Nuclear Energy

Part VIII : *Dismantling and decommissioning of nuclear facilities*

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Séminaire Dassault Systèmes: 22 – 23 mai 2013

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- The main steps of D&D operations
- Technical means and tools
- Radioactive waste from D&D operations
- Regulatory issues
- ***Economic aspects***
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The cost of D&D

- Estimation of the actual costs of D&D are subject to substantial variations for similar types of installation.

- It depends in particular on assumptions made on:
  - Definition of facility shutdown and the work associated with that process, such as post-operational clean-out.
  - The end-point of the D&D process.
  - Arrangements for managing or disposing of residual spent fuel.
  - Arrangements for managing and disposing of radioactive waste

- As a general indication of the overall level of D&D costs, the US regulatory body requires companies to have at least **$164 million** (at 2000 value) **available** to decommission a full-size **PWR** and **$211 million** (at 2000 value) to decommission a full-size **BWR**.

Some points of reference regarding D&D cost (1/2)

- Waste management: example for 4 PWR-900 Mwe in M€[(1)]

Type of waste	Conditioning cost	Disposal cost	T O T A L
VLLW	5.4	5.4	10.8
LLW- ILW (SL)	24	120	144
ILW-LL	22.5	6	28.5
T O T A L	51.9	131.4	183

This leads to a unit cost of

50 € / Kwe installed

To be compared to about 2000 € / Kwe installed of initial investment

(1) : Article de R. Lallement dans RGN N° 5 de nov. 2004

Some points of reference regarding D&D cost (1/2)

(OCDE study, 2003, IBSN 92-64-10432-1)

Total dismantling cost for various types of reactors (€/Kwe installed)

Type	Average	Stand. Dev.
PWR	**320**	195
VVER	330	110
BWR	420	100
PHWR	360	70
GCR	2500	NC

Contribution (in %)

Type of expense	Min.	max
Dismantling	25	55
Waste	**17**	**43**
Security – Monitoring	8	13
Site rehabilitation	5	13
Engineering, management	5	24

Globally, one can keep in mind the order of magnitude of 300 à 400 €/Kwe installed,
That is about 15 % to 20 % of the initial investment cost

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Example of reactors dismantled

Country	Name	Type	Mwe net	Dates of operat.	Duration (years)	D&D levels
USA	Fort St. Vrain	HTR	330	76 - 89	13	3
	San Onofre	PWR	436	67 - 92	25	2
	Yankee Rowe	PWR	167	60 - 91	31	3
	Main Yankee	PWR	860	72 - 97	25	3
	Trojan	PWR	1095	75 - 92	17	3
	Rancho Seco	PWR	873	74 - 89	15	2
	Shippingport	PWR	60	57 - 82	25	3
Spain	Vandellos	UNGG	480	72 - 90	18	3
Germany	Niederaichback	HWR	100	73 - 74	1	3
	Greifswald	VVER	408	73 - 90	17	3
Jaaon	Tokai (JPDR)	BWR	13	63 - 76	13	3
GB	Windscale	AGR	32	63 - 81	18	3
Belgium	Mol (BR3)	PWR	11	62 - 87	25	3
Italy	Carigliano	BWR	150	64 - 82	18	2
	Trino	PWR	260	64 - 90	26	2
	Latina	GCR	153	63 - 87	24	2
France	Chinon A1	UNGG	70	63 - 73	10	2 (museum)
	Chinon A2	UNGG	210	65 - 85	20	2
	Brennelis (EL4)	HWR	70	67 - 85	18	3 (in progress)

Enrichment facility of Capenhurst (GB)

➔ Some characteristics of the facility: in the 50s, the biggest building of Europe (on 1200 x 150 x 30 m) - 4800 floors of distribution - 1800 km of pipings sizing up to a 55 cm diameter (UF6).

➔ An intensive decontamination has been carried out in order to licence to reuse the 160 000 tons of metals and concrete (99 % recycled and freed (released) from any radioactive constraint

➔ To day, it remains only the grass !

Fuel fabrication plant of Hanau (Germany)

➔ A set of 4 facilities

➔ The site has been reused for other « classical » industrial use

➔ Waste which are contamitated with uranium and Plutonium are stored on the site, waiting for a final disposal

BWR reactor of Tokai (JPDR)

D&D has been fully completed in the year 1996

Main Yankee (USA) – PWR 900 Mwe – 1/3
(complete D&D ended in 2005)

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Big Rock Point (USA)

65 MW BWR

Operated: 1962 to 1997

Decom: 1997 to 2006

Plutonium fuel fabrication Winfrith (GB)

➔ This facility did produce plutonium fuels for FBRs

➔ Its complete dismantling was realized between 1996 and 1999 and the site was restored in its initial state

GCR reactot at Windscale (GB)

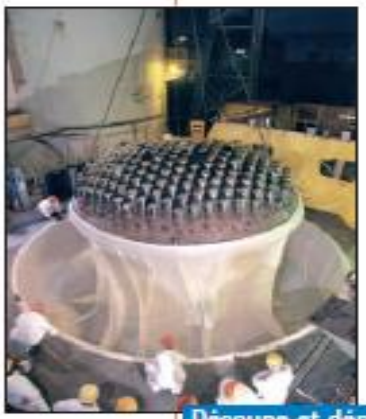

Vue extérieure de l'installation


Déchets de démantèlement entreposés après conditionnement


Extraction par le toit des 4 échangeurs de 100 t chacun (voir aussi page de couverture)


Découpe de la protection biologique supérieure


Démantèlement des assemblages des tubes guides


Découpe et dépose du couvercle supérieur du réacteur après confinement

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Take away points (1/3)

- Techniques for decontaminating and dismantling nuclear facilities are already available and well developed and they have been successfully applied to the D&D of many early facilities (many of them are based on conventional equipment, simply adapted to nuclear application where necessary)

- This has provided a substantial body of experience on a wide range of complex applications that is now being used on larger commercial facilities.

- It is now standard practice in the design of facilities and selection of materials to facilitate the implementation of D&D techniques

- The challenges for the future are to further improve strategies and processes for
  - Enhancing safety
  - lower occupational doses
  - protect the environmental
  - reduce the cost.

Take away points (2/3)

- Management and disposal of radioactive waste is a key element in satisfactory completion of D&D of nuclear facilities and is the major contributor to its overall costs

- Stringent regulatory controls protect the public, the environment and workers from the hazards associated with nuclear facilities

- The regulatory arrangements are often complex, costly and require highly qualified personnel, so there is a strong incentive to remove the necessity for them by removing these radiological hazards.

Take away points (3/3)

- A wide range of nuclear facilities (or contaminated sites) have been already successfully and completely decommissioned so far. This includes nuclear power plants (NPPs), "military" (defense) facilities (a lot!), nuclear fuel cycle facilities research reactors and laboratories, isotope production plants, particle accelerators, and uranium mines

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- Multiple decommissioning project are being carried out or planned soon

- In the next 10 / 20 years, a great number of nuclear facilities will be definitively shut down (particularly NPP), and then decommissioned

D&D is a mature and very promising market