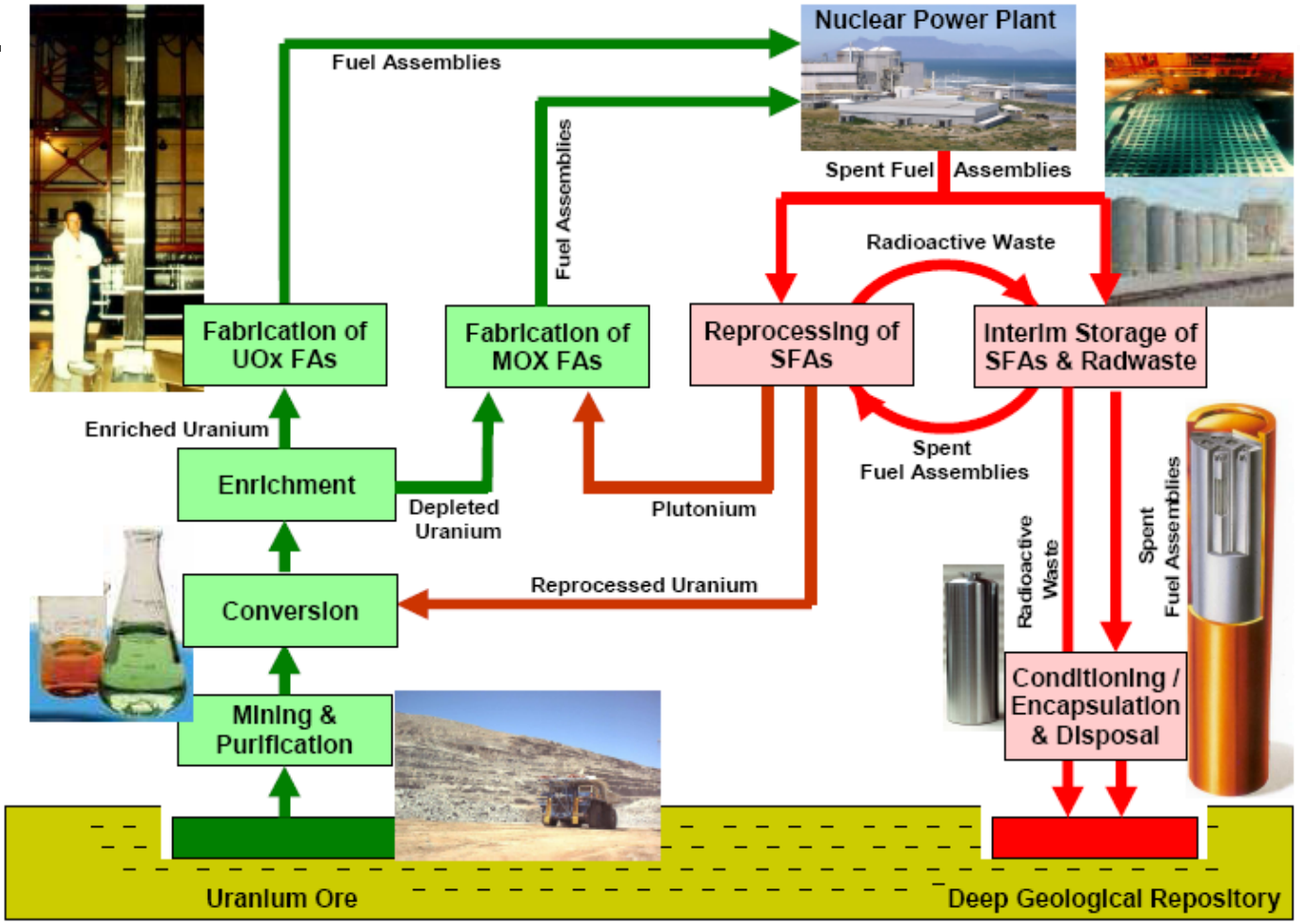
… as a function of time



Source: Nagra, 2002

Spent Fuel Management Options

Nuclear Fuel Cycle

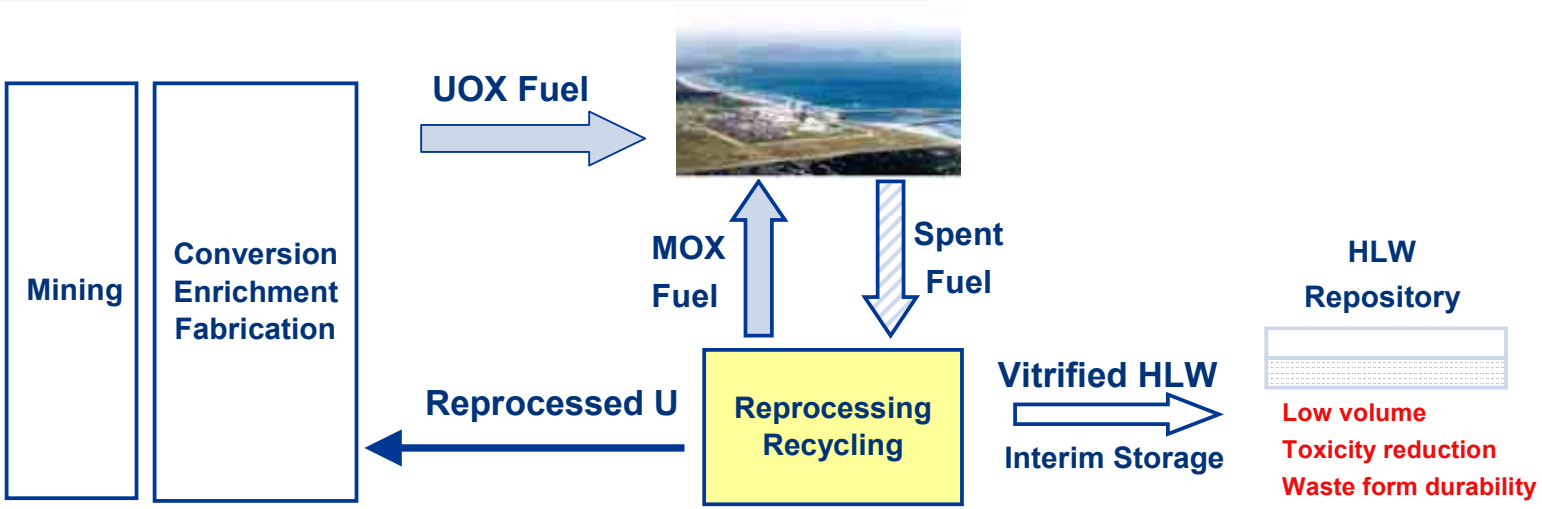


Spent Fuel Management Options

Main SFM Options

- Direct Disposal (Once-through Fuel Cycle)

- Reprocessing & Recycling (Closed Fuel Cycle)

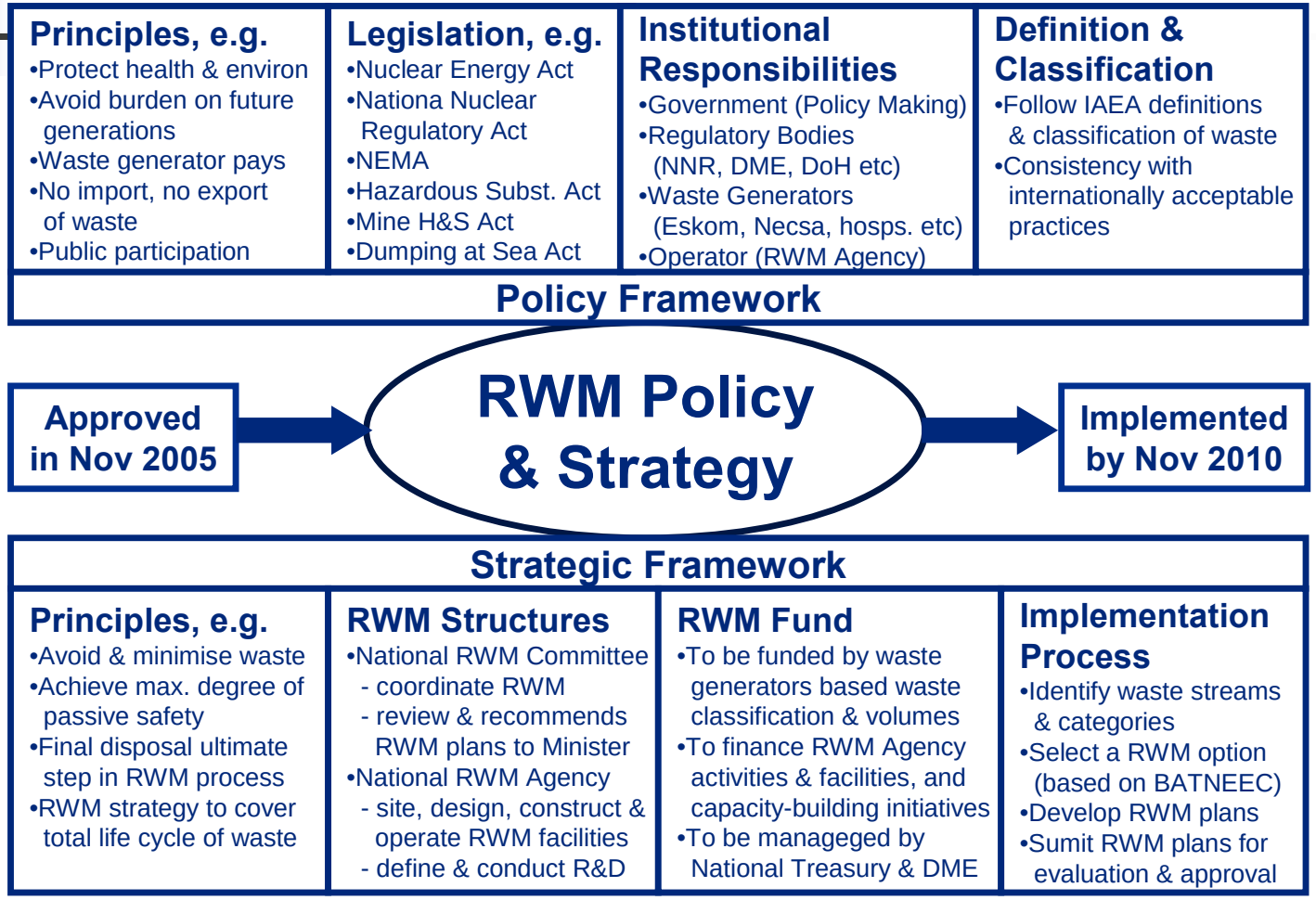


Spent Fuel Management Options

- Long-term / continued / indefinite storage
  - Deferral of decision
- Waste minimisation
  - through partitioning and transmutation of radionuclides
  - requires reprocessing
- Fuel-leasing or take-back option
  - Leasing State provides fuel through arrangement with own fuel ‘vendors’
  - Used fuel is returned to its country of origin which owns title to it or to a third party
  - Part of Global Nuclear Energy Partnership for securing the NFC and addressing non-proliferation challenges/issues
- International, multinational and regional repositories
  - could benefit countries with small nuclear programmes and/or without suitable geological sites

Spent Fuel Management Framework

National RWM Policy & Strategy



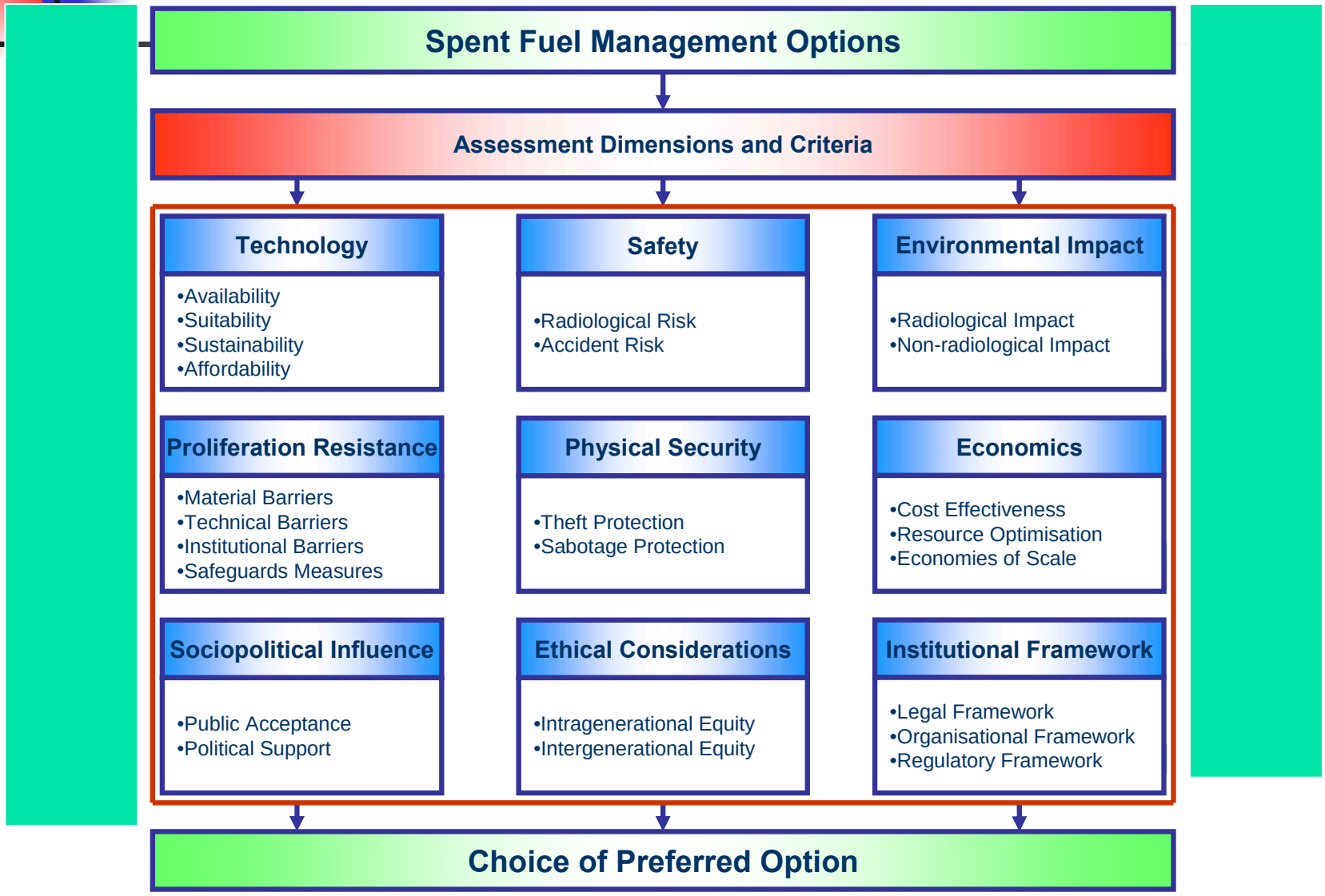
Evaluation of Options

Framework for Evaluation of SFM Options

- Framework Construction
  - Identification, characterisation and connection of elements relevant to analysis of SFM options
  - Verification and validation by literature, focus groups and surveys
- Guiding principles
  - Best Available Technology Not Entailing Excessive Costs (BATNEEC)
  - IAEA Fundamental Safety Principles for Radioactive Waste Management
  - National Radioactive Waste Management Policy & Strategies
  - IAEA Joint Convention on the Safety of Spent Fuel Management
- Framework Features
  - Assessment criteria
  - Qualitative and quantitative data

Evaluation of Options

Framework for Evaluation of SFM Options



Conclusions

- Spent fuel is radiotoxic – but it can be safely managed.

- Options / alternatives for SFM are available – some matured and in practice, others still under R&D.
- Facilities for SFM exist; only deep geological repositories have yet to be constructed and licensed.
- SF can be managed within international and national frameworks, as required by policy positions.
- Techniques available for making a choice of SFM options.
- Solid long-term SFM plans needed to gain public confidence in nuclear industry iro SF and radwaste management.
- Clear policy guidelines that address the challenges are key.