Funding Mechanisms for Radioactive Waste & Economics of the Back End of the NFC

Nuclear Energy Agency – RWM & DEV
Presented by Henri Paillere

(September 1961, 35 member countries today)

International Energy Agency:
All energy technologies except nuclear fission

The IEA is an autonomous body within the OECD framework.

(November 1974, 29 member countries today)

OECD Nuclear Energy Agency:
nuclear fission

The NEA is a specialised agency within OECD.

(December 1957 'European Nuclear Energy Agency' → April 1972 OECD Nuclear Energy Agency, 31 members today)

NEA Membership

- Australia
- Austria
- Belgium*
- Canada*
- Chile (2010)
- Czech Republic*
- Denmark
- Estonia
- Finland*
- France*
- Germany*
- Greece
- Hungary*
- Iceland
- Ireland
- Israel
- Italy
- Japan*
- Korea*
- Latvia
- Luxembourg
- Mexico*
- Netherlands*
- New Zealand
- Norway
- Poland
- Portugal
- Russia* (1st Jan. 2013)
- Slovak Republic*
- Slovenia*
- Spain*
- Sweden*
- Switzerland*
- Turkey
- United Kingdom*
- United States*

OECD and NEA member
OECD member, not NEA
NEA member, not OECD

* NEA countries that have NPPs (19 out of 31)

Nuclear Energy Agency

- Assists its 31 member countries (~84% of world installed nuclear capacity) in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for the safe, environmentally friendly and economical use of nuclear energy for peaceful purposes.
- Areas of work include:
  - Nuclear safety and regulation
  - Nuclear energy development
  - Radioactive waste management
  - Radiological protection and public health
  - Nuclear law and liability
  - Nuclear science & data bank

- The NEA also serves as the Technical Secretariat for the **Generation IV International Forum (GIF),** for the **Multinational Design Evaluation Programme (MDEP)** and for the **International Forum for Nuclear Energy Cooperation (IFNEC)**

Financing of radioactive waste management (1/4)

- “Polluter pays principle”: most nuclear utilities make payments into a trust fund;
- Key objective is to ensure that sufficient funds are in place to cover all costs for managing radioactive waste, including decommissioning, storage and disposal costs;
- The most common mechanism adopted for the accrual of funds are levies on nuclear electricity. E.g. 0.1 ¢/kWh in the US or 0.14 ¢/kWh in France. Or in other cases, waste producers pay lump sums (e.g. in Korea) or proportionally to the volumes of waste produced (e.g. in Belgium);

Financing of radioactive waste management (2/4)

- Levies and fee payments are accumulated in internal or external funds:
  - Internal fund: payments made over the life of the nuclear facility into a fund that is held and administered within the organization;
  - External fund: payments made into a fund that is held outside the organization, often within governmental bodies or administered by a group of independent trustees. A 3rd party administering funds promotes transparency, insolvency protection and enhances confidence.

Financing of radioactive waste management (3/4)

- Financial arrangements for waste management & decommissioning vary from country to country. E.g. nuclear utilities in Switzerland make separate payments into two separate funds: decommissioning and waste management,
- To guarantee adequate financing, periodic assessments of the RW management costs are essential;
- Expenses for disposal will appear over extended periods, some expenditure could incur long after payments from electricity generation has stopped, i.e. important to establish appropriate financial arrangement and careful management of the accrual of the collected funds.

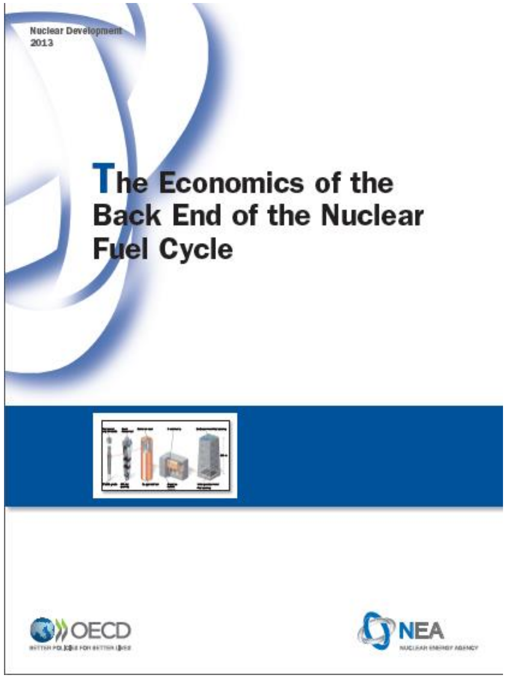
Financing of radioactive waste management (4/4)

- To ensure sufficiency, ring-fencing and periodic assessments of waste management funds are crucial;

- The deployment of deep geological repositories for radioactive waste will reduce uncertainties.

Economics of the Back End of the Nuclear Fuel Cycle Study

- To understand economic issues and methodologies for the management of SNF in OECD/NEA countries, including the funding mechanisms in place or under consideration.
- To assess the available knowledge from different countries on the costs of the various options for the long-term management and final disposal of radioactive wastes, and to the extent possible, compare the cost estimates on a common basis.
- To evaluate, in particular, the impact of uncertainties, e.g. variations in cost estimates for SNF interim storage, reprocessing, encapsulation, final disposal, etc.



http://www.oecd-nea.org/ndd/pubs/2013/7061-ebenfc.pdf

General structure of the study

- **Descriptive review of the different back-end options and current policies** and practices for the management of SNF and HLW, including financing arrangements and considerations on the cost estimates upon which these are based.
- **Quantitative part where economic aspects are assessed**, existing economic models comparatively appraised and high-level cost estimates and sensitivity analyses undertaken through a simple model to determine impacts of important variations and key cost drivers.
- **Influence of qualitative parameters**: Security of energy supply, non-proliferation, public attitudes, environmental effects, waste streams, transport of radioactive material, legal and regulatory aspects, development of fast reactors and advanced fuel cycles, retrievability and safety.

Descriptive review

- For the long-term management of SNF, two major options are adopted commercially at present:
  - Direct disposal, where the fuel is used once and is then regarded as waste to be disposed of.
  - Partial recycling, where the spent fuel is reprocessed to recover unused uranium and plutonium for recycling in light water reactors, in the form of reprocessed uranium oxide (REPUOX) and mixed-oxide (MOX) fuel respectively. Irradiated MOX and REPUOX bundles can be either stored (with the perspective of their reprocessing and recycling in future fast reactors – FRs) or disposed of after encapsulation.
- Both options, as well as any prospective advanced option, must eventually entail an operational repository for final disposal. The major difference in the deep geological repository needed will be in relative size.
- The report described the process that have occurred in national programmes for HLW and SNF disposal.

Descriptive review (continued)

- Assessments of the costs for managing SNF and radioactive waste from the civil fuel cycle are essential to establish the size of liabilities and guarantee their financing.
  - Cost assessments are performed regularly in most countries, encompassing the various stages of the back end.
  - However, differences across individual assessments can be quite large, making direct comparisons very difficult. Variations are attributable to disparate factors including differences in assumptions, technical solutions and national conditions.

- Expenses for disposal will appear over extended periods, and much of the expenditure could be long after income from electricity generation have stopped.
  - It is fundamentally important that appropriate financial arrangements are established and that the accrual of adequate and available funds for the eventual implementation of the selected back-end strategy is carefully pursued.

- To ensure availability, ring-fencing of funds is required so that resources accrued are only used for the intended purposes.
  - Segregation of funds is pursued by most countries in their national legislations.
  - Some funding systems contain further inbuilt features to minimise risks (e.g. guarantees may be requested from nuclear operators to protect against unforeseen developments)

Quantitative part:

- A review of the cost estimations undertaken in NEA member countries, together with an assessment of processes for the establishment and management of funds.
- A high-level assessment of the costs of the full cycle and its components, in the case of three idealised strategies, current and potential, for managing the back end. This assessment includes a sensitivity analysis, which helps to identify the principal cost drivers for the economics of the back end.

Idealised strategies considered:

The evaluation of the **cost for the total fuel cycle***, its breakdown, and a sensitivity analysis of costs associated with the management of spent nuclear fuel from light water reactors (LWRs) were performed for three assumed generic strategies:

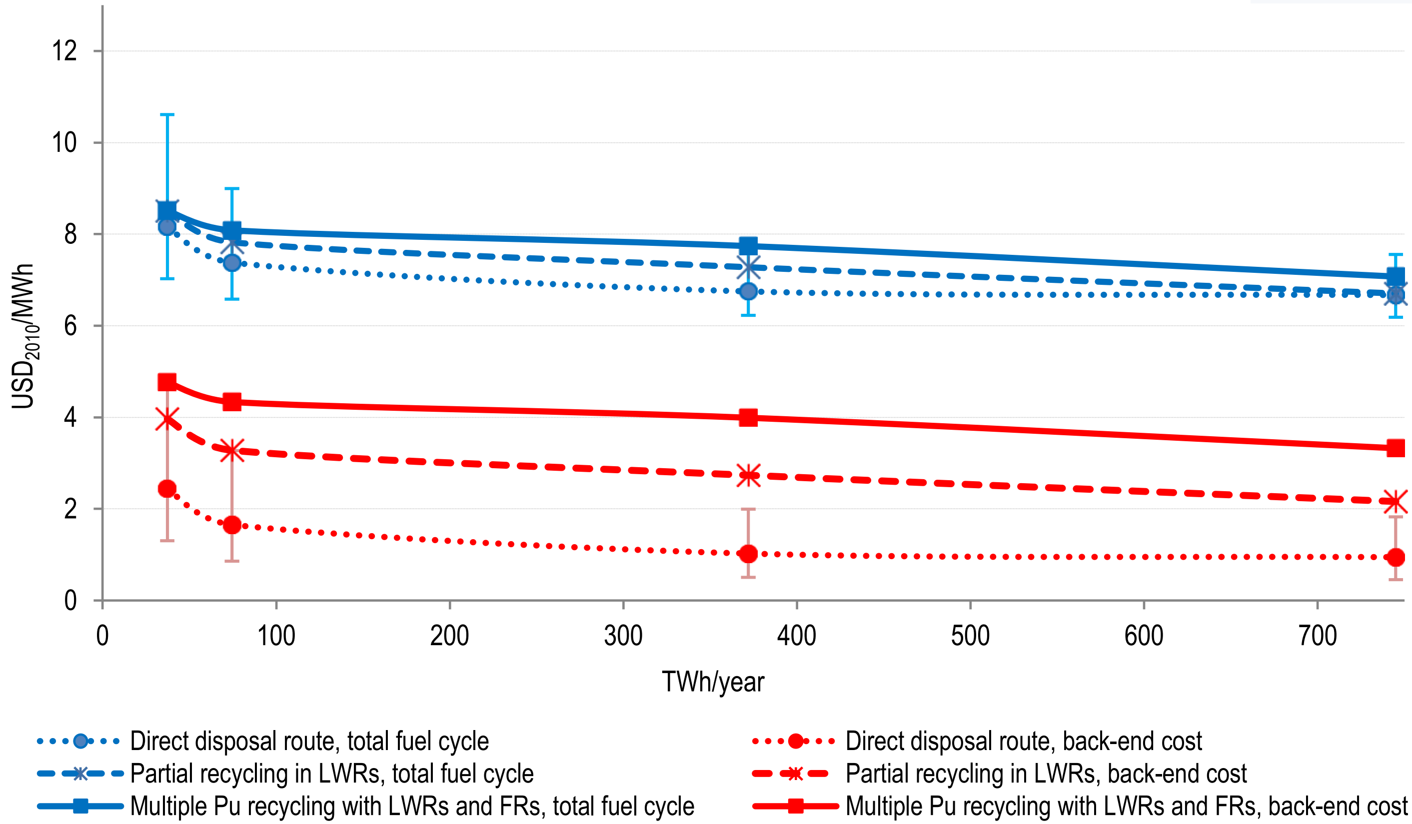
- **Open or once–through FC**, with direct disposal of spent nuclear fuel.
- **Partial recycling** or twice-through FC, where REPUOX and MOX are recycled once in LWRs and then disposed of.
- **Multiple plutonium recycling with LWRs and fast reactors (FRs)**. This strategy contemplates single MOX and REPUOX recycling in LWRs and multiple plutonium recycling in FRs.

*Including both the back-end and the front-end components, so that the use of recycled materials and the resulting savings in the requirements of fresh uranium can be taken into account for recycling options

$LCOE_{Fuel\ cycle}$ and $LCOE_{Back\text{-}end}$ for different reactor fleets and back-end strategies

(3% discount rate)

LCOE = Levelised Cost of Electricity



Note: The central values represent the results from the REFERENCE cost scenario, and the error bars correspond to the LOW and HIGH cost scenarios.

Calculations show that **costs calculated for the open FC option are lower than for the other idealised options** assessed. However, differences of **$LCOE_{Fuel\ cycle}$ for the three options are within the uncertainty bands**. For the recycling options, additional costs from reprocessing are being offset by the savings on fuel costs at the front end. Differences are more noticeable if the back-end component of the fuel-cycle cost is considered in isolation, since the offsetting effects are not taken into account.

Recommendations

1. While there may be reasons to extend the interim storage of SNF, these should not prevent governments from maintaining vigorous efforts towards the establishment of deep geological repositories, thereby addressing legitimate public expectations and fulfilling the "intergenerational equity" principle.

2. Public involvement in the establishment and implementation of the SNF management strategy is considered vital: mechanisms to improve stakeholder participation and transparency should be a high priority.

3. Governments should continue to be vigilant in ensuring that the funding systems adopted are stable and robust and that financial resources accrued by waste producers for the management of their waste will be adequate and available at the time they are needed. The following features are considered essential:
   - Regular and frequent reviews to allow for newly accrued knowledge on technical aspects and actual fund developments, as well as other qualitative factors (e.g. sociopolitical), to be taken into account, and, importantly, for emerging shortfalls to be swiftly addressed through the necessary corrective actions.
   - Ring-fencing of funds to ensure that resources are only used for the intended purposes.

Recommendations (continued)

4. For countries that are committed to ongoing use or development of nuclear energy, comparisons of the costs of different strategies for managing the back end should be drawn on the basis of the full fuel cycle cost. For countries which are phasing out or have already exited nuclear power, a direct back-end cost comparison may be more appropriate. In any case, assessments made for total or partial FC cost comparisons should be transparent about the assumptions made and the scope of the analysis.
5. In any decision-making process regarding the choice of SNF management strategy, a multi-criteria approach should be adopted at the national level that expands the quantitative economic considerations to include qualitative factors. These can have an important (or even determining) influence in the final decision and may also have a direct impact on the costs.
6. Especially where issues of long-term fuel supply and reduction of waste volumes are particularly important (e.g. in countries with larger nuclear programmes) research and development (R&D) on advanced nuclear systems, including FRs, should be supported by governments, since their implementation holds the potential for enhancing the long-term sustainability of nuclear power, notably in relation to management of waste. In this context, further engineering and cost analyses would be important to reduce the uncertainties in the costs of implementing advanced fuel cycle options.
7. International co-operation and sharing of experience for safe, reliable and economic implementation of the back-end strategies should be continued. Given the significant economic costs and expertise required for their realisation, sharing FC facilities and infrastructure would especially benefit countries with small nuclear programmes.

Nuclear Energy Agency

All publications available on www.oecd-nea.org