STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

Envisioning the fate of radioactive waste
Comparing geological disposal and Advanced nuclear waste technologies

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Introduction

Nuclear in Belgium

- **2 NPPs**, 7 reactors (1975 – 1985), ca. 52% elec supply
  - **Phase out** law 2003: 40 years + no new build
    'Force majeure' clause → 2015: 10 year lifetime extension 3 oldest
    → all down by 2025

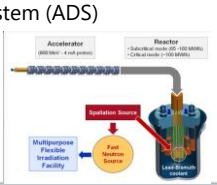
- **High level RWM**
  - Forerunner **Geological Disposal** research, backrunner GD policy
    - First URL in clay worldwide, huge amount of research, SEA in 2011
    - No political decision
  - Forerunner **Spent Fuel** research, backrunner SF policy
    - Inventor of innovative nuclear fuel (MOX fuel), MYRRHA proposal
    - No political decision (moratorium '93)

The Belgian nuclear research centre SCK-CEN

- ° 1952
- Foundation of Public Utility

1. PISA: Programme for the Investigation and Integration of Social Aspects in nuclear research

2. Waste and Disposal research group, URL HADES (EURIDICE)
3. Advanced Nuclear Systems research group, MYRRHA proposal
   : **M**ultipurpose H**y**brid **R**esearch **R**eactor for **H**igh-tech **A**pplications)
   - Fast spectrum research reactor coupled to an accelerator driven system (ADS)
     - 1 purpose: demonstrate the physics and technology of ADS for transmuting long-lived radioactive waste



➢ Three very different groups working on RWM

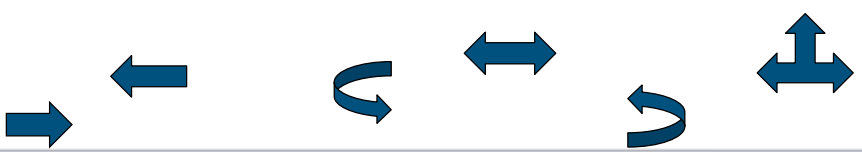
Internal scientific exchanges at SCK-CEN

Aims

- Getting to know each other's work better;
- Improving internal communication and dialogue;
- Bottom up critical reflection;
- Integrating technical and social aspects
- Identifying new research fields

Topic of this presentation
Geological disposal / Advanced nuclear waste technologies

- Implementing Geological Disposal
  - *"**Geological disposal** is now well established as the ultimate end-point for managing long-lived radioactive waste in a safe manner which will protect human and the environment passively for the required long time scales"*
- Developing Advanced Nuclear Technologies
  - *"**Partitioning and transmutation** offers a solution for radioactive waste, because the volume will be reduced by a factor 100 and also the time the waste remains dangerous will be drastically reduced, to 1000 to 400 years"*



Topic of this presentation
Uncovering socio-technical imaginaries + new research fields

- RWM
  - Dominated by techno-scientific research
  - "technical content" ↔"social context"
  - HOWEVER: discourses combine both
    - "modelling over 1 million years is scientifically ridiculous"
    - "100% efficient P&T doesn't exists, that's simple physics"
    - "shoving something nasty under the ground is not a solution"
    - "spending billions on something that will have minor impact is irresponsible"

➢ **STS** approach
- The design of technology reflects the imaginative faculties, cultural preferences and economic or political resources of their makers and users (Bijker et al 1987, Bijker 1997, Jasanoff 2004)
- **Socio-technical imaginaries**: "collectively imagined forms of social life and social order reflected in the design of technological projects" (Jasanoff and Kim, 2009, p. 120).

Main points presented

Socio-technical rationale
Geological disposal

1. Problem
   - Waste that remains hazardous over very long timescales
2. "Solution"
   - Long term containment and isolation
3. 1 + 2 ~ Geological disposal:
   - **Final disposal** of
   - **Ultimate waste** by means of
   - **Passive safety**
   - **As soon as possible**

Socio-technical imaginary
Geological disposal

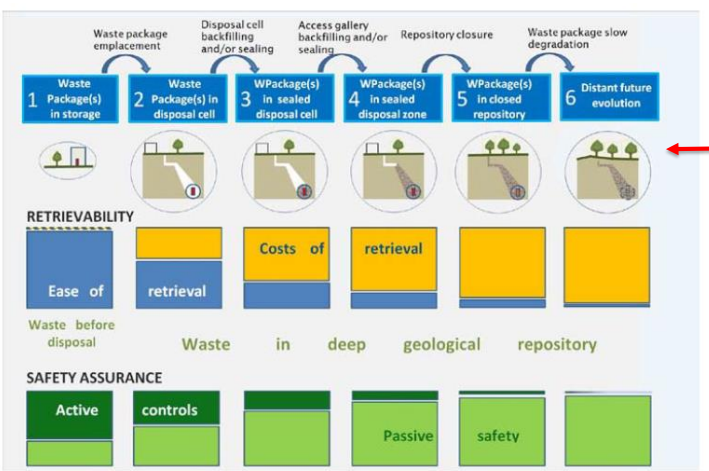


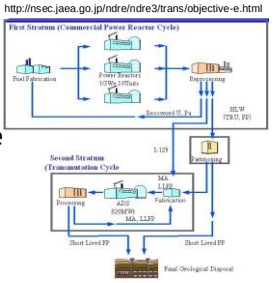
Figure 4: Lifecycle stages of the waste, illustrating changing degree of retrievability, passive vs. active controls and costs of retrieval in a deep geological repository. During the operational phase, not all waste packages present in the facility will be at the same lifecycle stage. Note: exact proportions of illustrated rectangles may vary depending on the repository design.

www.oecd-nea.org/rwm/rr

Socio-technical rationale
Advanced nuclear technologies

1. Problem
   - Waste that remains hazardous over very long timescales
   - Bad resource efficiency

http://nsec.jaea.go.jp/ndre/ndre3/trans/objective-e.html



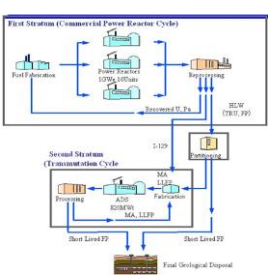
2. "Solution"
   - Limiting the amount, lifetime and hazard of waste

3. 1 + 2 ~ P&T:
   - **Partitioning, recycling and burning** of 'waste'
   - By means of the **active** development and application of
   - **New installations**

Socio-technical imaginary
Advanced nuclear technologies

- Vision:
  - phase out gen II
  - transition with some gen III
  - then gen IV + regional P&T sites
    - double strata strategy : fast reactor + ADS (for burning minor actinides both from the past (gen II and III) and FR)

- Four Building Blocks
  1. Reprocessing facilities (partitioning factories) √
  2. Dedicated fuel fabrication facilities **?**
  3. Fast reactors and ADS' (burning facilities) **?**
  4. Reprocessing facilities for ADS and FR spent fuel **?**



- Cycle of at least a 100 years

Summarized

- Geological disposal
  - **Final, national** radioactive **waste** management strategy
  - Aim: **passive safety** by means of containment and isolation
  - Based on **advanced research**
- Advanced nuclear technologies
  - **Ongoing, international** RWM strategy within broader nuclear **energy** production strategy
  - Aim: **active** safety → **intrinsic safety** by limiting the amount, lifetime and hazard of waste
  - Based on **proposed research**

Main discussion points

Socio-technical assumptions – Socio-technical constraints
Geological Disposal

- **Final disposal of ultimate waste?**
  - Management strategy vs. solution?
  - Tension between protection and freedom of future generations?
  - Extrapolation of labo results?
    - full validation impossible (time & space scale limitations)
    - "ceteris paribus"
  - Definitions of "waste" are temporal
  - Presented as a "one shot solution" while in fact you'll need a new GD every ca. 50 years
- **Passive safety?**
  - Parameter, model and scenario uncertainties
    - No scientific basis to deal with 'human intrusion'
  - How passive is passive safety?
    - Oversight?
- **As soon as possible?**

Socio-technical assumptions – Socio-technical constraints
Advanced nuclear technologies

- **Partitioning, recycling and burning?**
  - Recycling possibilities are limited
  - Transmutation possibilities remain uncertain
  - Partitioning alone may create more problems than it solves
  - Balance between production and consumption of waste? (operational waste, SF, decommissioning waste)
- **Active development and application of new installations?**
  - Life cycle analysis?
  - Balance between short term (operational) and long term (disposal) safety?
  - Forcing future generations to continue with nuclear?
  - Economic feasibility?
  - GD will remain necessary; is the added value for RWM worthwhile?

Preliminary analysis

Preliminary analysis

- Stories of both GD and P&T are dependent on a selection of s-t scenarios and on the s-t hypotheses you include in these scenarios
  - **GD** seems to be contextualized in a very long term uncertain future, where especially economy related activities are judged as highly unreliable.
  - **P&T** on the other hand seems to be contextualized in a medium long term future, in which continued investment in nuclear energy is foreseen.
  - **GD** seems to ultimately aim to prevent exposure to ionising radiation by means of passive safety. This leads to the question of how one can guarantee that the required passivity will be sustained.
  - **P&T** seems to ultimately aim to prevent exposure to ionising radiation by means of intrinsic safety. This leads to the question of how one can guarantee that the required activities to reach intrinsic safety, if ever possible, will take place.

Geological disposal

- RWM in isolation
  - < Nuclear expertise will be lost
- Trust in the passivity of nature – distrust in the activity of humans

Partitioning and transmutation

- RWM as part of nuclear energy cycle
  - < Nuclear expertise will be maintained
- Trust in the activity of humans – distrust in the passivity of nature

Related to a tension inherent to RWM?

- Closure: decisiveness, controllability and determinability ~ GD ?
  - Finality and protection
- Openness: undecidability, uncontrollability and contingency ~ ANT ?
  - Flexibility and freedom

➢ 'Virtual' attraction of both a 'closed' (predictable, controllable) and an 'open' (undecided, creative) vision on the future

Overall agreements

Overall SSH agreements

- Both GD and ANT are underbuilt by scientific findings **and** social visions
  - Both work with generic **reference scenario's**, both include **assumptions** (GD: passivity hypothesis - ANT activity hypothesis)

- "When technologists define the characteristics of their objects, they necessarily make hypotheses about the entities that make up the world into which the object is to be inserted.
  Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways.

  ➔ A large part of the work of innovators is that of "inscribing" this vision of the world in the technical content of the new object"
  (Akrich in Bijker & Law, 1992)

Overall pragmatic agreements

- Clear interaction between RWM and the future of nuclear energy
- The international dimension of RWM deserves further explicit attention
- We need to communicate in a more balanced manner, without hiding uncertainties

  ⟺ *large part of the work of innovators is that of "inscribing" their vision of the world in the technical content of the new object"* ***?***

- It is not GD versus ANT: search for complementarity
  - P&T scenario has **five** Building Blocks : + GD
  - Allows more balanced and inclusive knowledge + opens up new fields of research
    - Different conditioning methods?
    - Prolonging surface storage?
    - Records, Knowledge & Memory transfer?
    - Transfer of responsibilities?
    - Reversibility & retrievability?
    - Monitoring?

Thank you!

Questions, comments, ideas, …?

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"Nothing is less likely than a plausible future"
D. LOWENTHAL 1995, The Forfeit of the Future, "Futures", 27 (4)

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