Agence pour l'énergie nucléaire
Nuclear Energy Agency

OECD

Advanced Fuel Cycles and Waste Management

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Framework

- OECD/NEA study, approved by its Committees
- Carried out by an *ad hoc* Expert Group

12 Countries

- Belgium
- Finland
- France
- Germany
- Italy
- Japan
- Rep. of Korea
- Russia
- Spain
- Switzerland
- United Kingdom
- United States

2 International Organisations

- IAEA
- European Commission

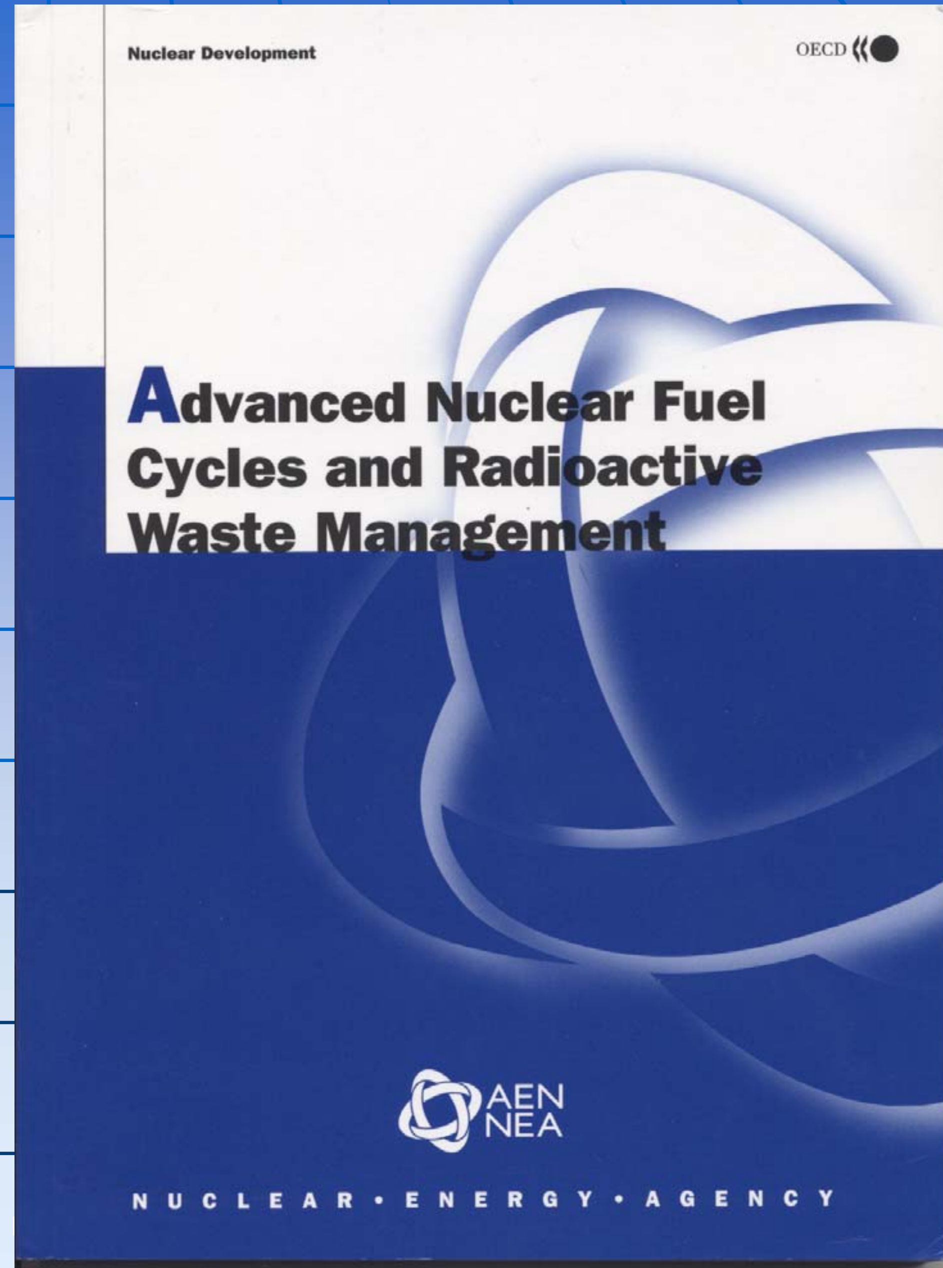
244 pages total

1 executive summary

18 tables

57 figures

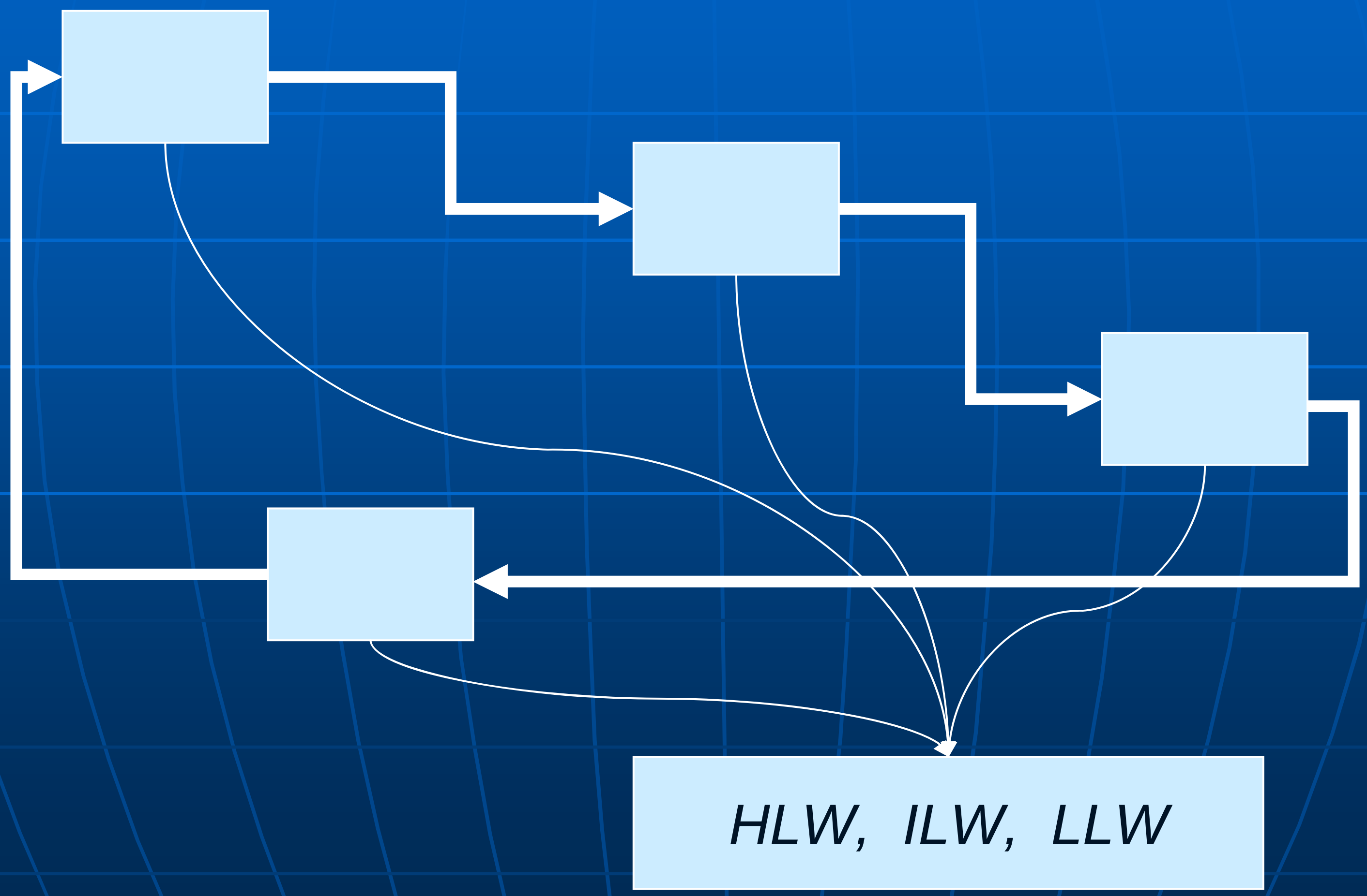
12 appendices



Main objectives

- Analyse advanced fuel cycle schemes from the perspective of their impact on waste repository demand and specification, building on previous NEA studies on partitioning and transmutation (P&T)
- Assess the performance of selected repository concepts using source terms for waste arising from selected advanced fuel cycle schemes
- Identify new options for waste management and disposal

Complete Fuel cycles include all waste



Scope

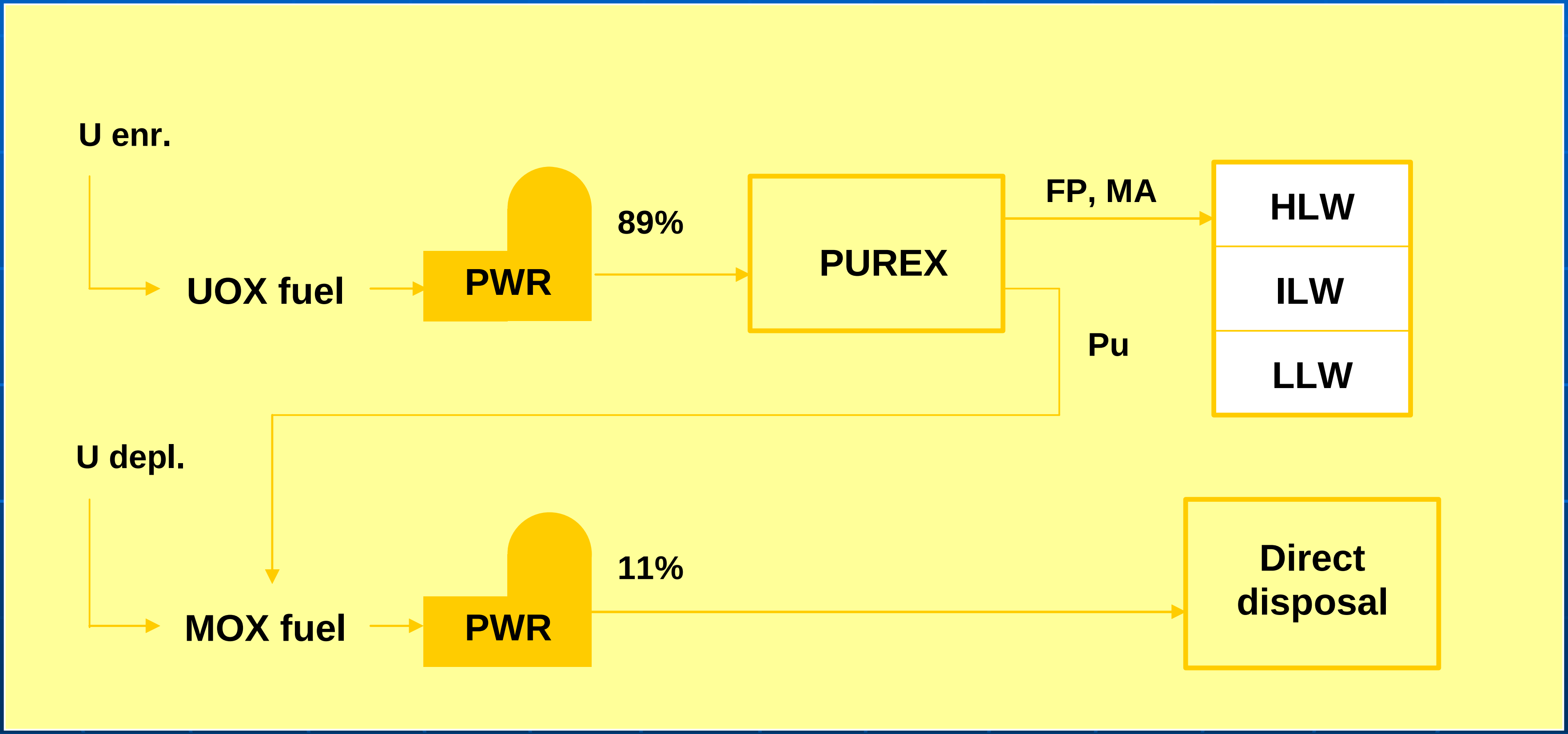
- 13 **fuel cycle schemes** within 3 families to illustrate differences between various technologies and levels of recycling capability
  - Current industrial technology and extension (open cycle + 3 schemes)
  - Partially closed fuel cycle (3 schemes + 1 variant)
  - Fully closed (3 schemes + 2 variants)
- 3 **waste categories**, according to IAEA Recommendations:
  - HLW (deep geological)
  - LILW-LL (geological)
  - LILW-SL (surface or sub-surface)
- 4 performance and capacity assessments for **repository concepts** in
  - clay
  - granite
  - salt
  - tuff

Fuel Cycle Schemes

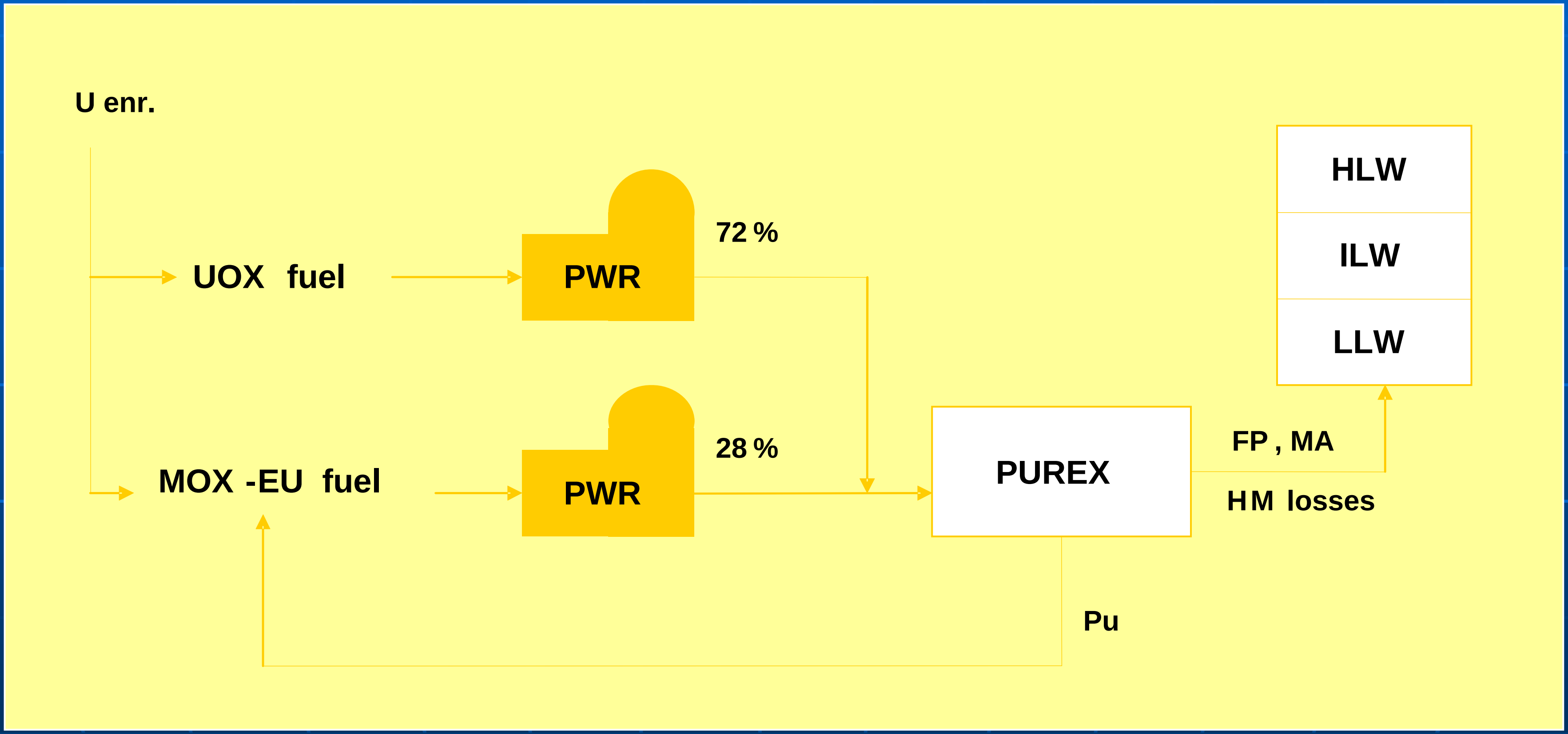
Current Industrial Technology and Extension	Partially-Closed Fuel Cycle	Fully-Closed Fuel Cycle
1a Open cycle	***2a*** ***Pu multirecycle in PWR***	**3a** TRU multirecycle in FR
1b ***Pu monorecycle in PWR***	**2b** Pu and Am multirecycle in PWR	**3b** All actinide burnt in double strata with ADS
1c Pu and Np monorecycle in PWR	**2c** Pu and Am multirecycle in PWR+FR	**3bV** No FR
1d DUPIC in PWR + CANDU	**2cV** Am storage	***3c*** ***All actinide recycled in FR***
		3cV1 ***GCFR***
		3cV2 LMFR

Recycling Capability ➔

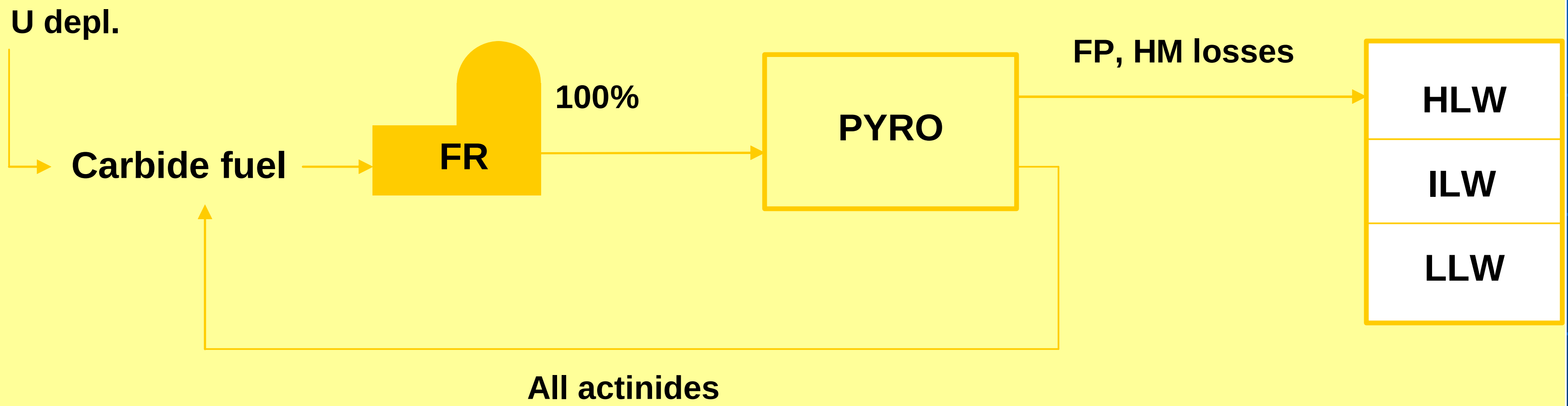
Scheme 1b *Pu monorecycle in PWR*



Scheme 2a *Pu multirecycle in PWR*



Scheme 3cv1 *all An recycled in GCFR*



Repository Performance Assessments

- Studies restricted to impact on normal operation:
  - ✓ FP migration dominates normal operation scenarios;
  - ✓ Actinide intake dominates accidental and intrusion scenarios;
  - ✓ Possibly loss of one major barrier (case of salt).
- Based on publicly available repository performance assessments and on participant contributions:
  - ✓ Granite study done by Spain – ENRESA;
  - ✓ Granite study done by Japan – JNC;
  - ✓ Clay study done by Belgium – SCK.CEN;
  - ✓ Salt study done by Germany – GRS;
  - ✓ Tuff study done by United States – ANL within AFCI.
- Selected Schemes : 1a, 1b, 2a, 3cv1.

Selected indicators

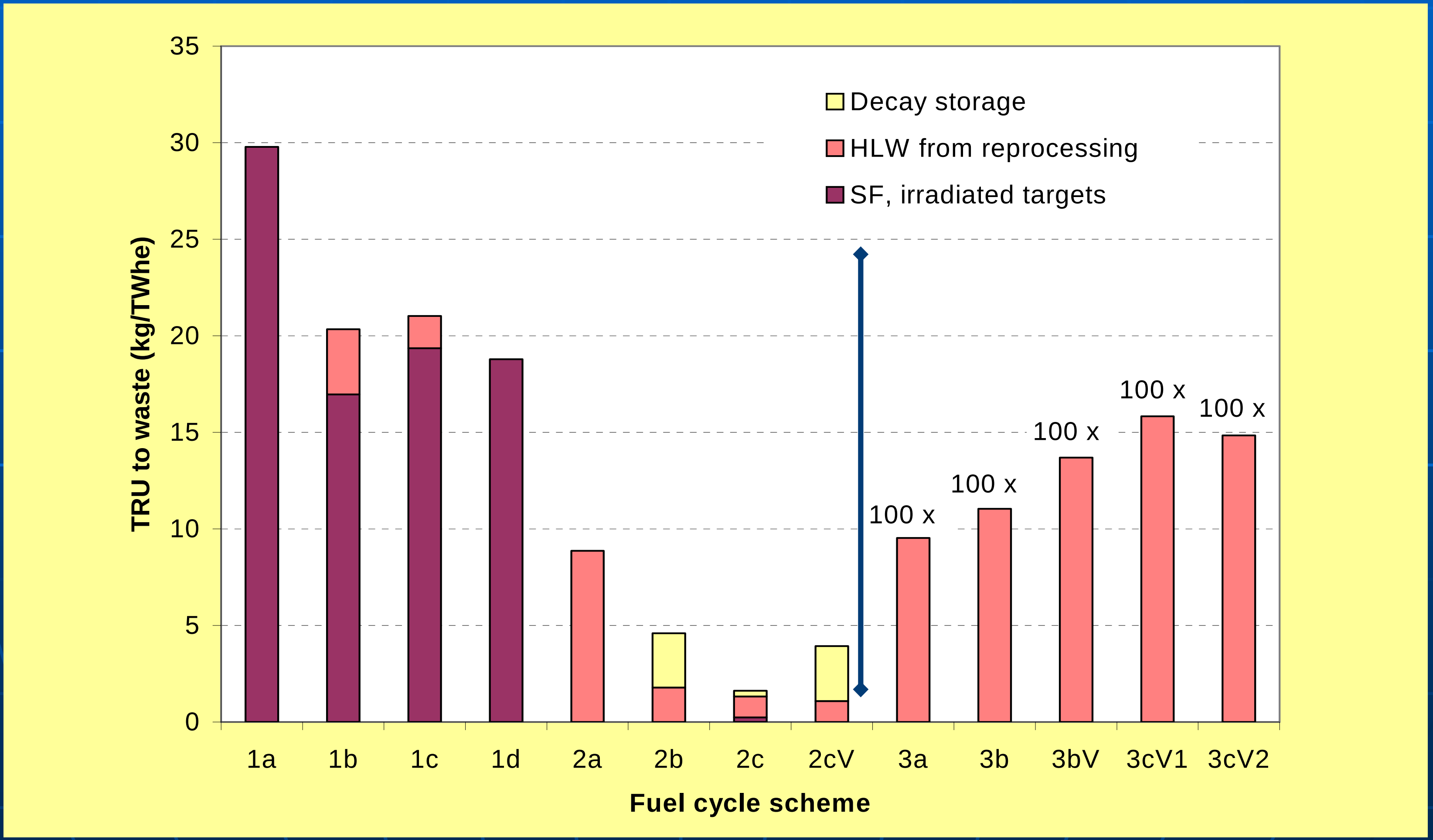
- Natural uranium consumption
- TRU loss/transfer to waste
- Activity of HLW after 1000 years
- Decay heat of HLW after 50 years
- Decay heat of HLW after 200 years
- Volume of conditioned HLW, incl. spent fuel
- Maximum dose from HLW disposal in granite
- Maximum dose from HLW disposal in clay
- Maximum dose from HLW disposal in tuff
- Fuel cycle cost
- Total cost of generating electricity

Natural uranium consumption per unit of electricity generated
(normalised to scheme 1a)

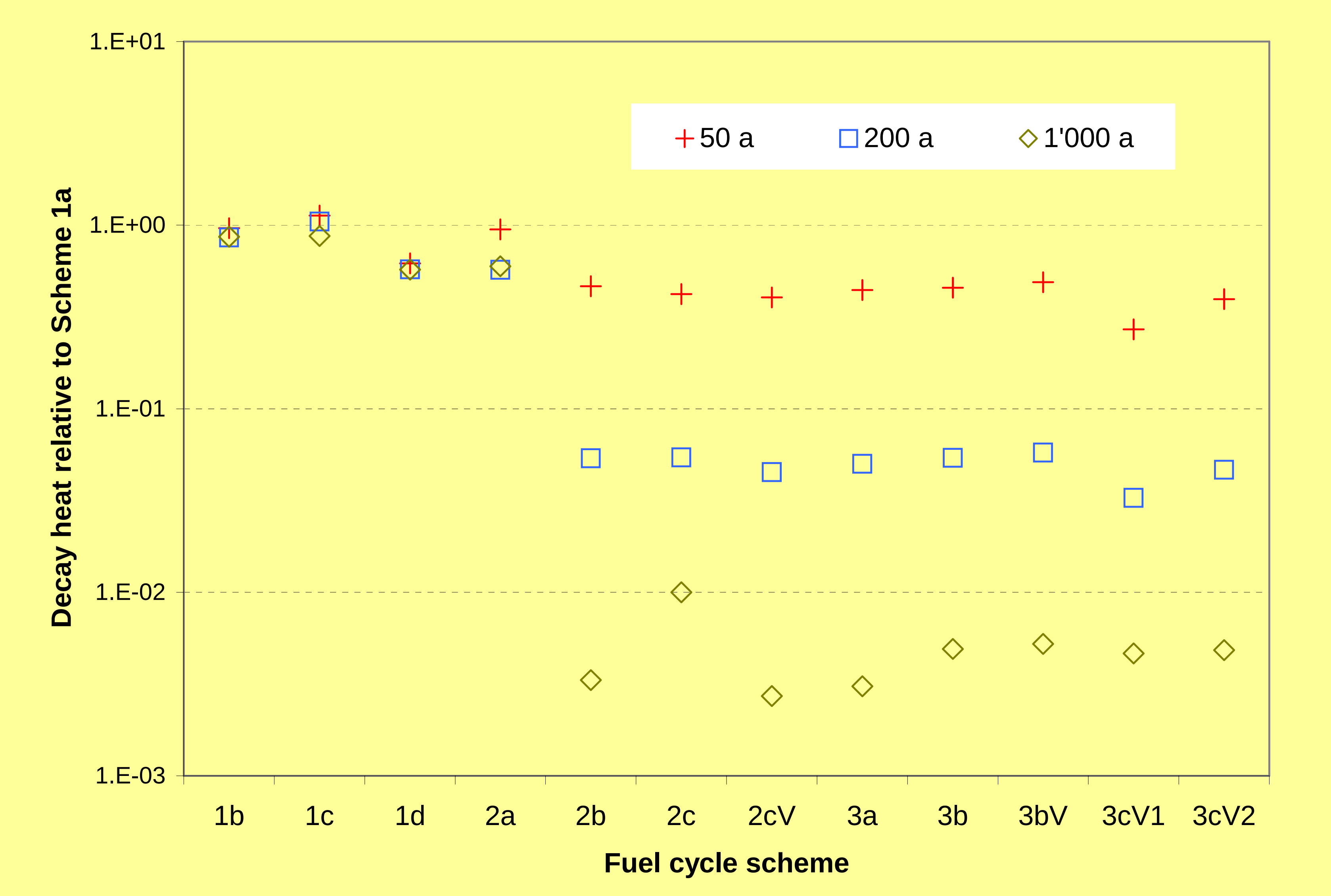
1b	1c	1d	2a	2b	2cV	3a	3b	3bV	3cV1	3cV2
0.89	0.90	0.59	0.87	0.99	0.44	0.63	0.65	0.76	0.004	0.036

Schemes 3cV1 and 3cV2 operate with depleted uranium

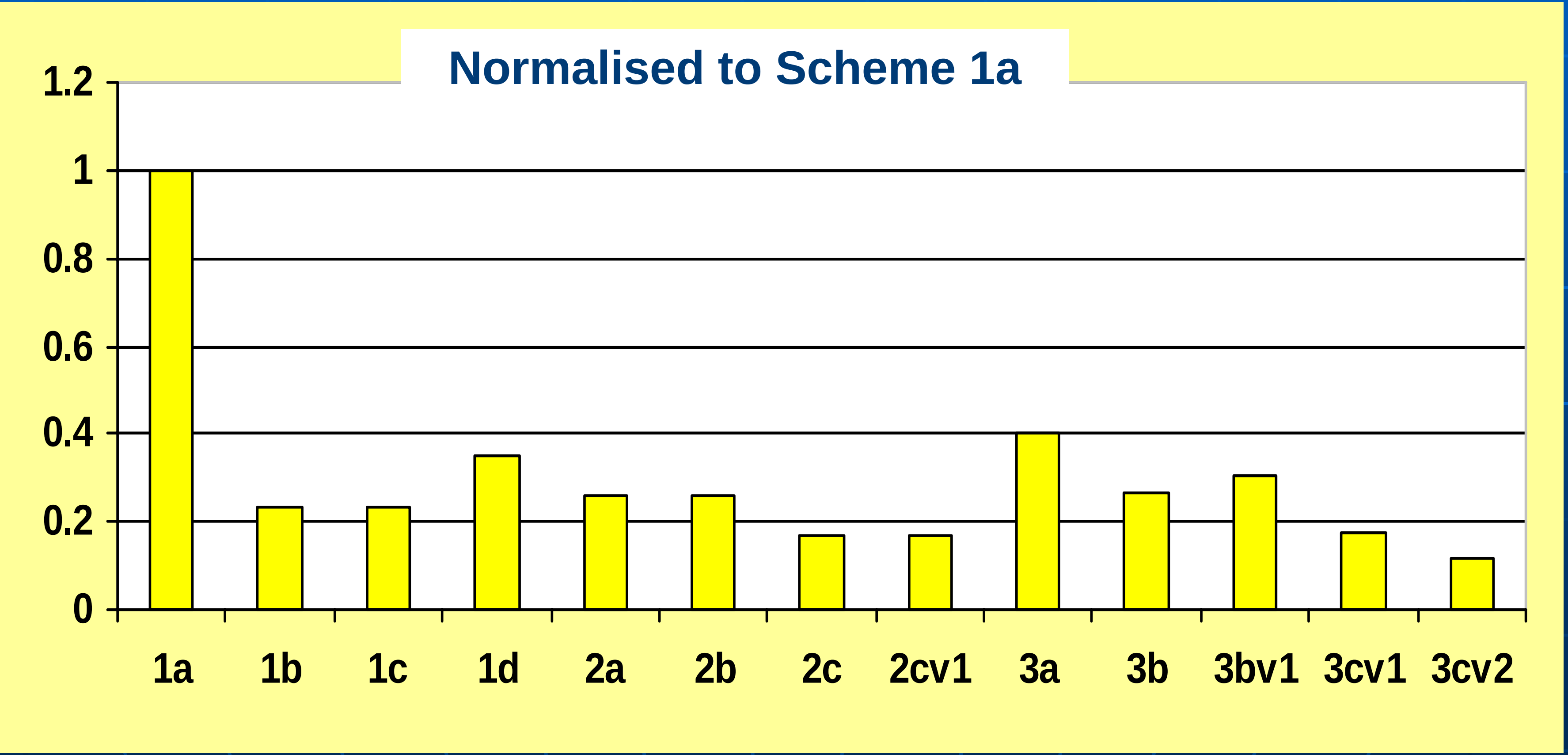
Transuranics losses to waste



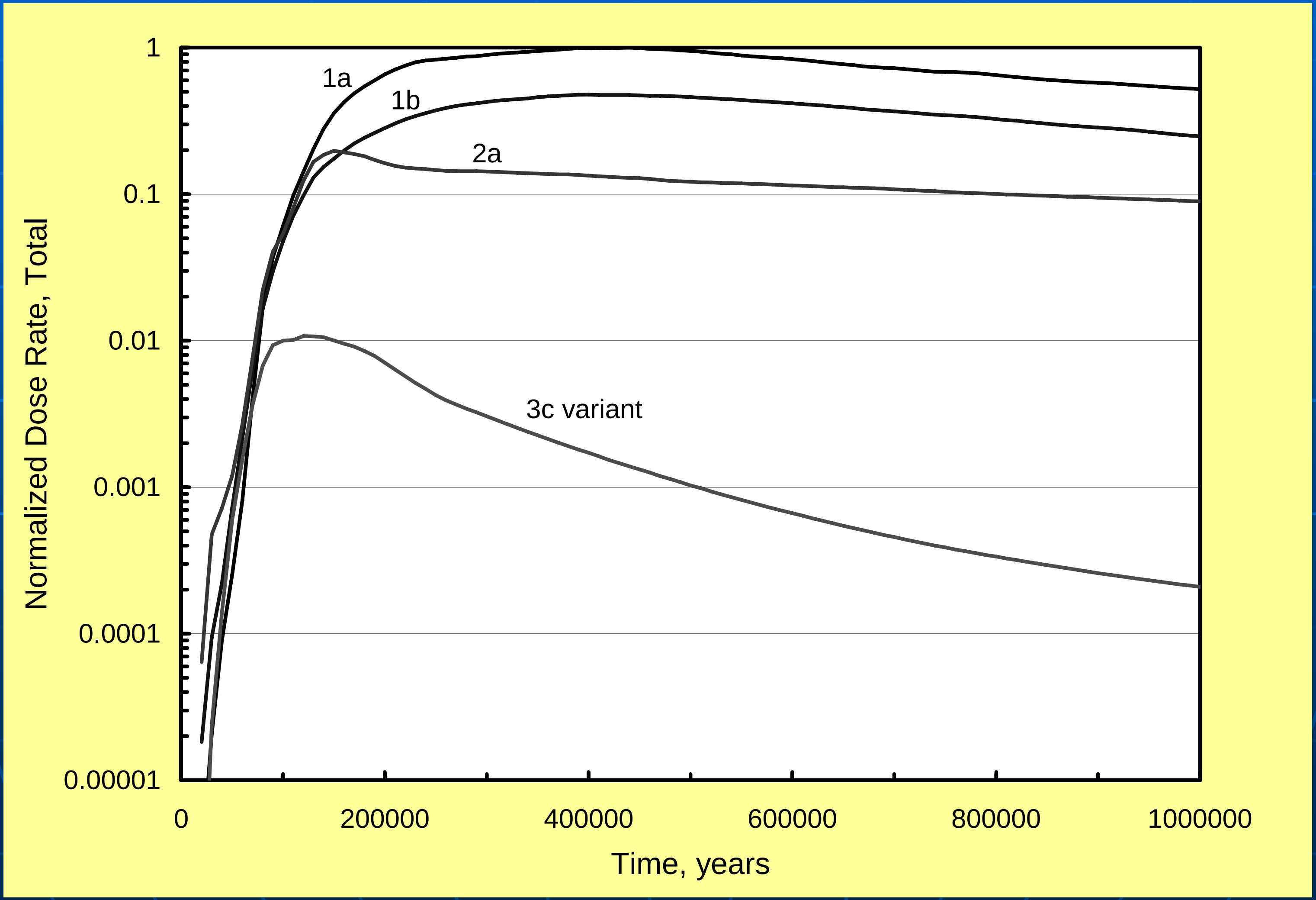
Decay heat per scheme (normalised to 1a)



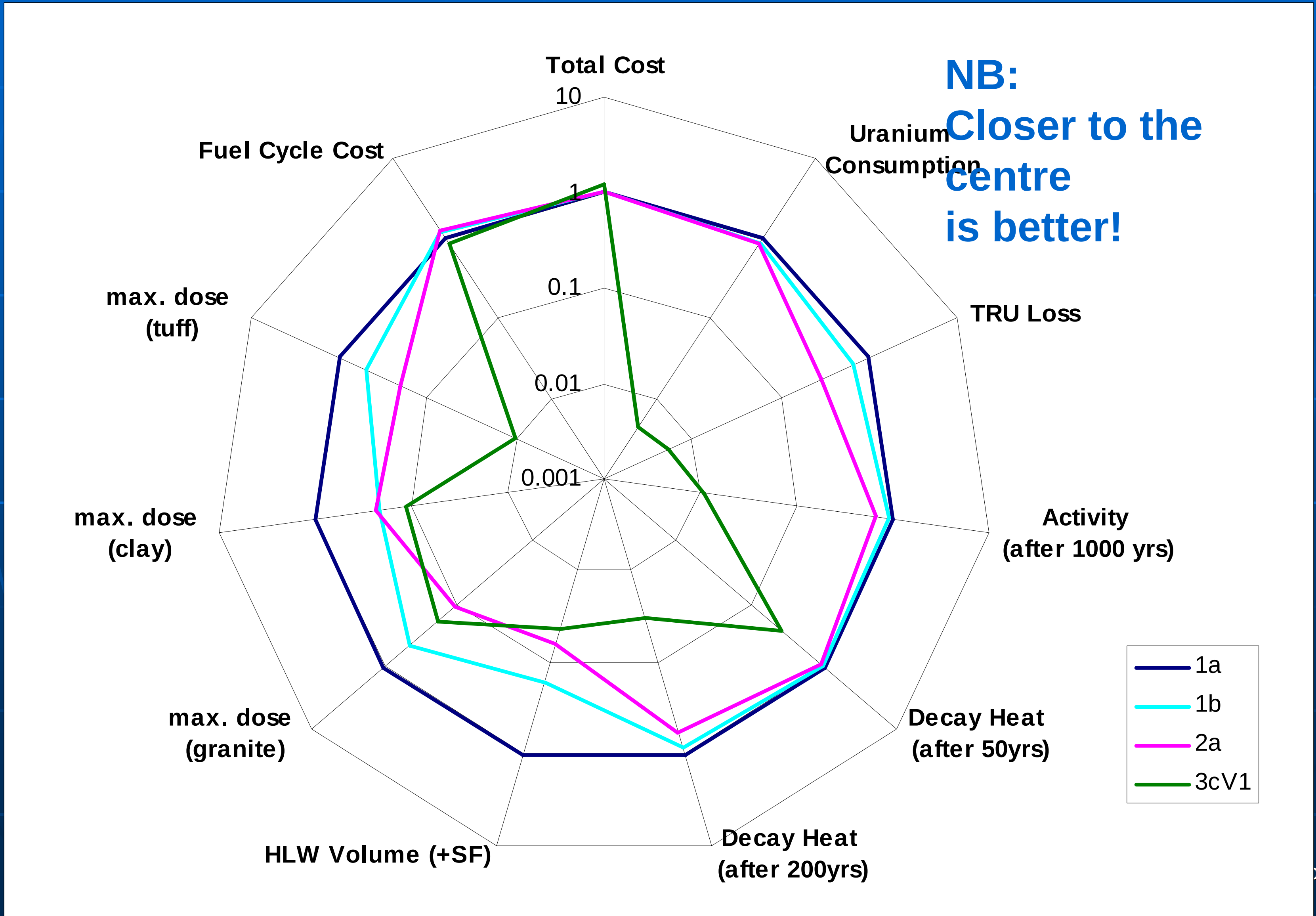
Volumes of conditioned HLW per unit of electricity generated



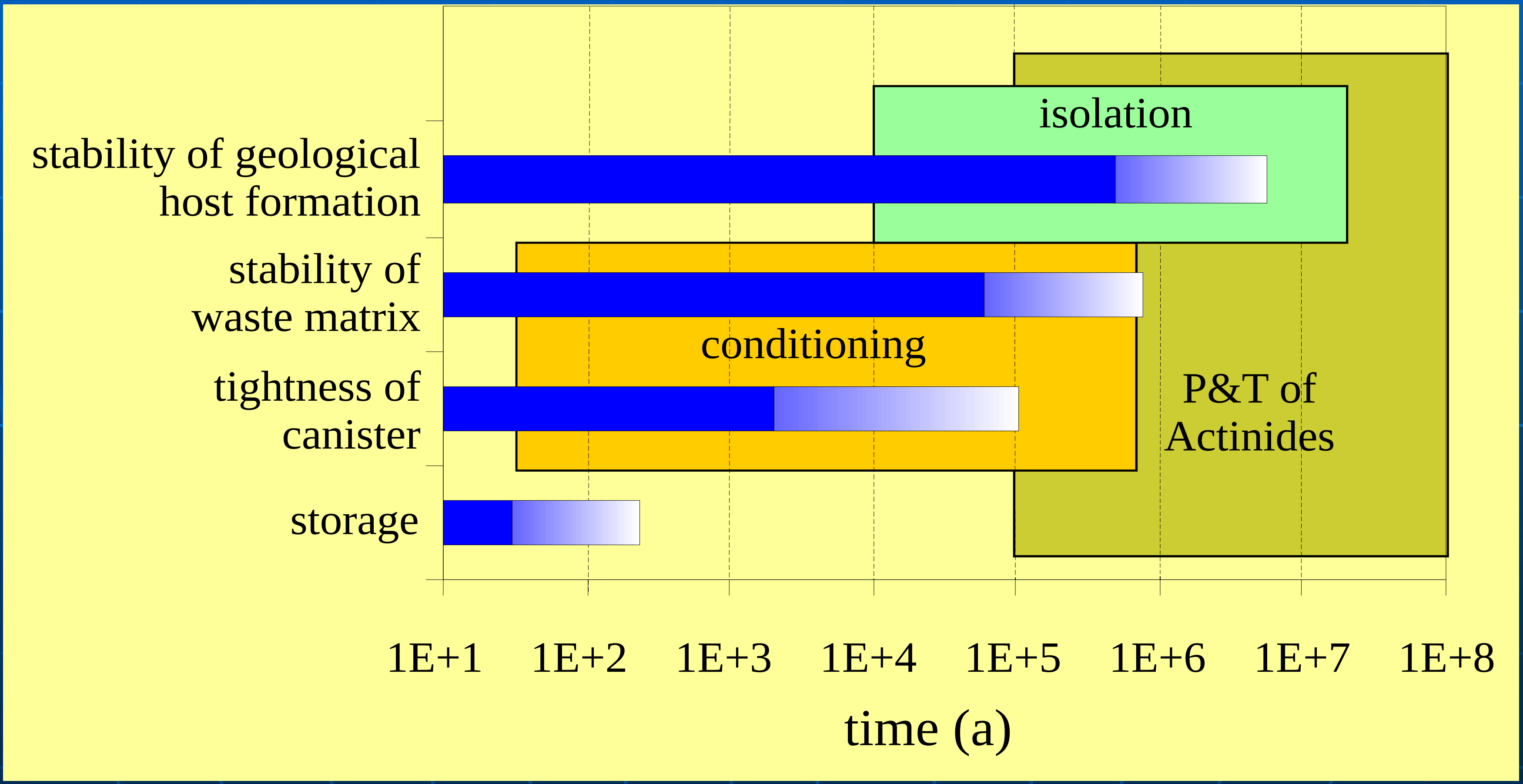
Dose rates for schemes 1b, 2a, 3cv1 in an unsaturated tuff repository



Indicators for illustrative schemes



Complementarities of conditioning, isolation and P&T



Main Findings and Conclusions (1)

- A variety of advanced fuel cycle schemes could be implemented to contribute to a robust, effective policy for resource saving and waste reduction
- Conditioning, geological disposal and P&T are complementary options

Main Findings & Conclusions (2)

- Waste heat load and volume reductions are driving factors for decreasing repository space requirements
- Activity, maximum dose and cost are not driving factors for policy making
- Total electricity generation costs vary by less than 20% whatever the scheme

Main Findings & Conclusions (3)

- In a sustainable development perspective, full fast reactor (FR) schemes are by far the most efficient:
  - ✓ Environmental dimension: reduction of the uranium mining requirements by a factor of 50 or more
  - ✓ Social dimension: reduction of waste volume by a factor of 30
- Intermediate steps towards FR mixes already improve some aspects of sustainability

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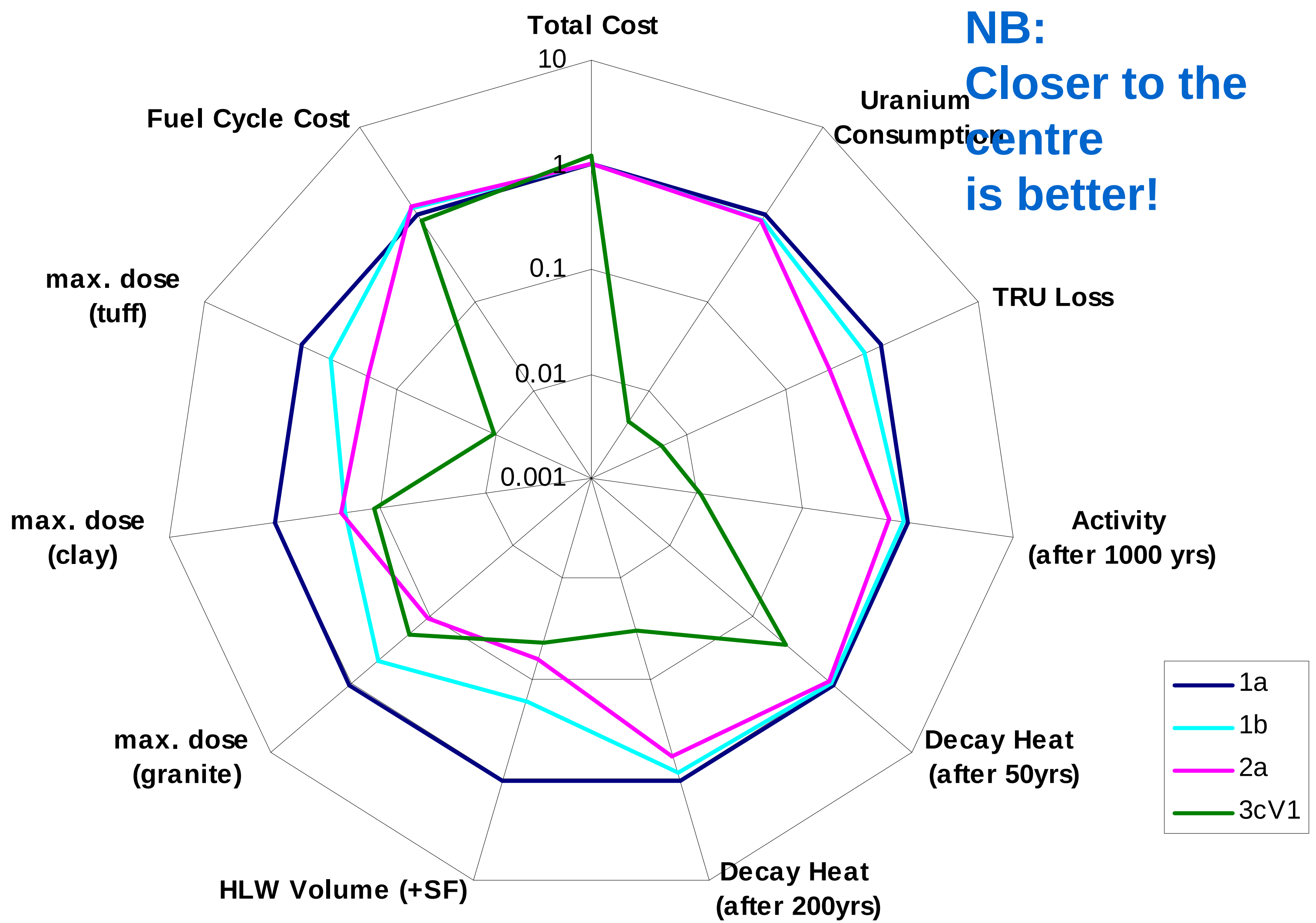
33 names (see list in full document)

Summary of the study



NB:
Closer to the centre is better!