REACTOR DECOMMISSIONING

This informal paper was prepared by Ernst & Young LLP on the specific instructions of the DTI and was prepared solely for the DTI's purposes as part of its consideration of Reactor Decommissioning. The paper may not have considered issues relevant to third parties. Any use that third parties make of this paper, or extracts from it, is entirely at their own risk and the DTI and Ernst & Young LLP accept and have no responsibility whatsoever in relation to any such use by any party.

Some information has been redacted from this report

REDACTED MATERIAL

Description of decommissioning

As summarised in the British Nuclear Group's Lifecycle baseline documents (2004) for the Magnox reactors, decommissioning is the set of activities undertaken at the end of a nuclear facility's operational life to take it permanently out of service with adequate regard for the health and safety of workers, the public and the protection of the environment, and achieves the agreed or assumed end state for the facilities and site.

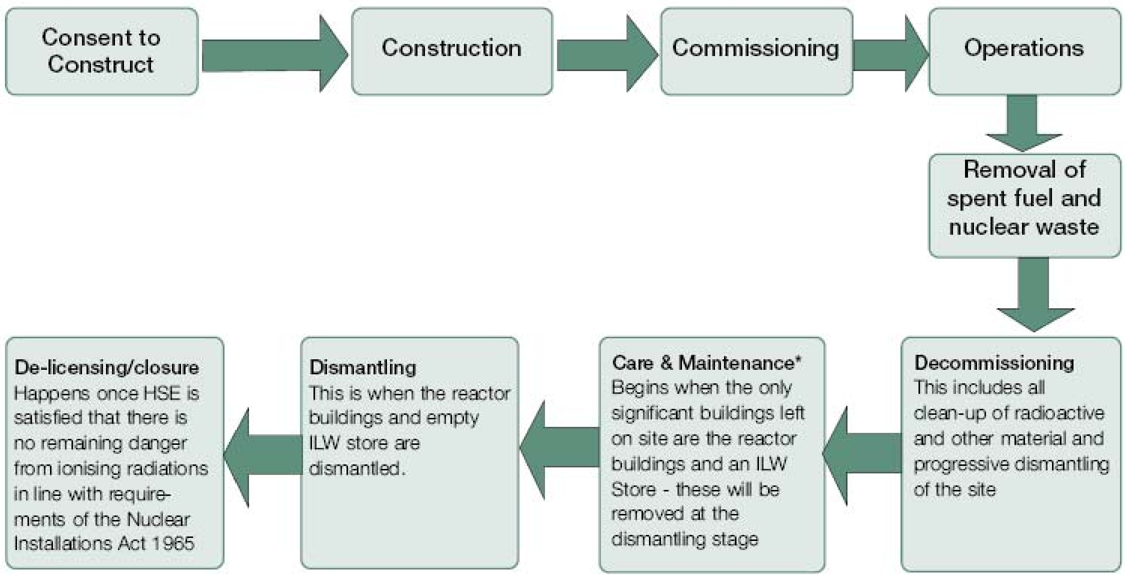
In 1999, the International Atomic Energy Agency ("IAEA") defined three stages of decommissioning, with the following broad characteristics:

Stage 1	shutdown of the plant, fuel removal, draining of circuits (>99% of radioactivity removed, dismantling of non-nuclear facilities. Reactor containment maintained, with controlled access.
Stage 2	dismantling of remaining non-nuclear buildings, and those nuclear buildings excluding the reactor buildings, evacuation of wastes to storage facilities, ongoing containment and surveillance of the reactor core and buildings, though usually requiring reduced ventilation, surveillance etc.
Stage 3	all materials, equipment and structures in which radioactivity levels exist above prescribed limits removed. Site released for alternative use - no radiological restrictions

The IAEA has subsequently developed its definition further, reflecting five Phases: Operational; Shut-down transition; Preparation for safe enclosure; Safe enclosure; and Final dismantling

The precise approach to the decommissioning activity in the UK depends upon the nature of the reactor itself, but also on the strategy agreed with the Nuclear Installations Inspectorate ("NII") - particularly with respect to the chosen end-date for return to alternative use, and whether a care and maintenance phase is planned.

The diagram below from the NDA draft strategy for consultation, (2005), summarises the typical stages:



One of the key differences between alternate proposed decommissioning strategies is whether a period of safe enclosure is anticipated, and to a lesser extent, what periods of care and maintenance are assumed between other elements of the decommissioning activities.

Safe enclosure involves the physical encapsulation of the reactor buildings (once reduced as far as is practical) within a new containment structure, potentially for several decades. Throughout this period only limited security and monitoring costs are incurred, so significantly deferring the point when the containment, reactor buildings and core are dismantled.

Care and maintenance periods may exist between major tranches of work, but are likely to be relatively short periods in which the site is left in a passive state, but without construction of new containment structures. The ongoing costs of security, monitoring etc are likely to be higher than during enclosure, and the deferral before further decommissioning activity shorter.

There is an ever-evolving view of the optimal approach to the decommissioning of the UK's legacy reactors, in part driven by changes in perceived strategic imperatives. The NDA's latest consultation is seeking agreement to prompt decommissioning, returning the whole of a Magnox reactor site to alternative use within 25 years, but this increases the NPV of the costs incurred when compared to both the previous BNFL/Magnox strategy of long term Care and Maintenance, as agreed in the 5 yearly QQR process, and the alternative proposed by BNG's Magnox Innovation programme.

The anticipated advantages of a more rapid decommissioning process are expressed by the NDA as:

- improving confidence and experience of the technology and cost estimates;
- earlier return to alternative use of the sites;
- potentially less transient ILW storage; and
- better use of a near–term skilled workforce.

However, a more rapid approach (and the benefits yielded) may also present greater risk, and therefore potentially greater cost, than would otherwise be necessary. Issues include:

- dealing with a higher level of radiological contamination, hence greater dosage to workers, and more costly techniques required, such as remote handling;
- risk that technology solutions assumed are either not developed, are unsuccessful, or create further unanticipated costs when applied;
- mistakes, failed approaches, inefficient spend etc will have a much higher NPV impact as the spend, and potential additional costs, will all be incurred much nearer-term.

The assessment of which approach is optimal requires the identification and weighting of several diverse factors (safety, cost, availability of waste routes etc). Prior to the NDA's more recent proposals, the UK's approach has generally been to weigh the potential safety and radiological dosage risks highly, and has lead to the development of safe-store and other deferred strategies.

Experience in the US and elsewhere suggests that complete decommissioning can be achieved relatively quickly, in some cases as fast as 7 years. However, in a commercial context, operators are tending towards a range of 20 - 30 years, with the underlying assumptions for the EPR and AP1000 seemingly (but not definitively) expecting a 25 year timescale.

Costs of decommissioning

The majority of reactors presently in some stage of decommissioning, and therefore for which engineering and cost experience is being gained, are neither of the type or design that would be considered for NNB, and have usually formed part of a public construction and operation programme at a time when decommissioning requirements were not primary concerns.

Equally, the experience being gained with early stage or pilot decommissioning is informing currently proposed designs, and giving rise to more assertive assurances from vendors that designs are mindful of end-of-life costs.

Reliable and relevant information on the actual costs of decommissioning reactors is limited, but growing. Generally the information that is available is subject to a wide range of uncertainties, assumptions, strategies and money values, and relates to a wide range of reactor types and issues. Consequently caution is required in drawing conclusions from the cost estimates, particularly as they might relate to the actual costs of decommissioning future reactors built.

Appendix A contains a summary of recent evidence or published reports as to actual or estimated decommissioning costs. Bayliss and Langley, UKAEA (2003), note that "there is an increasing cost trend over time for reactor decommissioning associated with increasing waste disposal costs."

Whilst acknowledging the lack of direct comparability with potential new reactor designs, there is a tendency in the cost estimates for existing Light Water Reactors (and hence ignoring the UK Magnox and AGR fleets) towards a cost range of £300m - £420m per installed 1,000MW, broadly expressed in 2006 money values.

The distribution of potential outcomes around this estimated central range is unlikely to be even, with the prospect of these costs being lower limited, whilst higher out-turns are more likely.

Issues that complicate direct comparison of cost estimates

Aside from the major differences in costs caused by the inherent design and technology differences between reactor types, a number of other factors also have a bearing on the comparability of cost estimates, and equally on an understanding of future cost projections.

Recognition of these factors is important, as many of the publicly quoted estimates do not provide specific information on assumptions made in these respects. Relevant factors could include any or all of the following:

Money values	in which year's money values are the costs expressed?
Contingencies	to what extent have contingencies been included in the cost estimates, and which risks are they intended to cover?
Scope	what specific steps, activities and costs are included/excluded from scope?
End status	what is the assumed condition of the site at the end of the decommissioning process, de-licensed, green-field, new nuclear use?
Waste	do waste disposal routes exist, and are treatment and

	conditioning costs known? What is the boundary between costs related to waste, and those relating to decommissioning?
Strategy	more rapid decommissioning is likely to be more expensive in NPV terms (requiring more remote handling, in higher dosage environments etc). Conversely, more extended care and maintenance phases may reduce NPV, whilst increasing absolute spend over time
Administration	are costs of relating to the regulatory environment included, such as site services, programme management, security etc?
Discounting	what discount rates have been applied to future cash flows?
Escalation	have current cost estimates been subject to prudent price escalation prior to being discounted?

Decommissioning cost estimates are susceptible to increase over time

Whilst a cost estimate may be made on the basis of the best available information, experience and expectations at the time of commissioning, there remain a number of risks that the cost estimate will be inadequate when compared to the actual out-turn cost estimate at the end of the station's operational life, and indeed the final costs of actually executing the decommissioning work:

(a) Estimating errors arising from:
- vendor optimism
- relevant price index increases being higher than expected (labour, pensions costs, materials etc)
- incomplete or inaccurate assumptions

(b) Regulatory changes
Whilst the decommissioning strategy and cost estimate can be established at the point of commissioning, nuclear stations are subject to continuous monitoring and regulation throughout their life, and there is a very high probability that the NII, HSE or other statutory or legislative changes will add to or amend the basis on which the decommissioning strategy must be executed, with a consequent increase in costs.

(c) Operational behaviours
Reflecting the risk that future operational behaviours, procedures or practices increase the extent or significance of contamination, or give rise to more complex and costly decommissioning requirements

Of these, (a) would usually be accommodated by including contingency within the cost estimate, but also through the escalation of the cost estimate (in today's money values) to reflect anticipated future price index rises, before discounting the up-lifted cost estimate back to today's NPV.

Example, taken from DTI model, for a 1,600MW EPR reactor:

Cost of decommissioning (2006 mv)	£500m	cost if done today
Escalated to end of life in 2046 (2006 mv)	£1,300m	likely cost in 2046, in today's money values, all other things being equal
NPV at start of life (2006 mv)	£65m	liability on balance sheet at start of life

Neither (b) nor (c) can be (or are likely to be) predicted at the point of commissioning, but experience suggests that both will occur through a station's operational life. Whilst (c) is within the control of the owner/operator, and should act as an incentive to avoid practices and behaviours that serve to increase the liability to be borne by the owner, (b) is largely outside the owner's control, and represents a potentially material uncertainty to a proposed NNB.

Decommissioning costs are largely unavoidable once operation starts

Once the core has been irradiated, the costs of decommissioning a nuclear reactor are largely fixed, and are entirely unavoidable. Whilst other issues (such as declining standards in operation or integrity) may cause some increase in aggregate costs, the broad level of decommissioning cost would be expected to remain broadly constant throughout its operation, all other things being equal.

Consequently, the latent liability and exposure for the costs of decommissioning exist fully on the first day of operation, even though, in the normal course of events, the NPV of the future liability will increase over time only slowly, building up to the eventual estimated cost as the effect of discounting unwinds.

REDACTED MATERIAL

Treatment of British Energy plc's decommissioning liabilities

Upon its privatisation in 1996, a number of measures were put in place to seek to provide assurance as to the funding of BE's reactor decommissioning liabilities. However, these were subject to substantial change upon the restructuring of BE in 2004. The positions prior to, and after, restructuring are summarised below.

Prior to restructuring

BE retained all liability for decommissioning, and was expected to be responsible for the total costs of its execution. Decommissioning itself was broken down into 3 Stages, which were to be funded in two different ways:

Stage 1

- the preparatory work in the three years prior to cessation of generation that was required to gain approval to, and facilitate the proposed decommissioning strategy;
- de-fuelling of the reactor itself, expected to take some two years post cessation of generation;
- engineering preparatory work making safe redundant systems and plant, and general facilitation works in anticipation of more substantive decommissioning or safestore; and
- dealing with potentially mobile operational wastes.

1 This stage of work was to be funded out of BE's operational cashflows, and was not subject to any specific requirement for the segregation of funds.

Stage 2

- development of the safestore structures for the reactor and radioactive waste buildings (in the case of Sizewell B being assumed to be approximately 10 years after end of generation);
- Site care and maintenance and security; and
- Decommissioning of other plant and facilities not subject to safestore.

Stage 3

- retrieval and management of stored active wastes on the reactor site; and
- Physical dismantling of safestore, reactor and waste structures, and site clearance to return to alternative use, including de-licensing.

In the case of both Stage 2 and 3 costs, these were subject to a requirement for BE to provide cash funds into a segregated fund, the Nuclear Decommissioning Fund (NDF) held off BE's balance sheet.

The NDF was formed at BE's privatisation, and was owned by The Nuclear Trust, an irrevocable Scottish Trust established by deed on 27 March 1996 between BE, the Secretary of State for Trade & Industry, and five Trustees (3 appointed by the Secretary of State, 2 by BE). The five Trustees were also the directors of the Fund.

The key characteristics of the Fund were:

- Established with a £228m initial endowment, followed by quarterly payments of £4.5m (indexed)

- Invested principally in equities and property (some 85% equity, 15% property at restructuring), but assumed on basis of actuarial advice to deliver a real rate of return of 3.5%
- That contributions would be re-assessed at 5-yearly intervals, based on actuarial and technical input (the 2001 review concluded that there was a need to increase the funding to increase prudence regarding waste)
- The actuarially assessed value of the fund was targeted to be 110% of the discounted value of the liabilities.

It should be noted that the Fund lost some 20% of its market value between 2001 and 2003 primarily as a result of the decline in the equity markets, and BE would have been required to substantially increase its contributions to the Fund (had it not commenced its restructuring) to make up the deficit, as well as increasing its contributions to reflect the assessed under-provision noted above.

After restructuring

A new Fund was established, the Nuclear Liabilities fund (NLF), with a comparable structure to that of the NDF (being a fund owned by an independent Scottish Trust, with the 5 Trustees also being directors of the Fund, and with equivalent appointment rights as for the NDF).

The NLF assumes responsibility for all decommissioning costs from the point of cessation of generation (i.e. vast majority of Stage 1 costs previously not captured by the NDF), but also takes responsibility for other fuel and waste costs (known as the Uncontracted Liabilities).

The NLF is funded as follows:

- Transfer of NDF at its market value
- Receipt of £275m of New BE Bonds;
- Annual funding obligation of £20m, indexed;
- £150,000 per tonne of fuel loaded into Sizewell B, indexed; plus
- a cash sweep of 65% of available free cash.

Further, in the case of the NLF, Government acts as funder of last resort, as BE has no further obligation beyond the specific charges noted above, irrespective of the actual costs, or changing estimate of the costs, of the future decommissioning liability. As a quid pro quo, excess amounts in the NLF can be distributed to Government, under certain conditions.

Because of the assumption of open-ended liability by Government, a number of provisions have been applied to seek to incentivise BE to minimise likely costs, whereby the NLF will not be responsible for incremental liabilities arising from

BE’s failure to meet a Reasonable and Prudent Operator test, or in the event of its breach of NIA 1965 licence obligations.

REDACTED MATERIAL