

# IFNEC IDWG

---

## Costing and Financing Radioactive Waste Management and Decommissioning

May 8<sup>th</sup> 2014, Bucharest

John Mathieson, Nuclear Decommissioning Authority

# Overview

---

- Requirements & general principles
  - Costing methodologies
  - Financing mechanisms
  - Some country examples
- 
- References

# Requirements (1)

---

- **Joint Convention:**
  - “adequate financial resources are available ... for spent fuel ... and radioactive waste management ... and for decommissioning”.
- **COUNCIL DIRECTIVE 2011/70/EURATOM ... for the responsible and safe management of spent fuel and radioactive waste**
  - “Member States shall ensure that ... adequate financial resources be available when needed ... for the management of spent fuel and radioactive waste”.
  - N.B. Directive is brought into law so there is sanction if the Member State does not comply!
- **IAEA Milestones**
  - “Funding” – fiscal responsibility of the Government in establishing the nuclear programme
  - “Financing” – fiscal responsibility of the owner/operator (which could be government or utility)
  - **3.4.1. Funding and financing: Milestone 1**
    - Long term financing to ensure safe and secure handling of spent fuel, radioactive waste, plant decommissioning, and the options for disposal
  - **3.4.2. Funding and financing: Milestone 2**
    - Plans in place to fully finance long term waste management and decommissioning

# Basic Principles

---

- Need to ensure that nuclear liabilities are adequately funded
- Most countries require developers to have fully funded decommissioning & SF disposal programmes (FDP)\* before NPP construction
- This comprises:
  - a decommissioning and waste management plan (DWMP)\* which generates a cost estimate, and
  - a funding assurance plan (FAP)\* to establish the fund
    - utility makes contributions over the lifetime of the plant
    - the fund grows from contributions and interest
    - pays out as the liabilities are discharged
    - (utility operational waste management not covered by the fund)
- Implements the “polluter pays” principle (usually!)
- \*UK terminology

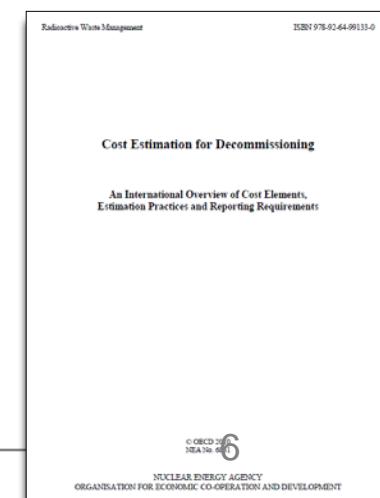
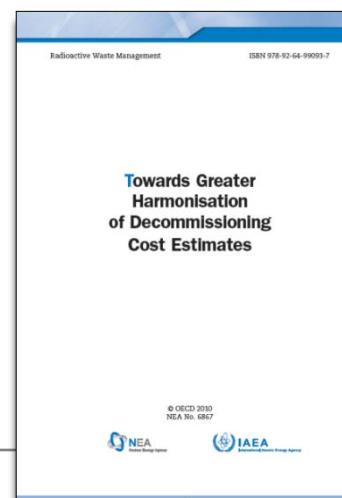
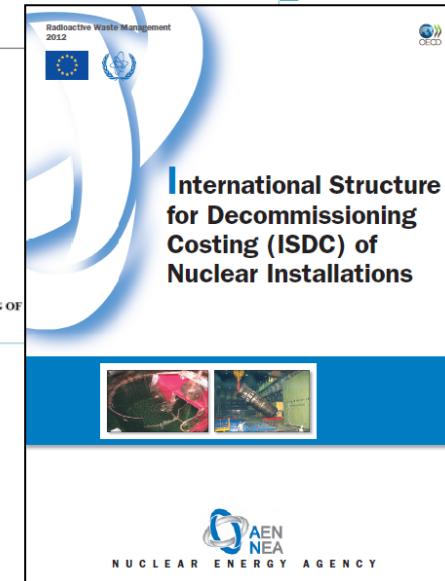
# Costing & Financing

---

- **What is being costed and financed?**
  - Interim storage facility (needed if repository not available)
  - Near surface repository
  - Decommissioning of NPP
  - Spent fuel disposal
  - Geological disposal facility
- **Who pays?**
  - a) Utility (costs passed on to electricity consumers)
  - b) Government (costs passed on to taxpayers)
  - c) Mixture of both
    - New build a)
    - Legacy b) if no provision made or there is a shortfall
- **Who spends?**
  - Utility
  - Waste Management Organisation (WMO)
  - (Regulators)

# NPP Decommissioning Costing

- Reactor type – waste streams
- Decommissioning strategy
  - Prompt or deferred
- Availability of disposal routes
- Purpose
  - Establish decommissioning funds & payments, & “strike price” for New Build
  - Establish contract baseline for decom.
  - Project development & implementation – other inputs documentation (e.g. EIA at this time)
  - Estimates
- Costing
  - Good international support (NEA, IAEA)
  - Not straightforward
  - Timeframes
  - Risks?
- Would include SF management as well



# Geological Disposal

- **Timeframes**
  - Decades to implement
  - Decades of operation
  - Centuries of post closure phase
- **Not many published examples**
  - (IAEA Drafting guidance)
  - Difficult to benchmark internationally – why??
  - EDRAM has done some work on comparisons
- **High fixed costs / high variable costs**
- **High risks to programme (delays)**
- **Purpose**
  - Project financing
  - Fund establishment & charge determination
  - Contract baseline for development
  - Charge determination for disposers
  - New nuclear build – New Build organisations need assurance on disposal costs for their financing model including decommissioning planning

GUIDELINES COMPARATIVE ANALYSIS COST ASSESSMENTS

1



International Association for  
Environmentally Safe Disposal of Radioactive Materials

Guidelines for comparing cost assessments  
for geological repository projects

Summary of the report of the EDRAM working group formed by ANDRA, DBE,  
NAGRA, NDA, NWMO, ONDRAF/NIRAS, POSIVA and SKB

International Association for Environmentally Safe Disposal of Radioactive  
Materials – EDRAM

September 2012

Users may copy content for their own use. In addition, excerpts from this publication may be included in documents, presentations and websites, provided that suitable acknowledgment of EDRAM as source and copyright owner is given.  
The conclusions and views presented in this report are those of the authors and do not necessarily coincide with those of the national organizations that are part of EDRAM.

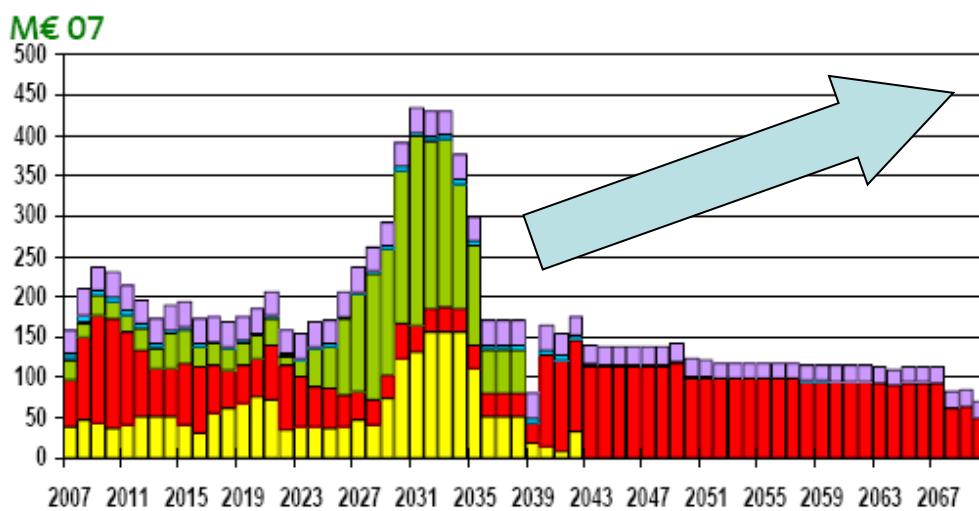
# Basic Principles of Costing

---

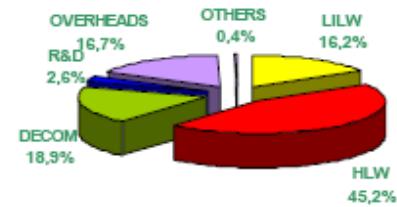
- **Factors to be considered**
  - Purpose(s) of the costing (discussed)
  - National policy, strategy and legal framework
  - Project specific considerations
- **Define a “Reference Scenario” / project baseline (inputs to cost model – Base Case)**
  - For disposal: Location, geology, design, inventory (including co-location of wastes), schedule
  - Inflation & discount rates
  - Other factors (financial, technical etc.) / assumptions??
- **Determine which models / tools can be used**
  - Computer codes, Project Management Software: GIGO Applies!!!
  - Parametric costing
  - Specific analogy costing
  - Engage experts to do this!
- **Outputs**
  - Fixed & variable costs
  - Probabilistic or deterministic
  - Sensitivity analysis required
  - Treatment of Uncertainties / Risks / contingencies
- **Benchmarking**
  - what is a “good” costing?
- **Documentation**
- **Review**
  - Review “regularly”, but if assumptions change too much may then need new base case!

# Cost output - Spain

## Future RW Management Cost



Feeds into funding requirements development



Note values are  
“discounted” and  
money value year  
quoted

Total estimated cost ≈ 14,000 M€07 (1985-2070)

Cost incurred up to 2006: 24%

Pending to be collected: 5,200 M€07 (discounted)

# The Fund

---

- **Similar to a pension or other savings / investment scheme!**
- **Fund should grow – combination of contributions & interest**
  - Must have good investment strategy
  - Good governance, including transparency
- **“Good” lifetime cost estimation essential**
  - To ensure charges / fees / contributions are fair
  - Amount of the waste / wasteforms – may change during lifetime
- **Fund is very long term**
  - Growth > inflation, but low risk investments
  - Should be segregated & protected from “raiding”
  - Issue for NPPs nearing end of life, or disposal facility required sooner than the fund allows
  - Single or separate decommissioning and disposal funds?
  - One national fund, or individual funds?

# Determining contribution mechanisms to the Fund(s)

- **(Nuclear) electricity price:**
    - (L/ILW RWM Fund = x% per kWh)
    - Decom Fund = y% per kWh
    - SNF Fund = z% per kWh
  - **Direct payments from non-electricity producers**
    - Volume based contributions
    - Multi-attribute based contributions
  - **State Budget**
    - Initial endowment to get the fund going
    - Contributions for pre-fund NPPs, “orphan” wastes
- 
- Fee can go to separate funds as each may have different objective

# Contribution mechanism issues

---

- **Electricity levy**
  - Imposed on all power producers (Spain as was), or just nuclear producers (Sweden, etc.)
  - Can be complex: Spain formula was very difficult – based on generation (not output)
  - Determined by costing exercise (Sweden, Finland)
  - Or simple: US formula same for all NPPs = 0.1¢/kWh
- **Volume based**
  - Simple to understand
  - Might not be fair or efficient
  - Will encourage volume reduction
  - May lead to too little waste if assumptions are not good!
- **For L/ILW disposal**
  - Operational waste arisings paid for through operations & not through fund

# Investment Strategy - set by FMB

---

- Set by a Fund Management Board
- Challenge – inflation
  - Growth target
  - Discount rate applied
- Low risk investments
  - not in electricity sector
  - protect real value
- Quoted in which currency:
  - Local or international, e.g. USD
- Fund borrowing by contributors
- Start at zero, or State Budget endowments
- What happens if early closure of NPP?

# Country Examples

---

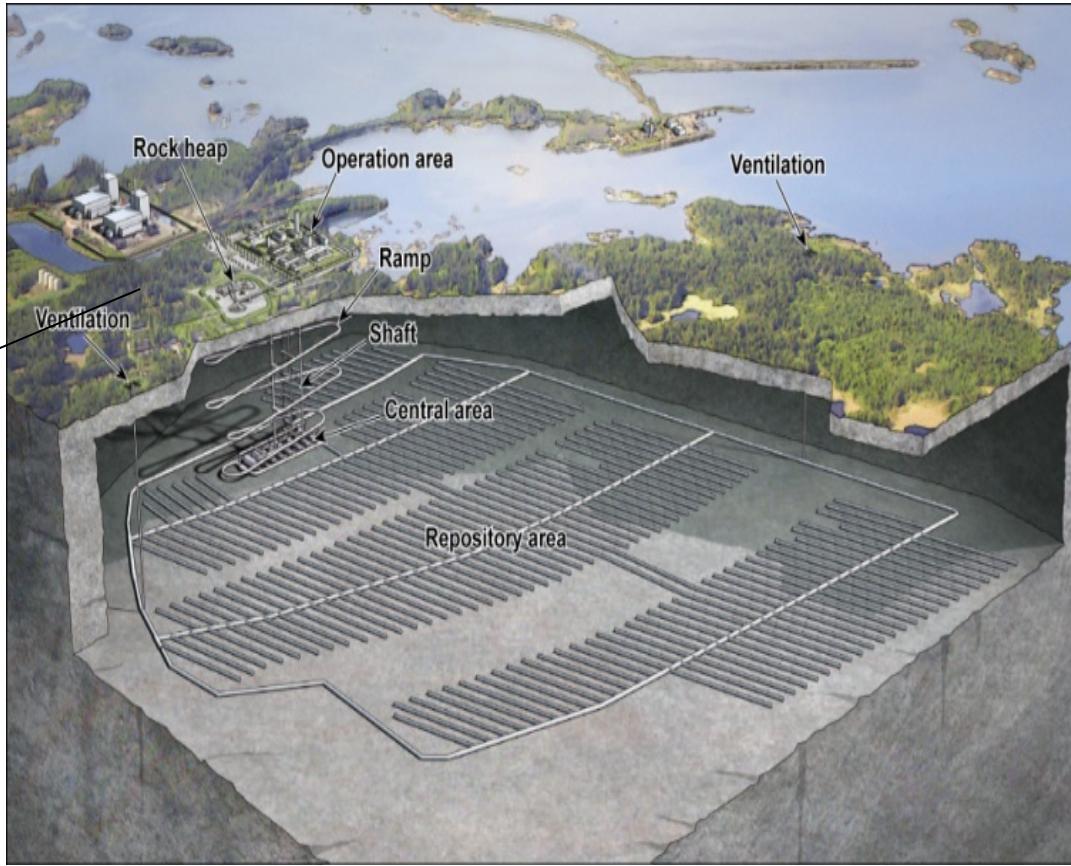
- Switzerland
- Netherlands\*
- Sweden\*
- Canada
- USA\*
- UK\*

# Netherlands

- **HLW storage 100 years**
  - Then disposal decision
  - R&D now (clay/ salt)
  - storage of all wastes at Vlissingen
- **1986 (what happened in 1986??)**
  - Geological disposal in salt for all Dutch radioactive waste
  - Cost was estimated at €1230M (€820M HLW)
  - Real interest rate of 3.5% and a discounting period of 130 years was used
- **When utilities pay fees, they discharge all liabilities to COVRA**
  - All producers pay contribution per m<sup>3</sup>
- **Post '86 new nuclear policy (i.e. no new build as before)**
  - COVRA had a shortfall of funds (not enough waste)
    - So they raised the tariff
    - Utilities responded by producing less waste!
    - Therefore less money to cover the liability
- **(now) Capital growth fund**
  - HLW : LILW = 2 : 1
  - After 100-130 years: € 2 billion
  - Real interest rate 2.3%
  - Safe investments
  - State as back-up

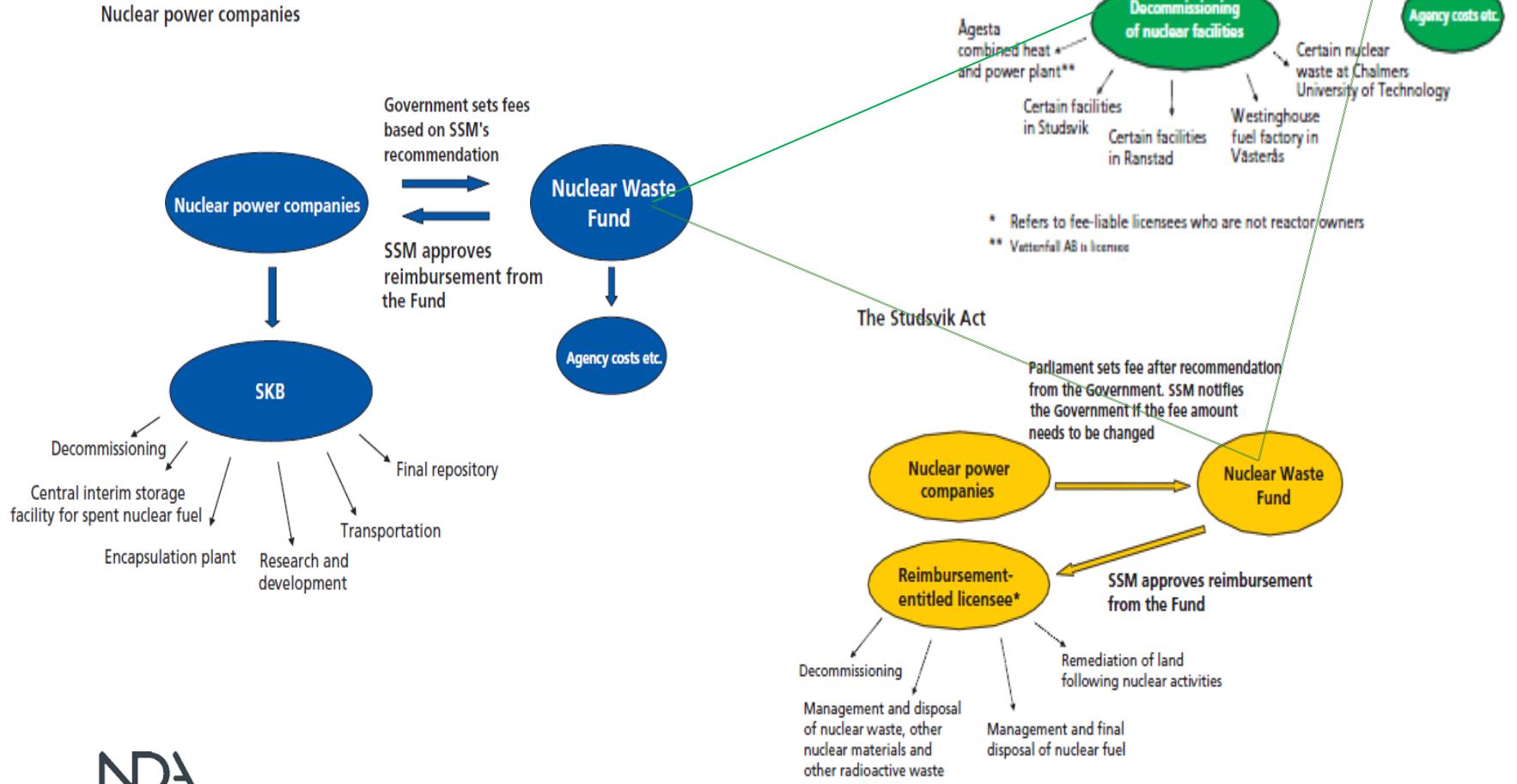


# Sweden



# Sweden

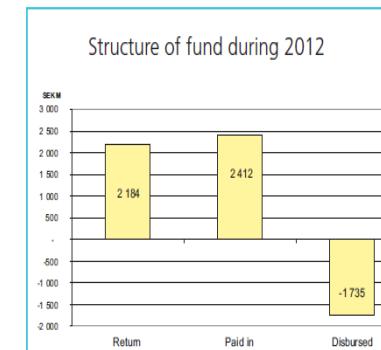
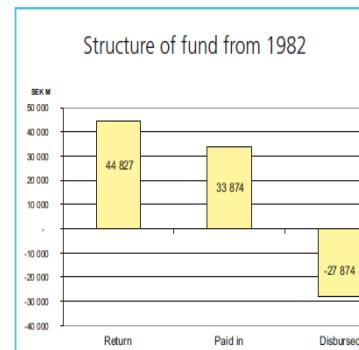
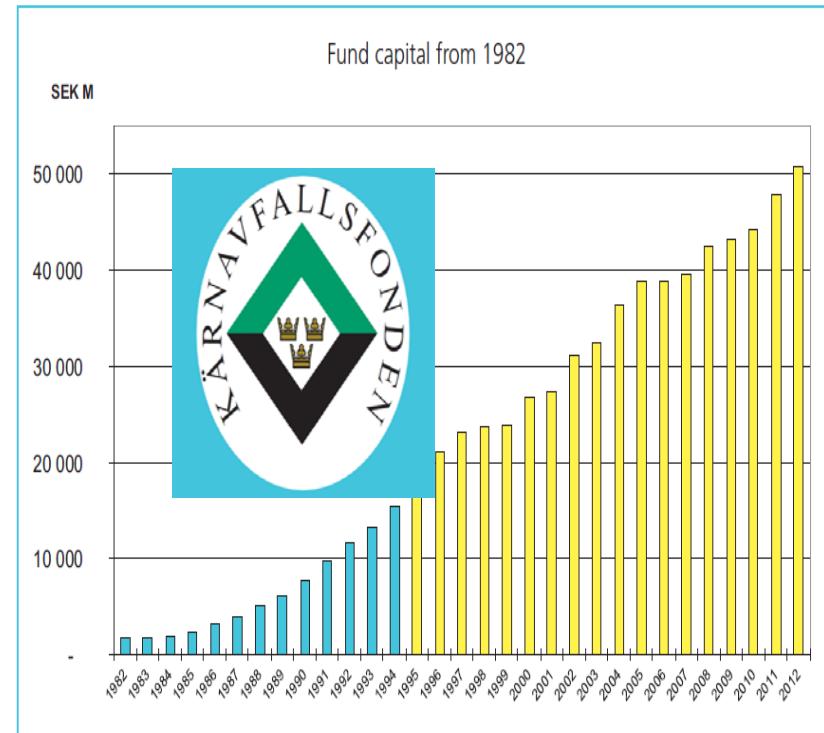
- SSM is the Nuclear Regulator



\*Refers to licensees for facilities covered by the Studsvik Act. At present these are AB SVAFO, Studsvik Nuclear AB, Vattenfall AB (50% of the Ågesta CHP plant), Ranstad Industricentrum AB and Uppsala University.

# Key numbers

- **SEK0.02/kWh (2012-14)**
  - Has been 0.01
  - Non-NPPS have different mechanism
- **SEK50.8bn fund balance**
- **Administered by Nuclear Waste Fund**
- **Investments:**
  - Swedish State Bonds
  - “Covered” bonds
  - Interest bearing accounts at the National Debt Office
  - Rate of return 2012 was 4.6%
- **Repository cost estimate 2013 SEK123bn**
- **Assumes 50-60 years operation for NPPs**
- **SEK31bn already spent on existing facilities and R&D (i.e. SKB & others)**
- [www\(skb.se](http://www(skb.se)



# USA – Geological Disposal – (Yucca Mountain)

- **Nuclear Waste Policy Act (1987 Amendment)**
  - Identified Yucca Mountain as the repository site
  - Required utilities to pay 0.1¢/kWh into Nuclear Waste Fund
    - Fee was determined as adequate
    - Department of Defense also contribute
- **Fund pays for development of Yucca**
- **Since 1998 USDOE takes title to discharged spent fuel**
  - Utilities sue DOE – no storage or disposal
- **Yucca programme “stopped” in 2010**
- **But in Nov 2013:**
  - NRC ordered to restart licensing assessment, previously suspended
  - Fee collection deemed “unfair”!

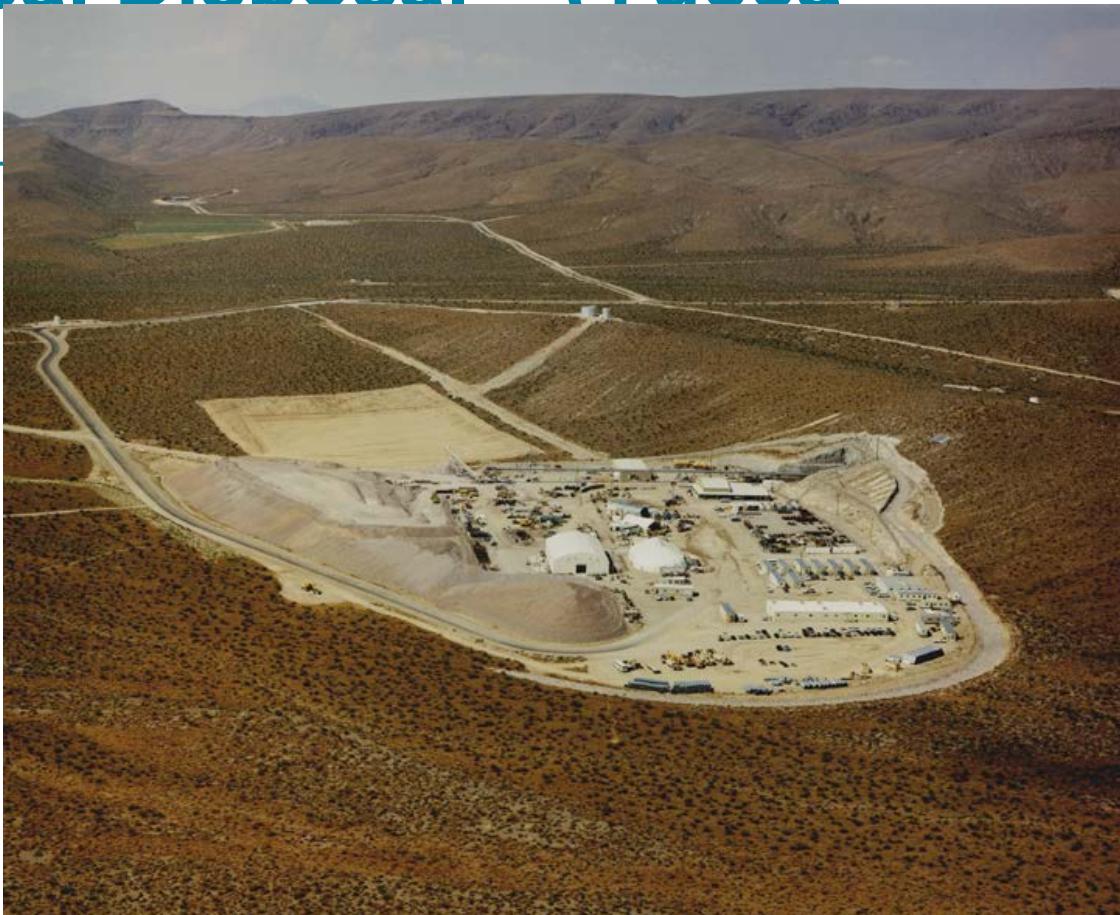


Table ES-1. Summary of the 2007 TSLCC Estimate – 2007 Dollars (in Millions of 2007\$)

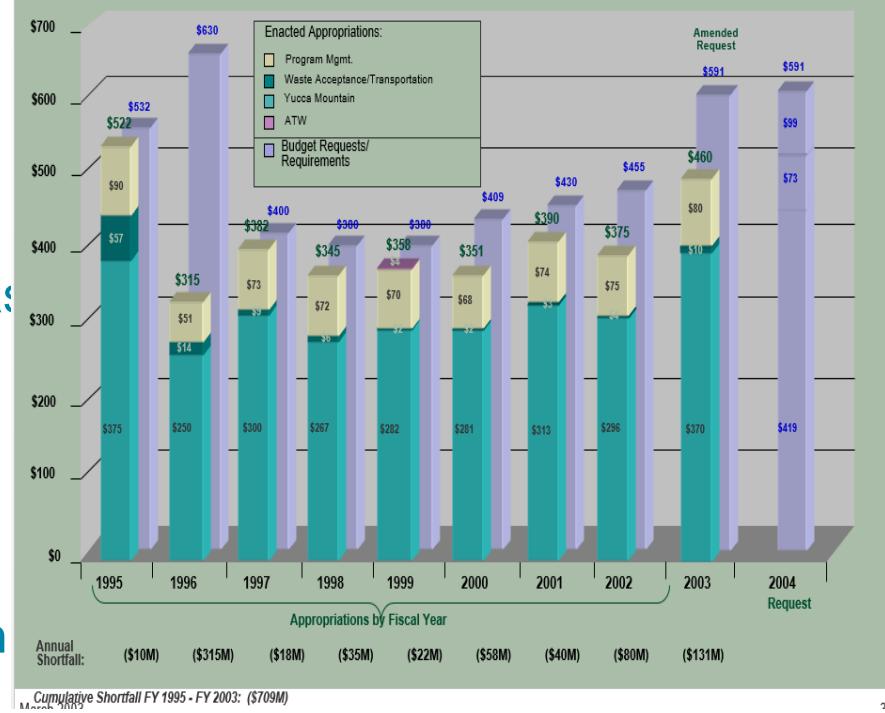
Cost Element	Historical Costs (1983 – 2006)	Future Costs (2007 – 2133)	Total Costs (1983 – 2133)
Repository	9,910	54,820	64,730
Transportation	780	19,480	20,250
Balance of Program	2,860	8,340	11,200
<b>Total</b>	<b>13,540</b>	<b>82,640</b>	<b>96,180</b>

# Nuclear Waste Fund Issues

- Re Geological disposal, the Fund is for Yucca Mountain
- DOE obtained budget for investigations thorough normal Government process i.e.:

- Fund is not ring-fenced and has been “raided”
- “Appropriated” by Congress
- DOE asked for \$Xm but were given \$Ym ( $y < x$ )
- Became a political football with State of Nevada

- Collects ~\$750m/year, plus \$1.5bn interest (2013)
- \$30bn value (2013)



# UK New Build

THE ENERGY ACT 2008

Funded Decommissioning Programme  
Guidance for New Nuclear Power  
Stations

December 2011

- **Legacy clean-up and disposal costs met by Government**
  - NDA responsible
- **EdF Energy has Nuclear Liabilities Fund for the existing fleet of AGRs & PWR**
- **All new builders required to have and approved Funded Decommissioning Programme**
  - DWMP
    - Realistic, clearly defined and achievable plans, robust cost estimates
    - A clear timeline showing key milestones and assumptions for the Base Case
    - Assumptions and parameters underpinning the DWMP
    - (NDA advises Secretary of State on DWMP)
  - Funding Arrangements Plan should show
    - Independence of the Fund from the operator & protected from creditors
    - Measures to ensure sufficiency of the Fund
    - Restrictions on the use of Fund Assets
    - Insolvency remoteness
    - Separate legal entity
    - Target Value for the Fund (including contingency)
      - Waste transfer price assumed for disposal costing
    - First contribution before criticality
    - Contributions take priority over other debts
    - Risk management
    - Reviewed regularly
    - Can have one fund for a fleet (but with separate accounts)

# Constitutional arrangements

---

- **Governance:**
  - a properly constituted board or equivalent
  - a clear delineation of respective duties
  - appropriate restrictions on powers
  - appropriate level of skill and care
  - N.B. Government not included!
- **Investment objectives:**
  - risk exposure & mitigation
  - asset allocation strategy to provide for a gradual reduction in investment risk at the end of life
  - permitted and prohibited asset or class of asset types
  - Investment decision-making inc. social, environmental & ethical considerations
  - performance measurement criteria and benchmarks

# What will be financed by the fund?

**Waste Transfer Price – the price paid by an Operator of a new nuclear power station in return for the Government taking title to and liability for their ILW and spent fuel, under the terms of a Waste Contract.**

Cost	How cost will be met	Included in the Waste Transfer Price?
Decommissioning the station. Includes but is not limited to the dismantling and demolition of all plant systems and civil structures	Independent Fund	No
LLW		
Packaging and disposal of LLW from operations, including transport	Operational Expenditure	N/A
Packaging and disposal of LLW from decommissioning, including transport	Independent Fund	No
ILW		
Conditioning and packaging of operational ILW	Operational Expenditure	N/A
Construction and maintenance of interim stores for ILW <sup>15</sup>	Independent Fund	No
Conditioning and packaging of decommissioning ILW	Independent Fund	No
Transport of operational and decommissioning ILW for disposal	Independent Fund	No
Disposal of operational and decommissioning ILW	Independent Fund	Yes

Spent Fuel		
Operation of fuel ponds during the generating life of station	Operational Expenditure	N/A
Operation of fuel ponds after the generating life of station	Independent Fund	No
Construction and maintenance of interim stores for spent fuel <sup>16</sup>	Independent Fund	No
Transport of spent fuel for disposal	Independent Fund	No
Encapsulation of spent fuel for disposal	Independent Fund	No
Disposal of spent fuel	Independent Fund	Yes
Non-radioactive hazardous waste		
Management and disposal of non-radioactive hazardous waste from operations	Operational Expenditure	N/A
Management and disposal of non-radioactive hazardous waste from decommissioning	Independent Fund	No

## Planning

Decommissioning planning before start of generation	Operational Expenditure	N/A
Pre-closure decommissioning planning <sup>17</sup>	Independent Fund	No
Any planning carried out during decommissioning	Independent Fund	No
<b>Other Costs</b>		
All other costs associated with operating the site until the end of its generating life. These costs include, but are not necessarily limited to, those associated with maintaining the infrastructure necessary for the Operator to comply with the requirements of the nuclear site licence <sup>18</sup>	Operational Expenditure	N/A
All other costs associated with operating the site after end of its generating life and until the site licence is surrendered. These costs include, but are not necessarily limited to, those associated with maintaining the infrastructure necessary for the Operator to be comply with the requirements of the nuclear site licence <sup>19</sup>	Independent Fund	No