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# Comparison among different decommissioning funds methodologies for nuclear installations

**Final Report**

## Country Report United Kingdom

on behalf of the European Commission  
Directorate-General Energy and Transport, H2

Service Contract TREN/05/NUCL/S07.55436

Wuppertal, 2007

**Editor:**

Wuppertal Institut für Klima, Umwelt, Energie GmbH  
im Wissenschaftszentrum Nordrhein-Westfalen



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**Final Country Report (WP 1/WP 3)**

**United Kingdom**

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Greenwich, 31 October 2006

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## Summary

The UK's decommissioning plans are advanced and probably better documented than elsewhere in Europe, mainly because UK was a pioneer in nuclear power and already has many retired nuclear facilities that need to be decommissioned. The UK government's Nuclear Decommissioning Authority (NDA) was set up in 2005 to take over the sites previously owned by BNFL and the UKAEA and is expected to manage the decommissioning of British Energy's sites.

The total cost of decommissioning Britain's civil nuclear facilities is currently estimated to be in excess of £75bn, although it is widely expected that this figure will rise. The cost estimates are dominated by two sites, Dounreay and Sellafield, which account for about 75 per cent of the total liability. These sites have two things in common: large amounts of plutonium were handled there and they were both sites of accidents that led to the release of radioactive material.

British governments have continued to avow the 'polluter pays' principle as a basis of their environmental policy, which implies that funds to decommission facilities should be provided by consumers of the output of these plants. Despite this, funding has been mismanaged and as a result, after more than 25 years of contributions, there is only about £800m in identified funds to pay for a liability of more than £75bn.

A segregated fund (NDF) for British Energy's power plants was set up when British Energy was created in 1996. However, the scope of the fund was inadequate - it did not cover stage 1 – and British Energy collapsed in 2002. This illustrates that even a segregated fund, which relies on contributions from consumers over the expected life of the plant, is not a guarantee that adequate funds will be available when needed.

British Energy was rescued at huge expense to British taxpayers. The NDF has been renamed the NLF and expanded to cover payments for some fuel waste management costs. British Energy will make contributions to the fund, but these are related to their ability to pay, not to the scale of the liability. The contributions are also heavily dependent on the profitability of British Energy. Should the company again find itself in financial difficulties, an eventuality that is by no means unlikely, the fund could again be at risk of falling far short of the required amount. Expanding the fund to include some spent fuel disposal costs might seem a good way to ensure these costs are covered. However, in practical terms, the effect of this change might be simply to allow the Treasury to access it earlier than it would have otherwise been able to postponing the time when taxpayer funds were needed. As the NDF only covered stages 2 and 3, most of the funds would not have been accessible for 70 years or more.

By international standards, UK timescales for decommissioning are long: completion of final clearance for nuclear power plants is not expected until up to 130 years after plant closure. NDA has an objective to reduce this to 25 years, which will tend to increase undiscounted costs and massively increase discounted costs. While the NDA has a supervisory role over plans to decommission British Energy's plants, it is not clear whether it is able to require British Energy to reduce the timescales for its plants, which on current plans assume site clearance is not complete until nearly 100 years after plant closure.

The Nuclear Decommissioning Authority might be a useful (not perfect) model for other countries for managing decommissioning once the facilities have closed. It creates an agency that was not party to the creation of the liabilities and is not a commercial concern. It therefore has no prior interest in minimising cost estimates or lengthening time-scales in order to reduce the present value of its liabilities or to bolster its technical reputation. The NDA has contributed to transparency by published a vast amount of useful and accessible material on its decommissioning plans and the estimated costs through the 'Lifecycle

Baselines' it publishes for each of its main facilities. The NDA may, in due course, suffer 'capture' by the nuclear industry or it might feel the need to cut costs to demonstrate its management skills but, to date, NDA has improved the transparency of the decommissioning Process significantly.

Ironically, the failure of British Energy and the transfer of most of its decommissioning liabilities to the taxpayer also removed the incentives on British Energy to reduce the decommissioning liabilities for short-term commercial reasons, albeit at the expense of having to abandon the 'polluter pays' principle.

It is difficult to determine to what extent the recent steep increases in decommissioning cost estimates are the result of the removal of the commercial pressures to reduce forecast liabilities and how far the increases are the result of more detailed planning of decommissioning.

While facilities are still in operation, the operator will have much more intimate knowledge of the facility and must play the lead role in planning and estimating the cost of decommissioning. However, British experience does seem to underline the importance subjecting plans and cost estimates to regular independent scrutiny to prevent commercial interests distorting plans.

The British government is now contemplating building up to ten nuclear plants. In October 2006, the British government was still developing its plans on how decommissioning would be provisioned for any new plants. It will be important to ensure that any measures adopted are likely to be more effective than the previous efforts in Britain to make the 'polluter pay' and ensure that those that have to decommission the nuclear plants that current consumers will benefit from are endowed with adequate funds to carry out the task even if, unavoidably, they will have to do the potentially hazardous job. Somewhat surprisingly, in the list of principles that would underlie a decommissioning, the polluter pays principle is not listed.<sup>1</sup>

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<sup>1</sup> The principles the government listed are: There should be an upfront assessment of decommissioning costs; Full responsibility for decommissioning costs to be retained by the private sector operator(s); Protection will be given to the public sector regarding credit risk and reduced reactor life; The framework should be robust and transparent through time; These principles will form the basis of arrangements which will apply consistently to all new build operators and reactor types. <http://www.dti.gov.uk/files/file31890.pdf>

## 1. Introduction and overview

The UK was a pioneer of nuclear power operating power plants from 1955 onwards. As a result of this long history, the UK will also be a pioneer in decommissioning these plants. Already, there are seven commercial nuclear power plants (NPPs) that have been closed and are at various stages of decommissioning and several other experimental, prototype and fuel cycle facilities that are being decommissioned. However, the technologies used – gas-cooled graphite-moderated reactors for all but one of UK's 19 NPPs – mean that the techniques will not be directly transferable to the rest of Europe and the costs might not be typical.

The most costly sites to decommission will be the Sellafield and Dounreay sites. The technologies used at these sites – reprocessing at Sellafield and fast reactors at Dounreay – are not widely used in the rest of Europe, so experience here will also be of limited relevance to the rest of Europe. In addition, accidents at the Windscale part of the Sellafield site in 1957 and Dounreay in 1977 will make the decommissioning task particularly challenging and expensive and mean that on current plans, there is no expectation that these sites can ever be restored to 'greenfield' status (i.e., released for unrestricted use).

Some of the early facilities, such as the first power plants and the first reprocessing plant were dual purpose civil and military facilities and a small part of the funding for decommissioning for these facilities is expected to come partly specifically from the Ministry of Defence. The vast majority of funding will be paid for by future taxpayers through the Treasury at the time the expenditure is incurred via a newly created government agency, the Nuclear Decommissioning Authority (NDA).

### 1.1 Government policy

In 2001-02, the British government undertook a major review of energy policy resulting in a White Paper<sup>2</sup>. The Department for Environment and Rural Affairs (DEFRA) states<sup>3</sup>:

The White Paper makes clear that developing energy efficiency and renewable energy is the Government's priority. The Government is therefore not making specific proposals to support new nuclear build now. It notes that "while nuclear is currently an important source of carbon free electricity, the current economics of nuclear power make it an unattractive option for new generating capacity and there are also important issues for nuclear waste to be resolved". But the possibility that new nuclear build might be needed in the future to meet carbon reduction objectives is not being ruled out.

In 2005, the British government announced a new review of energy policy, widely reported as paving the way for a new government policy leading to new orders for nuclear plants. For example, in a speech in May 2006, Tony Blair was quoted as saying nuclear power is 'back on the agenda with a vengeance'<sup>4</sup>. A consultation paper was published in January 2006<sup>5</sup> and, in July 2006, the government's report on the Energy Review was published. It was announced that a White Paper would be published at the 'end of the year'<sup>6</sup> [2006/07].

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<sup>2</sup> Department of Trade & Industry (2003) 'Energy White Paper: Our energy future – creating a low carbon economy' TSO, Norwich

<sup>3</sup> <http://www.defra.gov.uk/environment/radioactivity/government/uk/energypolicy.htm>

<sup>4</sup> The Independent 'PM says nuclear power is "back on the agenda"', May 17, 2006, p 4.

<sup>5</sup> Department of Trade & Industry (2005) 'Our Energy Challenge: Securing clean affordable energy for the long-term'

<sup>6</sup> <http://www.dti.gov.uk/about/dti-ministerial-team/page31953.html>

The British Government's policy on decommissioning of nuclear facilities is based on the government's White Papers of 1995 and 2004 on radioactive waste management<sup>7</sup> and policy on timing, the role of regulatory bodies and financial provisioning was summarised clearly in the Nuclear Installations Inspectorate's 2001 review of British Energy's decommissioning plans<sup>8</sup>:

1. The White Paper on radioactive waste management policy (Cm 2919, reference 1, paragraph 124) states: "The Government believes that, in general, the process of decommissioning nuclear plants should be undertaken as soon as it is reasonably practicable to do so, taking account of all relevant factors. In future it will ask all nuclear operators to draw up strategies for decommissioning their redundant plant. These will need to include justification of the timetables proposed and demonstration of the adequacy of financial provision being made to implement the strategies."

2. The White Paper concludes that there are a number of potentially feasible and acceptable decommissioning strategies for nuclear power stations and other nuclear facilities available to the operator. To ensure that the operators' decommissioning strategies remain soundly based as circumstances change, the White Paper places a requirement (reference 1, paragraphs 126, 127 and 183) that the Health and Safety Executive (HSE) reviews these strategies quinquennially, in consultation with the environment agencies. The HSE asked HM Nuclear Installations Inspectorate (NII) to undertake the reviews on its behalf. The NII is one of the specialist inspectorates of the HSE.

3. The White Paper records the importance of ensuring that appropriate financial arrangements are in place to cover the costs of decommissioning nuclear facilities. It concluded that segregated funds should be established for those parts of the industry that are privatised. A segregated fund has been established for British Energy plc (BE). The fund is designed to provide finance for BE's long term decommissioning liabilities. However, the fund excludes those liabilities relating to defuelling and post operational clean out of BE's nuclear facilities, as well as BE's liabilities for HLW and ILW stored on other licensees' nuclear sites. These excluded activities are financed from BE's operational funds and provisions.

As described in section 3.1.6, the situation described in paragraph 3 no longer exists. The scope of the fund has been widened to cover dealing with spent fuel from the Sizewell B PWR and it is no longer expected to cover the full cost of stages 2 and 3 of the decommissioning process. The government will now provide the balance of funds needed.

The Committee on Radioactive Waste Management (CoRWM) is an independent committee appointed by the UK Government. Its task was to review the options for managing those UK radioactive wastes for which there is no agreed long-term solution. CoRWM was asked to consult and to make recommendations to the UK Government in July 2006. In July 2006, CoRWM published its final report<sup>9</sup>.

## 1.2 Facilities

The UK's nuclear facilities can be split into three categories (see Table 1 and Table 2): the more modern nuclear power plants - owned by the privatised generation company, British Energy; all other civil nuclear facilities - owned by the government agency, the Nuclear Decommissioning Authority; and the military nuclear facilities - not covered in this report.

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<sup>7</sup> Department of Environment (1995) 'Review of radioactive waste management policy' Cm 2919, HMSO, London and UK Government (2002) 'A better quality of life: a strategy for sustainable development for the UK' (Cm 4345, The Stationery Office, London, ISBN 0-10-143452-9).

<sup>8</sup> Nuclear Installations Inspectorate 'A review by HM Nuclear Installations Inspectorate of the British Energy plc's strategy for decommissioning its nuclear licensed sites.' p 1. Health & Safety Executive, Bootle.

<http://www.hse.gov.uk/nuclear/beqqr.pdf>

<sup>9</sup> CoRWM (2006) 'Managing our radioactive waste safely: CoRWM's recommendations to government' CoRWM, London. <http://www.corwm.org.uk/pdf/FullReport.pdf>

### 1.2.1 British Energy

British Energy was created in 1996 when the more modern nuclear power plants were privatised. These included seven Advanced Gas-cooled Reactor (AGR) stations and one Pressurised Water Reactor (PWR). The AGR stations comprise twin reactors with an output of about 600MW (e) per reactor. These were completed between 1976 and 1989 and are expected, on current plans, to have an operating life of 35 years or more and will thus be closed between 2011 and 2024. These plants were built by the nationally-owned utilities, Central Electricity Generating Board (CEGB, five stations) and the South of Scotland Electricity Board (SSEB, two stations). In 1990, when the UK electricity industry was reorganised and privatised, the nuclear plants were found to be unsaleable and had to be transferred to new publicly owned companies, Nuclear Electric and Scottish Nuclear respectively. The PWR (Sizewell B) was ordered by the CEGB but largely built by Nuclear Electric. It was completed in 1995 and is expected to have a 40 year life and thus be retired in 2035.

This report focuses on the Hinkley Point B nuclear power plant, which is expected to be the first facility to be closed (in the same year as its sister station, Hunterston B), in 2011. However, few details have been published on the specific plan for Hinkley Point B.

### 1.2.2 Nuclear Decommissioning Authority (NDA)

In 2005, ownership of all civil nuclear facilities other than those owned by British Energy were transferred to NDA from British Nuclear Fuels Limited (BNFL, a publicly owned nuclear company then active in almost all aspects of nuclear power) and UKAEA (another publicly owned company that carried out R&D into nuclear power and built a number of prototype and demonstration facilities). The NDA was established under the Energy Act 2004<sup>10</sup>. The setting up of the NDA, which absolved BNFL for responsibility for meeting its liabilities, was investigated under the European Union's state aid regulations and in April 2006, the European Commission published its finding that the setting up of NDA did not contravene State Aid regulations<sup>11</sup>.

The NDA is a management organisation and it contracts out the operation of the facilities that remain in service to companies such as BNFL (the BNG division) and UKAEA. Decommissioning will be managed by NDA and the work will be allocated largely by competitive tender.

The main site owned by NDA, in terms of decommissioning liability, is Sellafield where a wide range of facilities exist and which accounts for about 70 per cent of the NDA's decommissioning liability. Other important sites include the 11 'Magnox' civil nuclear power stations and the Dounreay site where fast breeder technology was developed and demonstrated.

The 11 Magnox stations were the first generation British nuclear power plant design. The first two plants were dual purpose generation and plutonium production facilities and comprised four reactors each of about 50MW (e). They were built by the UKAEA and subsequently transferred to BNFL when it was created. These were completed from 1956-60 and both stations were closed in 2003/04. One of these, the Calder Hall plant is sited alongside the Sellafield site, but its decommissioning plans and budget are separate from that of the rest of the Sellafield site.

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<sup>10</sup> HM Government (2004) 'Energy Act', TSO, London. <http://www.opsi.gov.uk/acts/acts2004/20040020.htm>

<sup>11</sup> European Commission (2006) 'Commission Decision of 4 April 2006 on the State Aid which the United Kingdom is planning to implement for the establishment of the Nuclear Decommissioning Authority' Official Journal of the European Union, L 268/37, 27.9.2006. [http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l\\_268/l\\_26820060927en00370057.pdf](http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_268/l_26820060927en00370057.pdf)

The other nine stations were civil plants built by the former nationally owned generation companies, CEGB (eight stations) and SSEB (one station). In 1990, these were transferred to new publicly owned companies, Nuclear Electric and Scottish Nuclear respectively and, in 1996, the nine civil stations were transferred again to a new publicly owned company Magnox Electric, which, in turn, became a division of BNFL in 1998.

The nine civil Magnox stations were completed between 1962 and 1971 and they each comprise twin reactors with an output of 125-600MW (e) per reactor. Five of these stations have already been retired and the remaining four are expected to be closed by 2010. The other sites inherited by the NDA from BNFL were:

- **Capenhurst.** This was the site of a uranium enrichment plant, that operated from 1953-82. Decommissioning is expected to be completed in 2006, although uranium materials are expected to be stored there until 2120;
- **Drigg Low Level Waste Repository.** This is the UK's low level waste repository, sited adjacent to the Sellafield site, that opened in 1959 and continues in operation following major upgrades in 1995;
- **Sellafield.** Operations at Sellafield include treatment of fuels removed from nuclear power stations; Mixed Oxide (MOX) fuel fabrication; and storage of nuclear materials and radioactive wastes. The site was opened in 1947 and will continue in operation indefinitely;
- **Springfields.** Springfields manufactures nuclear fuel products for the UK's nuclear power stations and for international customers. Fuel manufacture began in 1946 and is scheduled to continue until at least 2023.

The sites inherited by the NDA from the UKAEA were:

- **Culham JET.** This is the site of fusion research and houses the Joint European Torus (JET). The site has been open since 1960 and operations are expected to close in 2007;
- **Dounreay.** This is the site of development in the UK of fast reactor technology and has housed two reactors (a prototype and a demonstration unit) and fuel cycle facilities including a reprocessing plant. The site opened in the early 1950s, the demonstration reactor was closed in 1994 and the reprocessing plant was closed in 1996.
- **Harwell.** Harwell was the first centre of nuclear research, being established in 1946. The site accommodated five research reactors of various types. Harwell also had a number of other nuclear research facilities, together with plutonium handling facilities, radioactive laboratories, nuclear waste treatment and storage facilities. The site closed in 1990.
- **Windscale.** The Windscale site is a separately licensed site within the Sellafield complex that housed three reactors. Two graphite pile reactors (opened in 1950) were closed in 1957 after a serious accident at one of them and a prototype AGR operated from 1963-81.
- **Winfrith.** Winfrith was established as a UKAEA research site in 1958 and housed eight research reactors. Winfrith also had a number of other facilities including fuel manufacture and examination, plutonium laboratories, nuclear waste treatment and storage and radioactive laboratories. The last reactor closed in 1995.

This report focuses on one Magnox plant closed several years ago, Berkeley closed in 1989 and which is near completion of stage 2 decommissioning and the Dungeness A Magnox plant expected to be closed in 2006. Amongst the other sites, this report focuses on the huge Sellafield site, which includes a range of facilities, some still in service, some retired, and the Dounreay site which housed prototype and demonstration fast reactors and some fuel cycle facilities, but which ceased operations in 1996.

## 2 Decommissioning strategies and cost

### 2.1 Current & past decommissioning activities

#### 2.1.1 Decommissioning activities at NDA facilities

There are four phases in the NDA's decommissioning plans: defuelling (conventionally stage 1); care and maintenance preparations (stage 2); care and maintenance; and final site clearance (stage 3). In 2006, of the 11 Magnox plants, four are in operation, three are being defuelled and five are being prepared for care and maintenance (the Calder Hall plant is being defuelled at the same time as care and maintenance preparations are being done).

For the Dungeness A Magnox station, defuelling is expected to account for 7 per cent of the total undiscounted cost, care and maintenance preparations for 35 per cent, care and maintenance for 11 per cent and final site clearance for 46 per cent. For the non-reactor sites, the decommissioning operations are broken down by different categories according to the type of facility and the decommissioning needs.

The NDA provides a 'Life Cycle BaseLine' (LCBL) for each site, covering a description of the decommissioning plans, including cost and timing. No estimates are shown of the cost of work carried out to date. The LCBL divides decommissioning activities into seven categories, which can be required in any of the four time phases. The seven categories are:

- Transition. Transition work scope provides for the restructuring of the site workforce to fit the changing site mission. For the Dungeness A plant, this accounts for about 4 per cent of the total decommissioning cost;
- New construction projects. This category describes new construction necessary throughout the lifecycle. The decommissioning of a nuclear site requires a significant amount of new construction in order to facilitate the deplanting, decontamination and demolition of the facilities. However for planning and costing purposes this category only includes work during Final Site Clearance (FSC). For the Dungeness A plant, this accounts for about 17 per cent of the total decommissioning cost and includes installing reactor dismantling equipment and waste management facilities;
- Decommissioning and termination. The work contained in the Decommissioning & Termination category includes all activities undertaken on a site to decommission facilities starting from the end of defuelling, through to the agreed or assumed end state for the facilities and the site. Also included are contaminated land studies and any resultant remediation and post-decommissioning activities. For the Dungeness A plant, this accounts for about 18 per cent of the total decommissioning cost;
- Waste and nuclear materials management. This category deals with the management of different types of waste on site throughout the lifecycle. This complies with statutory requirements and the Government's policy on waste. For the Dungeness A plant, this accounts for about 22 per cent of the total decommissioning cost;
- Site support. This category includes activities that directly support projects and operations on a site as a whole but are not dedicated to a single Operating Unit or project. For the Dungeness A plant, this accounts for about 27 per cent of the total decommissioning cost and includes expenditure on site services and operations and project support;

**Table 1 Civil nuclear power plant in the UK**

<b>Nuclear power plant</b>	<b>Output (MW(e))</b>	<b>Operational period</b>	<b>Site owner</b>	<b>Site licensee</b>	<b>Decomm started</b>	<b>Expected completion</b>	<b>Decomm stage</b>
<b>Berkeley</b>	2 x 138	1962-89	NDA	Magnox Electric	1989	2083	1+
<b>Bradwell</b>	2 x 123	1962-2002	NDA	Magnox Electric	2002	2104	1-
<b>Calder Hall</b>	4 x 50	1956-2003	NDA	Magnox Electric	2003	2117	1-
<b>Chapelcross</b>	4 x 50	1959-2004	NDA	Magnox Electric	2004	2128	1-
<b>Dungeness A</b>	2 x 275	1965-2006	NDA	Magnox Electric	2007*	2111	
<b>Hinkley Point A</b>	2 x 250	1965-2000	NDA	Magnox Electric	2000	2104	1+
<b>Hunterston A</b>	2 x 169	1964-1989	NDA	Magnox Electric	1989	2090	1+
<b>Oldbury</b>	2 x 300	1967-2008	NDA	Magnox Electric	2009*	2118	
<b>Sizewell A</b>	2 x 290	1966-2006	NDA	Magnox Electric	2007*	2110	
<b>Trawsfynydd</b>	2 x 250	1965-1991	NDA	Magnox Electric	1993	2098	1+
<b>Wylfa</b>	2 x 590	1971-2010	NDA	Magnox Electric	2010*	2125	
<b>Dungeness B</b>	2 x 607	1983-2018	British Energy	British Energy			
<b>Hartlepool</b>	2 x 625	1984-2014	British Energy	British Energy			
<b>Heysham 1</b>	2 x 611	1983-2014	British Energy	British Energy			
<b>Heysham 2</b>	2 x 615	1988-2023	British Energy	British Energy			
<b>Hinkley Point B</b>	2 x 625	1976-2011	British Energy	British Energy			
<b>Hunterston B</b>	2 x 624	1976-2011	British Energy	British Energy			
<b>Sizewell B</b>	1188	1995-2035	British Energy	British Energy			
<b>Torness</b>	2 x 645	1988-2023	British Energy	British Energy			
<b>Retired NPPs</b>	<b>2260</b>	<b>1956-2004</b>					
<b>Operational NPPs</b>	<b>12307</b>	<b>1965-</b>					

Source: Various plus author's research

Notes.

1. All sites except those owned by British Energy are owned by the Nuclear Decommissioning Authority.
2. The break-up of British Nuclear Fuels means the licensee for a number of facilities is changing: The civil nuclear power plants are licensed to Magnox Electric, a division of British Nuclear Group, which is, in October 2006, owned by British Nuclear Fuels, but which is expected to be privatised.
3. Dates marked "\*" are forecast start dates.

**Table 2 Other civil nuclear facilities in the UK**

Facility	Type of facility	Operating period	Site owner	Site licensee	Decomm started	Expected completion
<b>Capenhurst</b>	Enrichment plant	1953-1982	NDA	BNG	1982	2006
<b>Dounreay</b>	Prototype NPP + others	1975-1994	NDA	UKAEA	1994	2036
<b>Harwell</b>	5 research reactors	1946-1990	NDA	UKAEA	1990	2025
<b>Sellafield</b>	Various facilities	1947-?	NDA	BNG	-	-
<b>Springfields</b>	Fuel manufacture	1946-2023	NDA	Springfields Fuels	-	-
<b>Winfrith</b>	8 research reactors	1958-1985	NDA	UKAEA	1995	2020
<b>Windscale</b>	3 reactors	1950-1982	NDA	UKAEA	Mid 1980s	2015
<b>Culham JET</b>	Fusion facility	1960-2007	NDA	n/a	-	2022
<b>Drigg</b>	LLW repository	1959-2050	NDA	BNG	-	-

Source: Various plus author's research

Notes.

1. Capenhurst, Drigg and Sellafield are licensed to the BNG; Springfields is licensed to Springfields Fuels, a division of Westinghouse. A bid for Westinghouse led by Toshiba was accepted in February 2006.
2. Nuclear materials are expected to be stored at the Capenhurst site until 2120 so the site will not be released for unrestricted use on completion of decommissioning.
3. The Dounreay, Sellafield and Windscale sites will only be decommissioned to 'brown field' status and then will be placed in passive safety condition

- Support services. The activities covered in this category include provision of support to the decommissioning programme and management throughout the lifecycle. This support will fluctuate in response to the amount of decommissioning work taking place on site, and the differing needs of the three phases. For the Dungeness A plant, this accounts for about 10 per cent of the total decommissioning cost. It includes functional support and corporate support: The main areas of work covered within functional support are: finance & commercial; NDA contract management; human resources & training; environment, health, safety & quality; site management team;
- Stakeholder support. This covers expenditure to ensure the continued support of stakeholders for the decommissioning strategy. For the Dungeness A plant, this accounts for about 2 per cent of the total decommissioning cost and includes communications with Members of Parliament, County and Community Councils, Community Groups, Local Businesses, Emergency Services, Schools & Colleges, Green Groups, Media and the General Public.

### 2.1.2 Decommissioning activities at BE facilities

All British Energy's facilities are still in service. It has not published any recent detailed plans on how it expects to carry out the decommissioning of its facilities. Its most recent publicly available plans were published in September 2000 and a review of these plans by the British government's Nuclear Installations Inspectorate was published in June 2001<sup>12</sup>.

<sup>12</sup> Nuclear Installations Inspectorate 'A review by HM Nuclear Installations Inspectorate of the British Energy plc's strategy for decommissioning its nuclear licensed sites.' Health & Safety Executive, Bootle. <http://www.hse.gov.uk/nuclear/beqqr.pdf>

## 2.2 Future decommissioning strategies

### 2.2.1 NDA strategies

#### **NDA NPP sites**

The NDA is currently reviewing the UK's decommissioning strategy and, in particular, it is hoping to dramatically accelerate the time-scale for Magnox decommissioning, from more than 100 years to 25 years. It has not yet been determined whether this is a viable plan and what the cost implications would be.

On 2006 cost estimates, the total liability for the sites for which NDA is responsible is £61.2bn including remaining operating costs. Discounted, this reduces to £35.4bn (see Table 3). The undiscounted total is dominated by the cost of clean-up of the Sellafield site (including Drigg, Windscale and Calder Hall, which are either within or adjacent to the Sellafield site) with about 70 per cent of the expected cost. Dounreay is also an important cost element with about 5 per cent of the cost. Despite this huge expenditure, both sites will only be decommissioned to care and maintenance condition not green-field site. These two sites also account for 45 per cent of current decommissioning expenditure. The total NDA Liability will inevitably be significantly changed, especially if the plan to reduce the time-scale for decommissioning the Magnox plants is implemented.

Table 4 shows the remaining costs by decommissioning stage. No estimate has been published of the cost of the work carried out to date, so there is no information on the cost of completed stages. The costs shown for partly completed stages are not useful for analytical purposes because of the lack of data on costs to date. The range of costs is wide (see Table 4). For the four plants that are still in service, the total cost of decommissioning the most expensive plant (Oldbury) is 35 per cent more than the cheapest (Sizewell A) and there does not seem a strong relationship with size. Some of the most expensive sites, such as Chapelcross and Trawsfynydd are forecast to cost much more than the average. For the defuelling stage (stage 1), the Wylfa is expected to cost nearly double the cost for Wylfa, but since the electrical output of Wylfa is double that of Sizewell A, this is not surprising. Care & maintenance preparations (stage 2), the variability is again wide with Oldbury expected to cost nearly double what Sizewell A is forecast to cost and again there appears little correlation with unit size.

**Table 3** Estimated decommissioning costs by site

Site	Expected cost (£m)	Remaining operation cost	Discounted cost (£m)	Decomm budget for 2005/06 (£m)	Closure date	Planned completion
<b>Berkeley</b>	773.7	-	327.7	39.1	1989	2083
<b>Bradwell</b>	1086.6	20.9	544.7	64.7	2002	2103
<b>Calder Hall</b>	1073.9	-	341.8	22.5	2003	2117
<b>Chapelcross</b>	1332.1	-	535.0	67.3	2004	2128
<b>Dungeness A</b>	1001.4	156.4	584.1	5.7	2006*	2111
<b>Hinkley Point A</b>	1213.7	-	545.6	55.3	2000	2104
<b>Hunterston A</b>	1071.7	-	522.7	56.1	1989	2090
<b>Oldbury</b>	1076.6	283.3	743.6	0.4	2008*	2118
<b>Sizewell A</b>	870.6	131.1	475.4	0.4	2006*	2110
<b>Trawsfynydd</b>	1116.1	-	431.4	45.1	1993	2096
<b>Wylfa</b>	1006.5.7	606.1	862.6	0.6	2010*	2125
<b>Capenhurst</b>	562.9	-	309.7	25.4	1982	2120
<b>Dounreay</b>	2949.5	-	2228.6	149.7	1996	2036
<b>Harwell</b>	956.7	-	788.0	60.7	1990	2025
<b>Sellafield</b>	29534.9	10422.6	21929.6	290.5	-*	2150
<b>Springfields</b>	445.4	2375.1	2429.8	3.9	-*	2023
<b>Winfrith</b>	477.5	-	412.3	37.5	1995	2020
<b>Windscale</b>	693.9	-	432.0	25.6	1980s	2015
<b>Culham JET</b>	198.5	-	165.2	-	2007*	2022
<b>Drigg</b>	1053.6	-	545.9	17.4	-*	2150
<b>TOTAL</b>	48495.7	12786.3	35361.7	967.9		

Sources: NDA (2006) 'Strategy' Nuclear Decommissioning Authority, Cumbria.  
[http://www.nda.gov.uk/documents/nda\\_final\\_strategy\\_published\\_7\\_april\\_2006.pdf](http://www.nda.gov.uk/documents/nda_final_strategy_published_7_april_2006.pdf)

## Notes

1. Costs shown under are remaining costs and include 'total operations cost'.
2. Closure dates marked \* are expected closure dates.
3. Costs are discounted at 2.2 per cent per annum.

The cost of care and maintenance also varies widely and the cost does not seem to correlate, as might have been expected, with the time expected to be spent in care and maintenance. For final site clearance, the cost of the most expensive plant (Calder Hall) is forecast to be 60 per cent more than the cheapest plant (Sizewell A) and again there appears to be little correlation with unit size.

**Table 4 Estimated decommissioning costs (£m) and timescales of reactor sites by stage**

Site	Forecast cost	Defuelling	Care & maintenance preparations	Care & maintenance (cost per year)	Final site clearance
Berkeley	773.7†	* / 1989-92	172.9† / 1992-2009	131.9 (2.0) / 2009-74	468.9 / 2074-83
Bradwell	1086.6†	139.9† / 2002-06	353.7 / 2006-2017	116.3 (1.5) / 2017-95	476.7 / 2095-2104
Calder Hall	1073.9†	50.8† / 2003-08	205.6† / 2004-2019	114.6 (1.3) / 2020-2105	702.8 / 2105-17
Chapelcross	1332.1†	179.7† / 2004-09	300.6 / 2009-2021	176.2 (1.9) / 2021-2116	675.6 / 2116-28
Dungeness A	1042.9	74.6 / 2007-09	364.8 / 2009-2021	116.1 (1.4) / 2021-2102	487.4 / 2102-11
Hinkley Pt A	1213.7†	* / 2000-04	435.3† / 2004/2015	147.1 (1.8) / 2015-95	631.3 / 2095-2104
Hunterston A	1071.7†	* / 1990-95	417.1† / 1995-2016	107.9 (1.7) / 2017-81	546.6 / 2081-90
Oldbury	1167.5	125.2 / 2009-10	402.5 / 2011-2020	175.2 (2.0) / 2020-2109	464.6 / 2109-18
Sizewell A	860.8	74.4 / 2007-09	211.1 / 2009-2018	145.0 (1.7) / 2018-2102	430.3 / 2102-10
Trawsfynydd	1116.1†	* / 1993-95	264.2† / 1995-2012	180.1 (2.4) / 2012-88	671.7 / 2088-98
Wylfa	1127.2	143.9 / 2010-12	308.7 / 2012-2025	99.2 (1.1) / 2025-2116	575.4 / 2116-25
Mean	1049.6	104.5	306.7	137.2 (1.7)	557.4

Source: LCBLs for the individual sites

[http://www.nda.gov.uk/Our\\_Business--Life\\_Cycle\\_Baseline\\_\(708\).aspx?pg=708](http://www.nda.gov.uk/Our_Business--Life_Cycle_Baseline_(708).aspx?pg=708)

#### Notes

1. Cells marked '\*\*' are for phases that are completed, costs marked '†' are for remaining costs for phases that are underway.
2. For Calder Hall, the second phase is described as 'interim decommissioning'.
3. The mean values for each are calculated only for sites where the stage has not commenced.

Examining the time expected to be taken for each stage (Table 5), variability is somewhat less with only one plant expected to take less than 100 years to be decommissioned and the maximum time-scale being 124 years. For the plants still in service, defuelling, and care and maintenance preparations are generally expected to be completed significantly quicker than for plants where the work has been completed or started.

**Table 5 Time taken to carry out decommissioning phases in years (range)**

	Total	Defuelling	Care & maintenance preparations	Care & maintenance	Final site clearance
<b>Completed phases</b>	-	4 (2-5)	-	-	-
<b>Part completed phases</b>	106 (94-124)	5 (4-5)	16 (11-21)	-	-
<b>Phases not started</b>	108(103-115)	2 (1-2)	11 (9-13)	81 (64-95)	10 (8-12)
<b>Average</b>	<b>107 (94-124)</b>	<b>3 (1-5)</b>	<b>13 (9-21)</b>	<b>81 (64-95)</b>	<b>10 (8-12)</b>

Source: LCBLs for the individual sites

[http://www.nda.gov.uk/Our\\_Business--Life\\_Cycle\\_Baseline\\_\(708\).aspx?pg=708](http://www.nda.gov.uk/Our_Business--Life_Cycle_Baseline_(708).aspx?pg=708)

The costs and time for final site clearance at the Calder Hall and Chapelcross sites is higher than for the other sites, perhaps reflecting that these are old sites, with four reactors compared to two at the other sites. The power density of the plants is low and thus a large amount of waste will be generated relative to the electrical output of the stations.

## Berkeley NPP

The Berkeley Magnox power station was the first of the purely civil nuclear plants to go into service in Britain and it was also the first to be retired. It is the most advanced in terms of its decommissioning of the retired British plants. In addition to the power station, the site also houses laboratory and head office facilities.

It was completed in 1962 and retired in 1989. Stage 1 of decommissioning has already been completed and it is expected that stage 2 will be completed in 2009. The British Nuclear Group (BNG) then expects the plant to enter a 'care and maintenance' phase of about 65 years. Current BNG plans expect stage 3, clearance of the two reactor buildings, to commence in 2074 and for the site to be de-licensed by 2083<sup>13</sup>.

No estimate of the cost of the work carried out so far has been published, but it is estimated that the remaining work will cost £774m in undiscounted, current terms (see Table 6). This sum is reduced by nearly 60 per cent by discounting to only £328m (at the rate used by NDA of 2.2 per cent), with more than three quarters of the remaining expenditure taking place more than ten years forward. Expenditure falls steeply after year five, when the plant goes into the care and maintenance phase. Overall, the largest cost is 'decommissioning and termination', accounting for 30 per cent of the remaining cost, with more than half of this occurring in the next five years. The next largest cost is 'waste and nuclear materials treatment' accounting for about 27 per cent of total cost, but nearly all this expenditure is incurred more than 10 years in the future, reflecting the fact that waste disposal is mainly carried out in stage III, which on these plans is not expected to start until 2074. 'Site support' and 'new build projects' each account for about 17 per cent of the remaining expenditure and these take place mainly during stage III.

**Table 6 Estimate of remaining cost to decommission Berkeley (£k)**

	Years 1-5 (%)	Years 6-10 (%)	Years 11+ (%)	Total (%)
<b>Transition</b>	8916 (5)	246 (2)	336 (0)	9497 (1)
<b>New build projects</b>	0	0	128235 (22)	128235 (17)
<b>Decommissioning &amp; termination</b>	121012 (69)	4435 (34)	102834 (18)	228281 (30)
<b>Waste &amp; nuclear materials management</b>	1507 (1)	550 (4)	207080 (35)	209138 (27)
<b>Site support</b>	26656 (15)	4506 (34)	99027 (17)	130188 (17)
<b>Support services</b>	14455 (8)	3178 (24)	40052 (7)	57685 (7)
<b>Stakeholder support</b>	2352 (1)	260 (2)	8060 (1)	10673 (1)
<b>Total</b>	<b>174898 (22)</b>	<b>13176 (2)</b>	<b>585624 (76)</b>	<b>773697 (100)</b>

Source: British Nuclear Group (2005) 'Lifecycle Baseline: Berkeley' BNG, Berkeley.

[http://www.nda.gov.uk/documents/berkeley\\_site\\_summary\\_2005-6.pdf](http://www.nda.gov.uk/documents/berkeley_site_summary_2005-6.pdf)

Note: The breakdown of spend is only available by the time periods shown.

In 2006, the NDA set itself the objective of accelerating the time-scale of decommissioning reactors so that site clearance could be completed within 25 years of plant closure. This would have a major impact on the discounted cost of decommissioning and would have a significant impact on public spending.

<sup>13</sup> For more details of the Berkeley site, see [http://www.nda.gov.uk/About\\_the\\_NDA--Locations--Berkeley\\_Power\\_Station\\_and\\_Laboratories\\_\(921\).aspx?pg=921](http://www.nda.gov.uk/About_the_NDA--Locations--Berkeley_Power_Station_and_Laboratories_(921).aspx?pg=921)

## Dungeness A NPP

The Dungeness A power station was opened in 1965 and is expected to be closed in 2006. The figures shown in Table 7 exclude some costs that will be incurred over the remaining operating life of the plant. BNG's plan is to complete defuelling (Stage I) by 2009 and for the care and maintenance period (end of stage II) to start in 2021. Decommissioning would be completed in 2111. Dungeness A has a much higher electrical output than Berkeley, but because there is no published value of the cost of operations already carried out at Berkeley, it is difficult to compare the two costs. The time-scale is a little longer than for Berkeley, 105 years compared to 94 years.

**Table 7 Estimate of remaining cost to decommission Dungeness A (£k)**

	Years 1-5 (%)	Years 6-10 (%)	Years 11+ (%)	Total (%)
<b>Transition</b>	28342 (20)	7848 (4)	11703 (2)	47893 (4)
<b>New build projects</b>	7352 (5)	47716 (27)	126295 (17)	181363 (17)
<b>Decommissioning &amp; termination</b>	3952 (3)	39243 (22)	152696 (21)	195891 (18)
<b>Waste &amp; nuclear materials management</b>	7403 (5)	4248 (2)	220544 (30)	232195 (22)
<b>Site support</b>	67665 (47)	59642 (33)	154148 (21)	287275 (27)
<b>Support services</b>	24546 (17)	17464 (10)	62877 (9)	104887 (10)
<b>Stakeholder support</b>	3894 (3)	3338 (2)	11126 (2)	18358 (2)
<b>Total</b>	<b>143154 (13)</b>	<b>179499 (17)</b>	<b>739389 (69)</b>	<b>1067862 (100)</b>

Source: British Nuclear Group (2005) 'Lifecycle Baseline: Dungeness A' BNG, Berkeley.  
[http://www.nda.gov.uk/documents/dungeness\\_a\\_site\\_summary\\_2005-6.pdf](http://www.nda.gov.uk/documents/dungeness_a_site_summary_2005-6.pdf)

Note: The breakdown of spend is only available by the time periods shown.

The total estimated decommissioning cost is £1068m, which, with discounting (at NDA's rate of 2.2 per cent), reduces to about £500m, with about 70 per cent of the work taking place more than ten years into the future. Overall, the costs are spread mainly between 'site support' (27 per cent), 'waste and nuclear materials management' (22 per cent), 'decommissioning and termination' (18 per cent) and 'new build projects' (17 per cent).

Expenditure varies between £30m and £60m per year during the first 10 years and drops after year 16, when the care and maintenance phase starts. It then rises sharply in 2102 when the final phase starts. In the first five years, the dominant cost is 'site support and support services' accounting for about two thirds of total expenditure. After year five, the preparations for care and maintenance become more important and 'new build' and 'decommissioning and termination' become more important accounting for about half the expenditure. After year ten, 'waste and nuclear materials management' becomes the largest cost, accounting for about 30 per cent of expenditure.

In 2006, the NDA set itself the objective of accelerating the decommissioning of reactors so that site clearance could be completed within 25 years of plant closure. This would have a major impact on the discounted cost of decommissioning and would have a significant impact on public spending.

## Other NDA sites

The wide range of activities carried out at the other NDA sites means it is not possible to carry out any meaningful comparative analysis (see Table 8).

## Dounreay

The Dounreay site accommodated three main facilities: the Dounreay Fast Reactor (DFR), a 14MW plant that operated from 1959-77; the Prototype Fast Reactor (PFR), a 250MW plant that operated from 1974-94; and a reprocessing plant for fast reactor fuel that closed in 1996. A complication with the site is that solid intermediate waste and some fuel was dumped in a vertical unlined water filled shaft. It was estimated that 147 kg of highly enriched uranium and 2.2 kg of plutonium, and more than a hundred pieces of fuel elements were dumped in the shaft. Boronated glass had to be dumped in the shaft in 1968 to prevent a criticality and in 1977, a hydrogen explosion blew the shaft open spreading radioactive waste over the surrounding environment.

**Table 8 Forecast decommissioning costs & timescales for non-reactor sites (£m)**

Site	Cost	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Capenhurst	711.2	77.0/1982-2010	36.8/2010-15	236.9/2015-31	360.5/2031-2120	-/2120-*
Dounreay	2949.5	2207.6/2005-25	524.3/2026-36	17.6/2036-47	200.0/2047-66	-/2066-2336*
Harwell	915.6	345.6/2005-12	428.2/2012-20	141.8/2020-25		
Sellafield	39985	3285/2005-32	13633/2005-16	2382/2005-24	6631/2005-40	14054/2040-2120*
Springfields	1586.3	459.1/2005-09	580.9/2009-16	353.6/2016-23	131.3/2023-28	61.4/2028-31
Culham	190.1	11.4/2005-08	63.2/2009-11	100.3/2011-18	9.1/2018-19	6.1/2019-20
Drigg	1053.6	11.7/2005-06	29.2/2006-34	309.2/2005-50	172.2/2005-50	531.7/2050-67*
Winfrith	477.5	25.1/2005-08	353.6/2005-17	15.5/2012-18	55.2/2015-18	28.2/2018-20
Windscale	693.9	278.9/2005-15	53.6/2016-25	58.9/2026-40	302.6/2041-65*	

### Notes

1. The discrepancy between the total figures and those in Table 3 is because these figures include costs from remaining operation.
2. Sites marked '\*\*' are not expected to be de-licensed at the end of the process
3. The phases are the individual sites are:
  - Capenhurst. Phase 1: diffusion plant decommissioning. Phase 2: Quiescent storage. Phase 3: Uranium deconversion. Phase 4: Quiescent storage 2. Phase 5: Site end state post 2120. No cost is given for phase 5.
  - Dounreay. Phase 1: Hazard reduction and ILW management. Phase 2: Decommissioning and remediation. Phase 3: Interim storage. Phase 4: Off-site transfer and final demolition. Phase 5: Care surveillance and site closure 2066 to 2336. No cost is given for phase 5.
  - Harwell. Phase 1: Waste operations. Phase 2: Decommissioning and land remediation. Phase 3: Site closure.
  - Sellafield. Phase 1: Passivation clean-up. Phase 2: Passivation commercial. Phase 3: Consolidation. Phase 4: Quiescent. Phase 5: Restoration.
  - Springfields. Phase 1: Magnox, oxide & hex production. Phase 2: Oxide and hex production. Phase 3: Oxide only. Phase 4: Oxide decommissioning. Phase 5: End of site.
  - Culham. Phase 1: Decommissioning preparation. Phase 2: tritium removal. Phase 3: Waste operations. Phase 4: Site clearance. Phase 5: Site closure.
  - Drigg. Phase 1: Plutonium contaminated materials retrieval. Phase 2: Remediation activities. Phase 3: LLW operations. Phase 4: Future LLW disposals. Phase 5: Site closure.
  - Winfrith. Phase 1: Hazard reduction. Phase 2: Decommission redundant facilities. Phase 3: Decommission operational facilities. Phase 4: Decommission off-site facilities. Phase 5: Site close-out and delicensing.
  - Windscale. Phase 1: High hazard reduction. Phase 2: Commercial operations and decommissioning. Phase 3: Care & maintenance & interim store. Phase 4: Final decommissioning and site restoration

The decommissioning estimates were reduced between 2004 and 2005 by about £1bn partly through a large reduction in 'support costs' and the time-scale shortened so

decommissioning will be completed in 2036 not 2063 previously forecast (see Table 5). The 2036 date is described as an 'interim end-point'. From 2036-2047 conditioned ILW and packaged nuclear material will be in storage at the site. This will continue until the conditioned ILW and packaged nuclear material can be transferred off-site. From 2047-2066, the conditioned ILW and packaged nuclear waste will be transferred to another UK location. All other infrastructure will also be decommissioned apart from that which will support the final phase of Care, Surveillance and Site Closure from 2066. The Care, Surveillance and Site Closure phase is assumed to last at least a further 300 years.

The UKAEA's estimated costs only cover operations up to 2036 with a total expenditure of £2949m (see Table 9). Discounting (using the NDA's rate of 2.2 per cent) reduces this to about £2150m, reflecting the fact that the estimate only covers costs up to 2036.

The main cost, accounting for a third of expenditure is 'decommissioning and termination', with 'new build projects', 'waste and materials management' and 'site support' each accounting for about 20 per cent. Annual expenditure over the first ten years varies between £115-150m. After year ten, 'new build projects', 'site support' and 'support services' become less important and 'decommission and termination' (39 per cent) and 'waste and nuclear materials management' dominate accounting for two thirds of spend.

**Table 9 Estimate of remaining cost to decommission Dounreay (£k)**

	Years 1-5 (%)	Years 6-10 (%)	Years 11+ (%)	Total (%)
<b>New build projects</b>	163658 (25)	183076 (31)	211814 (12)	558559 (19)
<b>Decommissioning &amp; termination</b>	136810 (21)	156210 (26)	668979 (39)	962000 (33)
<b>Waste &amp; nuclear materials management</b>	95609 (14)	73460 (12)	411317 (24)	580387 (20)
<b>Site support</b>	150571 (23)	115212 (19)	239450 (14)	505233 (17)
<b>Support services</b>	100304 (15)	50468 (9)	120033 (7)	270804 (9)
<b>Stakeholder support</b>	15070 (2)	12684 (2)	44734 (3)	72488 (2)
<b>Total</b>	<b>662022 (22)</b>	<b>591123 (20)</b>	<b>1696327 (58)</b>	<b>2949471</b>

Source: UKAEA (2005) 'Lifecycle Baseline: Dounreay' UKAEA.  
[http://www.nda.gov.uk/documents/dounreay\\_site\\_summary\\_2005-6.pdf](http://www.nda.gov.uk/documents/dounreay_site_summary_2005-6.pdf)

Note.

1. The breakdown of spend is only available by the time periods shown.
2. UKAEA estimates contain no costs categorised as 'transition'.

## Sellafield

Sellafield dominates the decommissioning liabilities for the UK, even if we exclude the Windscale, Calder Hall and Drigg sites, accounting for about 70 per cent of the UK's civil nuclear liabilities. It is a compact site of only 4 km<sup>2</sup>, employing about 10,000 people. It is a complex site with several significant facilities. The main plants on the site are:

1. Legacy ponds and silos: storage of historic waste;
2. Sludge packaging plant: treatment and interim storage of sludges from legacy ponds;
3. Box encapsulation plant: used for treatment and interim storage of sludges from legacy ponds
4. Sellafield drypac plant: used to treat sludges from legacy ponds;
5. Sellafield MOX plant: used to manufacture mixed oxide fuel;
6. Magnox separation plant: used to reprocess Magnox fuel. This plant is scheduled to close in 2012;
7. THORP head end and chemical separation: used to reprocess oxide fuel. This plant was closed in 2005 after a major spillage and it was not clear in May 2006

whether it would re-open. Its current contracts are scheduled to be completed in 2011.

8. HAL evaporator and storage: used to concentrate and store highly active liquor;
9. Waste vitrification plant: converts highly active liquor into glass;
10. Sellafield product and residue store: site store for plutonium and plutonium residues;
11. Engineered drum stores: site stores for plutonium contaminated material;
12. Encapsulated product stores: site stores for grouted wastes;
13. SIXEP/EARP: treatment of liquid effluent prior to discharge to sea.

The BNG's LCBL report does not provide a breakdown of the decommissioning costs between the different facilities. BNG splits the decommissioning activities into five phases:

- Passivation – Clean-Up. This is the phase in which the major hazards and environmental risks on the Sellafield Site are reduced substantially. This includes the waste retrieval operations from Legacy Ponds and Silos and the ongoing reduction in Highly Active Liquor (HAL) stocks in line with regulatory requirements. During this time, the majority of the waste on the site will have been retrieved, immobilised, packaged in modern containment and held in modern stores where it can be monitored and retrieved. Work to scope the extent of contaminated land will be completed and options for remediation will be identified. This phase is underway and is expected to be complete by 2032 and is expected to account for about 8 per cent of the total cost of decommissioning at Sellafield;
- Passivation – Commercial. This is the phase in which commercial operations at Sellafield are completed. Thorp and Magnox reprocessing will have been completed thus honouring existing contracts. The Mixed Oxide (MOX) plant will have completed its operations producing fuel for overseas customers. The contracts with utility customers will have generated considerable revenue, around £9.5bn, which is available to fund clean-up activities. This phase is underway and is expected to be complete by 2016 and is expected to account for 34 per cent of the total decommissioning cost;
- Consolidation. This is the phase during which remaining operations, chiefly storage, are rationalised and redundant buildings may be decommissioned to suitable hold points. During this phase all opportunities will be taken to reduce the site infrastructure to provide simplified, effective services at significantly reduced costs. A simpler, structured, prioritised programme of appropriate decommissioning will be completed before a quiescent hold point is reached. This phase is underway and is expected to be complete by 2024 and is expected to account for 6 per cent of the total decommissioning cost;
- Quiescent. This is the phase during which the only significant activities are associated with the safe and secure storage of materials, pending the availability of final disposal routes and decisions on the site end point. We will minimise the cost at this time by deploying safe, simple and effective solutions to interim waste storage through effective waste sentencing and packaging and use of low maintenance facilities. We will seek to restrict the duration of this phase as much as possible in order to minimise the potential loss of key skills. This phase is underway and is expected to be complete by 2040 and is expected to account for 17 per cent of the total decommissioning cost;
- Restoration. This is the final phase in which wastes are exported to the Intermediate Level Waste (ILW) and High Level Waste (HLW) repositories. For the purpose of this Lifecycle Baseline (LCBL) it should be noted that UK-owned Plutonium and Uranium is assumed to remain in indefinite storage at Sellafield. The products of reprocessing and stored fuel will be removed, the final stages of contaminated land addressed and the site cleared to an agreed end point. This

phase is expected to commence in 2040 and to account for 35 per cent of total decommissioning cost.

Site restoration is expected to be complete by 2120. It will then hold a strategic stock of nuclear materials for the UK. The eventual reuse or disposal of these is subject to ongoing review by the UK government. The site will be subject to 'indefinite institutional control' after 2120.

**Table 10 Estimate of remaining cost to decommission Sellafield (£k)**

	Years 1-5 (%)	Years 6-10 (%)	Years 11+ (%)	Total (%)
<b>New build projects</b>	1132502 (27)	676618 (20)	2222985 (8)	4032105 (11)
<b>Decommissioning &amp; termination</b>	132346 (3)	236129 (7)	6569634 (24)	6938109 (20)
<b>Waste &amp; nuclear materials management</b>	1220118 (29)	1124059 (33)	9460868 (35)	11805044 (34)
<b>Site support</b>	1352188 (32)	1054221 (31)	6578436 (24)	8984845 (26)
<b>Support services</b>	302587 (7)	233994 (7)	1119929 (4)	1656509 (5)
<b>Stakeholder support</b>	82170 (2)	74008 (2)	1361604 (5)	1517782 (4)
<b>Total</b>	<b>4221911 (12)</b>	<b>3399029 (10)</b>	<b>27313456 (78)</b>	<b>34934394 (100)</b>

Source: UKAEA (2005) 'Lifecycle Baseline: Sellafield' BNG.

[http://www.nda.gov.uk/documents/sellafield\\_site\\_summary\\_2005-6.pdf](http://www.nda.gov.uk/documents/sellafield_site_summary_2005-6.pdf)

Note.

1. The breakdown of spend is only available by the time periods shown.
2. No expenditure is listed for transition. New costs from commercial operations are not included.

Total estimated decommissioning cost, excluding new costs from commercial operations (£5050bn) is £34.9bn, which discounted at 2.2 per cent reduces to about £17bn (see Table 10). The main costs are 'waste and nuclear materials management' (34 per cent), 'site support' (26 per cent) and 'decommissioning and termination' (20 per cent). Nearly 80 per cent of the expenditure takes place more than 10 years forward, when 'decommissioning and termination' becomes a major cost.

### **NII comments**

The NDA is required by the Energy Act 2004 to consult all the principal nuclear regulators, including the Nuclear Installations Inspectorate (NII), the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA) and the Office of Civil Nuclear Security (OCNS), in preparing its Strategy and Annual Plans.

NDA's Draft Initial Strategy was published in August 2005<sup>14</sup>. The NII was amongst those that commented<sup>15</sup> and the NDA's Final Strategy was published in April 2006<sup>16</sup>. Whilst it supported the NDA's 'intention to expedite decommissioning timescales' the NII asked NDA to provide references or detailed reasons to back up the feasibility of the proposed 25 year timetable. NII was concerned that the Strategy placed 'too much emphasis on 'value for money' and 'acceleration' without addressing, as a priority, securing health and safety'. There was also concern about the competitive aspects of tendering, particularly the 'resource implications and diversion of attention that the draft competition programme may have for HSE [NII's parent body] and for the license companies, potentially to the

<sup>14</sup> NDA (2005) 'Strategy: Draft for consultation', NDA, Calderbridge.

[http://www.nda.gov.uk/documents/nda\\_draft\\_strategy\\_for\\_consultation\\_2005a.pdf](http://www.nda.gov.uk/documents/nda_draft_strategy_for_consultation_2005a.pdf)

<sup>15</sup> <http://www.hse.gov.uk/nuclear/strategy.pdf>

<sup>16</sup> NDA (2006) 'Strategy', NDA, Calderbridge.

[http://www.nda.gov.uk/documents/nda\\_final\\_strategy\\_published\\_7\\_april\\_2006.pdf](http://www.nda.gov.uk/documents/nda_final_strategy_published_7_april_2006.pdf)

detriment of nuclear and conventional safety'. The NDA does not state in its Final Strategy how it dealt with these points.

### 2.2.2 British Energy sites

British Energy's decommissioning plans are reviewed by the regulatory agencies on a quinquennial basis. The most recent review by the NII before finalising this draft was published in 2001<sup>17</sup> and was based on three documents submitted by British Energy<sup>18</sup>.

While British Energy stated that decommissioning will take place 'as soon as reasonably practicable to do so taking into account all relevant factors', the basis of the British Energy strategy was that for the AGRs, there should be a delay of at least 85 years after the end of generation before final dismantling is started and for Sizewell B, a delay of at least 50 years. This appears to be based on prompt completion of stages 1 and 2 followed by a period of 75 years of 'safestore' for the AGRs and 40 years for Sizewell B. British Energy justifies this on grounds that deferral would reduce doses to workers by gaining benefit from radioactive decay.

From the point of view of provisioning, contributions to the NLF were calculated on the basis that stage 3 at the AGRs was commenced 70 years after plant closure and 10 years for Sizewell B. In short, the costs were only discounted for 70 and 10 years respectively.

A new review was completed in 2006, but by October 2006, it had not been published by the NII nor had the NDA review of these plans been published. However, in its annual report, British Energy reported that the review had resulted in an increase of undiscounted decommissioning liabilities of £2032m (discounted £956m). British Energy stated<sup>19</sup>:

The increase in estimate is primarily due to higher costs being assessed for decommissioning. The estimate is based on a highly detailed costing study, which draws on experience gained in both the US and UK, and includes provision for the earlier completion of certain decommissioning workstreams. As indicated above, the Group will be indemnified by the Government for any future shortfall on NLF funding of qualifying uncontracted nuclear liabilities and qualifying decommissioning costs and therefore the increase in liabilities as described is fully offset by a corresponding increase in the Government's indemnity at that date.

So the increased costs will be met by future taxpayers.

### NII's comments

The NII had two major criticisms of British Energy's 2001 strategy<sup>20</sup>: that the long time-scales were not justified and that the data on which cost estimates were based out of date. The NII said that deferral would not necessarily reduce dose rates because prompt decommissioning might require use of remotely operated equipment and might lead to lower dose rates. NII recommended that British Energy update its plans, which were based on data from the early 1990s to reflect British Energy's more recent thinking

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<sup>17</sup> Nuclear Installations Inspectorate (2001) 'A review by HM Nuclear Installations Inspectorate of the British Energy plc's strategy for decommissioning its nuclear licensed sites', HSE, Bootle.

<http://www.hse.gov.uk/nuclear/beqqr.pdf>

<sup>18</sup> British Energy 'Corporate decommissioning strategy' E/REP/GEN/0004/00, British Energy 'Corporate decommissioning strategy' E/REP/GEN/0005/00 and British Energy 'Corporate arrangements for the management of decommissioning' E/REP/GEN/0035/00.

<sup>19</sup> British Energy (2006) 'Annual report and accounts 2005/06', British Energy, Livingston, pp 17-18.

<sup>20</sup> Nuclear Installations Inspectorate (2001) 'A review by HM Nuclear Installations Inspectorate of the British Energy plc's strategy for decommissioning its nuclear licensed sites', HSE, Bootle.

<http://www.hse.gov.uk/nuclear/beqqr.pdf>

### **Hinkley Point B NPP**

The Hinkley Point B NPP is expected to be the first AGR to close, in 2011. British Energy has published no plans for decommissioning this plant. In its 2005/06 annual report, British Energy estimated the undiscounted cost of decommissioning its eight stations as £8578m. The AGRs are likely to be more expensive to decommission than Sizewell B because of their larger mass, but if we assume the cost of the eight stations is equal, Hinkley Point B will cost about £1bn to decommission. The discounted liability (British Energy uses a discount rate of 3 per cent) is £2.7bn, reflecting British Energy's assumption that site clearance would be started at least 70 years after plant closure. In 2001, British Energy's policy was that stage 3 would not be commenced for at least 85 years after plant closure, but it provided provisions on the basis that decommissioning would start 70 years after plant closure.

### **NDA's responsibilities for British Energy sites**

The NDA determines the decommissioning strategy, with the approval of government. It also has to approve the strategy for the British Energy plants. In its 2005 Strategy document (p 49) it states that: 'We are responsible for the oversight of British Energy's planning for and decommissioning of its nuclear power stations'. NDA is responsible for:

reviewing and approving annual plans that (a) detail BE's work programme and costs for the following rolling three years and (b) detail changes in BE's nuclear liabilities cost estimates; reviewing and approving BE's strategies and budgets for decommissioning its power plants and discharging its uncontracted liabilities; confirming whether certain increases in BE's nuclear liabilities arising from changes in its operations should be funded through the Nuclear Liabilities Fund (NLF; and approving, for payment by the NLF, those invoices submitted by BE for work carried out in discharging those liabilities covered by the NLF.

In response to a question about the reviews undertaken to date of any payments made from the NLF, an NDA representative stated<sup>21</sup>:

'The review process is currently underway and nearing completion. Only one minor payment has been approved in relation to a contract between BE and BNG. I'm afraid the documentation relating to this process is the property of British Energy and "Confidential", we are therefore not in a position to supply copies to third parties (supplied in confidence exemption s.41 of FOI Act 2000 would apply).'

There have been reports that the government will require the NDA to manage the decommissioning of British Energy's NPPs although this has yet to be confirmed.

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<sup>21</sup> NDA, personal communication

### 3 Funds and fund management

#### 3.1 History of provisioning

There have been at least five major changes in the way decommissioning provisions for the civil nuclear power plants have been collected.

##### 3.1.1 Up to 1990

Up to 1990, the CEGB and the SSEB collected provisions from electricity consumers to pay for the decommissioning of their Magnox (excluding Calder Hall and Chapelcross) and AGR stations. These were retained in the form of internal unsegregated provisions in the accounts. The provisions effectively existed as a proportion of the assets of the companies. The combined value of these provisions was £3.8bn. In theory, when decommissioning was required, the company could sell some assets or use cash-flow, if sufficient was available to meet the liabilities. When the company was privatised, the government retained all the proceeds from the sale (only about a third of the asset value of the companies) and did not pass any provisions on to the successor companies, Nuclear Electric and Scottish Nuclear. So effectively the contributions made by consumers up to 1990 will not be available to pay for decommissioning.

##### 3.1.2 1990-1996

It was found that the likely income from sale of electricity to the new electricity market for the nuclear plants in England and Wales fell far short of the amount to pay for operating the plants, dealing with the spent fuel produced and paying for decommissioning. As a result, the plants could not be privatised and remained in public ownership in Nuclear Electric and Scottish Nuclear. A consumer subsidy was created, the Fossil Fuel Levy (FFL), to ensure Nuclear Electric was able to continue to trade legally. The FFL approximately doubled the income of Nuclear Electric and the total income to Nuclear Electric from the FFL and from sales of electricity was guaranteed. So if the market price of electricity was lower than expected, the FFL would increase and vice versa. The intention was that the subsidy would do no more than ensure Nuclear Electric was 'cash positive'. In 1990, the European Commission judged the FFL a state aid, but allowed it to be introduced provided it was removed by 1998. From 1990-96, about £6bn was collected from consumers. In theory, the FFL was payable to all technologies that did not use fossil fuels but, in practice, about 97 per cent of the amount collected was paid to Nuclear Electric. Michael Heseltine, then the responsible government minister, told Parliament this was 'to pay for the decommissioning of old and unsafe stations'<sup>22</sup>. This statement was not accurate. There were no restrictions on the way Nuclear Electric could spend the FFL and it was therefore used by Nuclear Electric as additional cash flow. A small amount of decommissioning work was carried out, but, given that Nuclear Electric's marginal expenditure was on the construction of the Sizewell B plant, which it built with no recourse to borrowing despite being effectively bankrupt, it must be concluded that a large amount of the FFL was effectively spent on building Sizewell B. A large amount, nearly £3bn, however, was unspent.

When the newer nuclear plants were privatised in 1996, the sale price for the eight nuclear stations, including Sizewell B, was only about half the cost of building Sizewell B. Government retained all the proceeds of the sale and used them as additional income. So effectively, Sizewell B was almost given away and the proportion of the FFL spent on Sizewell B was lost.

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<sup>22</sup> Heseltine M, President of the Board of Trade, Hansard, 19 October 1992.

The electricity market structure was different in Scotland and no wholesale market existed. Scottish Nuclear received a guaranteed price for its power at significantly above the average price paid. So consumers in Scotland were also effectively paying a subsidy to the nuclear power plants, but very little of this subsidy was spent on decommissioning the retired station (Hunterston A).

### **3.1.3 Magnox Electric/BNFL (1996-2005)**

About £2.7bn of the unspent FFL was passed to Magnox Electric and then to BNFL, where it was retained as an identified but unsegregated fund known as the Nuclear Liabilities Investment Portfolio (NLIP). The fund was nominally separate and invested in specific funds. But it was not segregated so if BNFL had been required to discharge debts of any type, it would have been obliged to use the fund. It is not clear whether BNFL wanted to create a segregated fund, but it seems likely that the Treasury rule, that government entities are not allowed to set up segregated funds, would have prevented it from doing so. With additions and interest, the NLIP had a value of £4016m on March 31, 2004. However, when the assets of BNFL were removed by the government and placed in the Nuclear Decommissioning Authority, the fund was appropriated by the UK Treasury and placed in the consolidated fund (its normal tax and other sources income). The government promised to fund some of the costs of the NDA, so arguably, the NLIP is being passed on to the NDA, but only a small proportion of its activity is currently decommissioning Magnox plants, so the fund is not used for the purpose it was previously designed for and the proportion of the FFL passed to Magnox Electric was lost.

### **3.1.4 The Secretary of State's Undertaking (1998-2005)**

This NLIP was supplemented by a commitment from the Treasury (the Secretary of State's Undertaking) in March 1998 to pay £3700m (in March 1998 values), payable between 2008 and 2116. The BNFL Annual Report of 2005 stated:

The Secretary of State's Undertaking is an agreement between Her Majesty's Secretary of State for Trade and Industry and Magnox Electric plc. The Secretary of State has undertaken to pay Magnox Electric plc £3,700million (March 1998 money values) together with interest at a rate of 4.5% per annum above inflation (based on RPI) on the outstanding amount. Payments commence in the year ending 31 March 2008 and cease in the year ending 31 March 2116.

This sum was to grow in real terms by 4.5 per cent a year and at April 1 1999, the Undertaking was valued at £3934m. So, by 2008 when it would have been first payable, the Undertaking would have stood at £5.75bn. Any funds that had not spent until towards the end of the period during which they are payable (up to 2116) would have grown in value by a factor of more than 100. Under the then planned decommissioning timing, the most expensive phase of decommissioning would not have taken place until after 2100. Assuming a government commitment to provide funds in more than a hundred years time is in any way meaningful the Secretary of State's undertaking would have covered any plausible decommissioning costs many times over. This undertaking may have been designed to facilitate privatisation of BNFL by underwriting any plausible liabilities, but it did not provide actual resources. The creation of the NDA took BNFL's liabilities away from it and privatisation of some of the component parts of BNFL is able to proceed. The Secretary of State's Undertaking was 'extinguished' when the European Commission when the European Commission's investigation into state aid to BNFL resulting from the transfer of liabilities to the NDA allowed the creation of the NDA. On March 31 2005, the Secretary of State's Undertaking was reported by BNFL to be worth £5956m.

In practical terms, the Secretary of State's Undertaking was never more than a device to allow BNFL to continue trading. In the event of BNFL's failure, the government would have

had to pay assume the responsibility for dealing with its liabilities in any case so the Undertaking did not represent a meaningful additional commitment.

### **3.1.5 British Energy (1996-2005)**

Of the unspent FFL receipts, £228m was passed on to British Energy to be placed in the segregated fund (Nuclear Generation Decommissioning Fund or NDF) it was required to set up for decommissioning its plants. The target value of the fund was 110 per cent of the accrued discounted liabilities that were to be covered by the fund. Whilst this appeared to represent a major step forward in protecting funds compared to earlier provisioning schemes, the weakness of the system was that the funds were only required to pay for stages II and III of decommissioning with the cost of stage 1 to be paid from cash flow. Whilst it was plausible for the first stations to be retired, for the last stations still in service, there would have been no plants remaining to generate cash flow to pay for stage 1.

It is not clear why the decision to exclude stage 1 from the decommissioning fund was taken, a decision that is contrary to practice in other countries with segregated decommissioning funds. However, the sale value of the eight stations was very low, about £1.7bn, probably less than 10 per cent of their replacement cost and only about half the cost of building Sizewell B alone. If British Energy had been required to contribute the cost of phase 1 to the NDF, it is likely the market would have valued the company at an even lower and possibly negative figure.

While these two stages are the most expensive in undiscounted terms, using the positive discount rate adopted by British Energy, 3 per cent, and assuming that decommissioning is not completed until up to a century after plant closure, the sums required to fund stages II and III are very small. For example, if it is assumed stage III decommissioning costs about £500m but is not carried out until 80 years after plant closure, the amount required at plant closure in the fund to pay for stage III would be only £47m. As a result, British Energy was required to make additions of only less than £20m per year to the fund despite the undiscounted liability for decommissioning being in the order £5bn.

The value of the fund fluctuated widely over the period 2000-04. No payments were made from it during this period and the fluctuations reflect changes in market value. In 2003, exceptional charges of £124m were recorded and in 2002, exceptional charges of £27m were recorded, while an exceptional increase in value of £59m was recorded in 2004.

By September 2002, British Energy had effectively financially collapsed because its income from sales of electricity was insufficient to meet its costs and liabilities, partly decommissioning, but mainly dealing with spent fuel. In fact, the trustees (the Nuclear Trust) of the decommissioning fund, the NDF, appear to have precipitated the collapse of British Energy by serving a default notice relating to the solvency of British Energy because it was unable to pay even the small sum required for the NDF. The UK government mounted an extremely expensive rescue, assuming most of the liabilities in return for rights to 65 per cent of the company's future net income, the so-called 'cash sweep'. This was subject to a state aid investigation by the European Commission, which allowed the rescue, with some conditions, in 2004, and the company was re-launched in March 2005.

The UK decommissioning fund included debt and equity securities with market values of £44m and £396m respectively at 31 March 2004 compared to £43m and £291m in 2003.

**Table 11 Value of the NDF (£m)**

Year	Contribution	Value
2000	18	360
2001	18	397
2002	18	411
2003	19	334
2004	-	440

Source: British Energy Annual Report and Accounts.

Note: Contributions are made during the year and are credited in the next annual report, e.g., the £19m contributed in 2003 is reflected in the 2004 figure.

### 3.1.6 British Energy (2005 onwards)

The scope of the segregated fund, the NDF, renamed the Nuclear Liabilities Fund (NLF), was widened to include uncontracted nuclear liabilities, mostly dealing with spent fuel from the Sizewell B PWR. The assets of the NDF were transferred to the NLF and British Energy Holdings plc issued £275m in New Bonds to the NLF. The ratings agencies gave these bonds a very low rating. Standard and Poors rated them BB, Fitch rated them BB- and Moody's Ba3.

The NLF had a value of about £782m in March 2005. Government now controls the segregated fund and British Energy pays in a flat sum of £20m per year. British Energy states that the government will pay any income from the 'cash sweep' into the segregated fund. The rights to 65 per cent of British Energy's income can be converted into shares, representing 65 per cent of the value of British Energy (1,042 million additional shares). If the Cash Sweep was fully converted to shares, the NLF would hold up to 65 per cent of the enlarged equity share capital of the Company. However, the terms of the conversion include a limit on the voting rights of such shares equal to a maximum of 29.9 per cent whilst held by the NLF. The value of a converted Cash Sweep would be totally dependent on the share price. In the period from June 1 2005 to Aug 31 2006, the share price for British Energy varied between £3.33 and £7.30.

The government announced it would consider selling the shares when the review of energy policy, was complete. However, in August 2006, British Energy announced to shareholders that its output for 2006/07 would be reduced because of problems with the boilers at two of the AGR stations. This led to a fall of 10 per cent in the price of the shares and the government put plans to sell the shares, reported to be an early priority in August, on hold. It is not clear yet whether the proceeds of any share sale would be paid into the NLF or whether they would be paid into the government's consolidated fund (general tax income).

There is no commitment by British Energy to ensure the fund will be adequate to meet all the liabilities it is eligible to pay for and the government is underwriting the fund, although it will not make any contributions until the fund is exhausted.

#### The discount rate

A particular issue has arisen with the discount rate. Under the NDF, the fund was a private sector fund and the rate at which liabilities were discounted, 3 per cent, was decided by British Energy subject to the approval of the company's auditors and the NII. Now that the government is underwriting the costs, the discount rate used should be chosen by government. Until April 2005, Treasury guidelines were that for liabilities, costs should be

discounted at a rate of 3.5 per cent and that was the figure adopted by British Energy. From April 1 2005, the Treasury's recommended rate for liabilities was reduced to 2.2 per cent<sup>23</sup>. However, British Energy continued to use 3 per cent. British Energy was questioned about this in March 2006 by the UK House of Commons Public Accounts Committee, but British Energy officials were unable to explain their choice of discount rate<sup>24</sup>.

Over the minimum period of deferral assumed for the AGRs of 70 years, this will make a major difference to the discounted liability faced underwritten by the public. A liability discounted at 3.5 per cent for 70 years would have a discounted value of only 9 per cent of its undiscounted value, while a liability discounted at 2.2 per cent for 70 years would have a discounted value of 22 per cent of its undiscounted value.

### 3.1.7 Nuclear Decommissioning Authority (2005 onwards)

From 2002 onwards, it was clear that BNFL did not have the resources to pay for all its decommissioning and other liabilities and it was technically bankrupt. Plans to privatise BNFL were abandoned. The total undiscounted cash flow that would be needed to discharge its liabilities was estimated at £41,361m, of which BNFL would be liable for about 68 per cent. Given that its assets only amounted to £5657m plus an undertaking by the government to pay £5525m in clean-up costs, the need to reform BNFL was clear. It was decided to remove all its historic UK assets from it, including the nuclear power plants and the Sellafield complex and place them in a new government owned organisation, the Nuclear Decommissioning Authority (NDA). This included some operating facilities, for example, some of the Magnox plants and some reprocessing facilities.

In 1996, UKAEA was split into two parts: one part retained the existing liabilities and was responsible for dealing with them; and the other contained the technical expertise and was privatised as AEA Technology. Subsequently, AEA Technology withdrew from all activities in the nuclear sector, but UKAEA has tried to develop a competitive business dealing with clean-up and decommissioning. The liabilities of the UKAEA were also transferred to the NDA. NDA was formally started on April 1 2005, but transfer of the assets did not occur because of an investigation by the European Commission into whether the transfer represented an unfair state aid, on the grounds that BNFL would be allowed to continue to trade after the transfer having failed to discharge its liabilities. In April 2006, the European Commission approved the deal with some conditions<sup>25</sup>.

It is expected that both the British Nuclear Group (BNG) division of BNFL, the division responsible for operating the main facilities and the UKAEA will be privatised now that they have been relieved of their financial obligation to decommission their sites.

In the preparation for the creation of the NDA, there was considerable debate about how it should be funded. The 2002 White Paper on dealing with nuclear waste<sup>26</sup> raised the issue, for long-term nuclear liabilities, of continuity of funding and the short-term nature of any

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<sup>23</sup> Note for investments, the Treasury recommends a discount rate of 3.5% should be used only for the first 30 years; for years 31 to 75 the figure should be 3% and for years 76 to 125 the figure should be 2.5%.

<sup>24</sup> Public Accounts Committee (2006) 'Minutes of evidence taken before the Committee of Public Accounts: Monday 27 March 2006. The restructuring of British Energy' Uncorrected transcript of oral evidence' To be published as HC 1025-i. <http://www.publications.parliament.uk/pa/cm200506/cmselect/cmpubacc/uc1025-i/uc102502.htm>

<sup>25</sup>

<http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/428&format=HTML&aged=0&language=EN&guiLanguage=en>

<sup>26</sup> UK Government (2002) 'A better quality of life: a strategy for sustainable development for the UK' (Cm 4345, The Stationery Office, London, ISBN 0-10-143452-9.

funding commitments the government can make under the system of three-year spending reviews that the British government operates. It acknowledged that:

'In the past, nuclear clean up has also been seen as a low priority for funding purposes relative to other programmes. Experience to date with UKAEA has therefore been that settlements have tended to be the minimum necessary to address safety and environmental needs and that limited funding has been available for other projects'

It offered two options for the NDA as ways to provide greater assurance of funding: a 'segregated fund' and a 'statutory segregated account'. The segregated fund would be an identifiable set of assets managed in the same way as pension funds. Of course, a key difference between this form of nuclear segregated fund and a pension fund is that people putting money into pension funds benefit personally from their contributions and therefore have an incentive to contribute, while the Treasury would tend to postpone operations and minimise contributions.

However, for the government to set up a segregated fund would go against general government policy. The Treasury has always resisted efforts to ' earmark' or hypothecate funds, preferring to have maximum flexibility to use funds in whatever way it sees fit. The Treasury argues that this allows it to get the best return on the money at its disposal.

A statutory segregated account would require annual notional payments towards clean-up and would represent a statutory commitment to fund decommissioning but the money would not be in a separate identifiable pot. Government would merely provide assurances that the money committed would be available when required.

In practice, the government would simply be writing committing to provide funds in the future, a responsibility it would have had in any case, and the government would be able to use the money as it wished until it was actually required. Clearly the latter would be the Treasury's preferred alternative because it would give it full freedom to use the money.

Neither scheme offered by government comes close to the polluter pays ideal. In both cases, contributions would be annual, from tax income and would be calculated on the basis of short-term need. If there was no immediate need for funds, no contribution would be made. Taxpayers 150 years from now could still be paying to clean up the current generation's nuclear power stations.

Ironically, the White Paper made much of the short time-frame of only three years that clean-up funds were committed under the previous arrangements and it promised a 10-year funding commitment to facilitate planning of expenditure. In December 2003, the Energy Minister, Stephen Timms was still voicing publicly the government's decision to set up a 'Statutory Segregated Account' to 'provide a rolling commitment of funds for a period of at least 10 years ahead.' However, in 2004, the time horizon was reduced back to three years. By not choosing a segregated fund, and by not extending the time-scale beyond the previous three years, it would appear that despite the apparent intentions of the White Paper, the British government has not made any additional commitment to funding the clean-up work. The government would ultimately have to pay for decommissioning if all other funding sources failed so the government has actually made no new commitment.

The NDA receives income from the operation of the facilities that it owns that are still in service as well as income from the Treasury and this contributes part of its budget, although this will necessarily tail off rapidly as the existing facilities close. NDA's budget for 2005/06 was £2.2bn and income from operating facilities was expected to represent about half NDA's income.

However, an equipment failure at the THORP reprocessing plant discovered in April 2005 in the Sellafield complex led to its long-term closure, so income from this facility will not be generated until and if the plant is re-opened. The clean-up and repairs to the plant will

also be a major cost to NDA. By June 2006, it was not clear when or if the THORP reprocessing plant would re-open, by the government's Health & Safety Executive has announced its intention to prosecute the license-holder for the site, BNG, for the failure.

### The discount rate

Prior to the setting up of the NDA, the UKAEA used a discount rate of 3.5 per cent, while BNFL used a rate of 2.2 per cent. NDA uses 2.2 per cent, the Treasury recommended rate.

## 3.2 Setting aside funds

Currently the only tangible funds are the previous provisions made by British Energy to the Nuclear Liabilities Fund (see Table 12). These will be supplemented by future payments to the NLF and any payments to the NLF made under the 'cash sweep'.

**Table 12 History of decommissioning provisions**

Scheme	Facilities covered	Owner	Provisions	Form	Remaining funds
<b>-1990</b>	9 civil Magnoxes & 7 AGRs	CEGB/SSEB	£3.8bn	Internal accounting provisions	£0
<b>1990-96 FFL</b>	8 civil Magnoxes, 5 AGRs and 1 PWR	Nuclear Electric	£6bn	Cash-flow to Nuclear Electric	£2.7bn to Magnox Electric & £228m to British Energy
<b>1996-2005 NLIP</b>	11 civil Magnoxes & other BNFL facilities	BNFL	£4016m	Internal fund	£0
<b>1998-2006 Secretary of State's Undertaking</b>	All facilities owned by BNFL	BNFL	£5956m	Government undertaking	£0
<b>1996-2005 NDF</b>	7 AGRs & 1 PWR	British Energy	£440m	External segregated fund	£440m to NLF
<b>2005- NLF</b>	7 AGRs, 1 PWR and spent fuel from Sizewell B	British Energy	£782m + Cash Sweep	External segregated fund	£782m + Cash Sweep
<b>2005- Statutory segregated account</b>	All liabilities except those owned by British Energy	NDA	£0	Government commitment	£0

Source: Author's research

The British Energy Annual Report of 2004/05 states:

The Group will also now make the following payments to the NLF: (i) an annual contribution initially equal to 65% of the Group's adjusted net cash flow, adjusted for certain corporate actions but never to exceed 65% (the NLF Cash Sweep Payment); (ii) fixed decommissioning contributions equal to £20m per annum (indexed to RPI from March 2003 but tapering off as the nuclear power stations are currently scheduled to close); and (iii) £150,000 (indexed to RPI from March 2003) for every tonne of uranium in PWR fuel loaded into the Sizewell B reactor after the Restructuring Effective Date [April 1, 2005].

The contributions to the NLF for decommissioning are only partly based on need: they are either flat rate fixed contributions, variable contributions depending on the amount of fuel used or are based on British Energy's ability to pay (the 'cash sweep'). It is not clear how realistic the contributions for dealing with spent fuel are.

As noted in 3.1.5, the 'cash sweep' would come to an end if the government converts this to shares and sells the shares. It remains to be seen whether the proceeds of such a share sale would be paid into the NLF.

### 3.3 Management of funds

There have been two identifiable funds set up to pay for decommissioning and other long-term liabilities: the Nuclear Liabilities Investment Portfolio (NLIP) operated by BNFL from 1998-2005; and the Nuclear Decommissioning Fund (NDF), which, in 2005, became the Nuclear Liabilities Fund (NLF) and applies to British Energy plants.

#### 3.3.1 Nuclear Liabilities Investment Portfolio

The NLIP was set up in 1998 using most of the unspent proceeds (£2.7bn) of the Fossil Fuel Levy (FFL). The fund was used by BNFL to discharge liabilities, with the agreement of BNFL's shareholder, the British government. BNFL's Annual Report of 2003 stated the investment policy it adopted for the NLIP as follows:

The Nuclear Liabilities Investment Portfolio (NLIP) represents funds earmarked for the costs associated with the discharge of nuclear liabilities. In order to ensure that funds are available when needed to meet the long-term nuclear liabilities, the investment policy has to address long-term returns and their relationship to inflation, the effects of taxation, credit risk and reinvestment risk. The fund is thus invested in a combination of index-linked gilts and a managed portfolio, invested through fund managers.

##### i. Gilts investment portfolio

The Group has invested £2,039 million of the portfolio in index-linked gilts and £309 million in conventional gilts, which are intended to be held until redemption. The index-linked gilts have an average maturity of 10.16 years and returned 2.04% p.a. after tax and inflation this year. The advantages of this instrument to the portfolio are tax-free indexation cover for inflation, a roughly constant annual post-tax real yield to maturity and excellent credit risk. There are two areas of risks associated with this instrument; firstly the taxation legislation may change; and secondly, given the longest maturity is up to 2024, but the nuclear liabilities go out to 2150, there will be a significant degree of refinancing risk if the Government does not issue longer-maturing index-linked gilts in due course.

##### ii. Managed portfolio

£1,495 million is invested through fund managers, against either a LIBID or index-linked benchmark dependent upon the maturity profile of the investment. The purpose of using fund managers is to provide some flexibility and add value by active strategic investment. Performance is monitored through monthly reports and regular meetings. The potential change in value on the funds is controlled by the benchmarks and by maturity limits. Credit risk on non-gilt investments is controlled by limiting the amount that can be placed with each counterparty and specifying a minimum creditworthiness of the counterparty as determined by the rating agencies.

From 2003 onwards, the BNFL Annual Reports acknowledged that the NLIP would be transferred to the NDA, once it was established. However, the European Commission's investigation into the NDA arrangements delayed the process and only £1369m out of a total value of the NLIP at that time of £3750m. It was expected that if and when the Commission cleared the NDA arrangements, the remainder of the NLIP would be transferred to the UK government. Commission clearance was given on 4 April 2006, but there has been no confirmation whether the transfer has taken place.

#### 3.3.2 Nuclear Decommissioning/Liabilities Fund

The NDF was set up in 1996 when British Energy was created as an investor-owned nuclear generation company, owning the eight most modern nuclear plants. It received £228m from the unspent proceeds of the FFL. The target value of the fund was 110 per cent of the accrued discounted liabilities. The British Energy Annual report of 2002/03 (Form 20-F) stated:

The Decommissioning Fund is owned by the trustees of an independent trust, the Nuclear Trust. The Decommissioning Fund was established to accumulate funds to meet our Stage 2

and Stage 3 decommissioning costs, including on-site waste management. We made an initial endowment of £228 million to the Decommissioning Fund in July 1996. We make quarterly contributions to the Decommissioning Fund, which are subject to an adjustment for inflation. During the year ended March 31, 2003, these contributions totalled £18 million.

However, by September 2002, British Energy was near collapse. British Energy reported in its Annual Report of 2002/03 (Form 20-F):

On September 25, 2002 the Decommissioning Fund served a default notice relating to the solvency of the Company, British Energy Generation Limited and British Energy Generation (UK) Limited. Unless the default is cured to the satisfaction of the Decommissioning Fund, or waived, the Decommissioning Fund has the right to require accelerated payment of all of the contributions due to the Decommissioning Fund prior to the next quinquennial review in Autumn 2005. The Decommissioning Fund has agreed not to take enforcement action without further notice while the British Energy Group continues to make progress toward completing its proposed restructuring. If the proposed restructuring is effective, the NLF will replace the Decommissioning Fund.

The government's rescue of British Energy was delayed by a state aid investigation by the European Commission and was not approved until September 2004. The company was re-launched on April 1, 2005, with the new Nuclear Liabilities Fund. The 2005/06 British Energy Annual Report does not detail the investment policies of the Nuclear Trust. The Nuclear Trust is a charitable trust governed by a Trust Deed; three independent trustees are appointed by the Secretary of State for Trade and Industry and two by British Energy.

### **3.4 Special cases: Fall-back option and transfer of ownership**

Clearly for the NDA assets, the government is the funder and there is no scope for a fall-back option. For the British Energy liabilities the Government also provides an indemnity to indemnify British Energy against any future shortfall on NLF funding of qualifying uncontracted nuclear liabilities (including PWR back end fuel services) and qualifying nuclear decommissioning costs.

## **4 Transparency of the funding scheme to the public**

The details of the funding schemes have always been in the public domain, through company reports, legislation and, increasingly web-sites. The creation of the NDA represents a major step forward in bringing this material together and making it accessible through their web-site. In particular, the Lifecycle Baselines for each facility represent a major improvement in publicly available documentation.

By contrast, the British Energy plans are not easily accessible although this may be related to the efforts to rescue the company and the fact that the new company has only been in existence since January 2005.

British Energy, the NDA and the Department of Trade and Industry were all contacted by the author as part of this project to clarify details of their decommissioning policy but none of these organisations granted an interview.

## 5 Stakeholder analysis

For some of the NDA sites, there are 'Site Stakeholder Groups' (SSGs)<sup>27</sup> which are fora 'for the local community to interface with the Nuclear Site Operator'. SSGs exist for four of NDA's sites, Berkeley, Oldbury, Chapelcross and Winfrith. A National Stakeholder Group (NSG)<sup>28</sup> was also set up by the NDA, managed by an independent charitable organisation, the Environment Trust<sup>29</sup>. Both the NSG and the SSGs are relatively new organisations and it is difficult to make a judgement yet on how effective they will be.

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<sup>27</sup> [http://www.nda.gov.uk/Stakeholder--Site\\_Stakeholder\\_Groups\\_\(1425\).aspx?pg=1425](http://www.nda.gov.uk/Stakeholder--Site_Stakeholder_Groups_(1425).aspx?pg=1425)

<sup>28</sup>

[http://www.nda.gov.uk/documents/summary\\_report\\_from\\_nda\\_national\\_stakeholder\\_group\\_nsg\\_april\\_2006.pdf](http://www.nda.gov.uk/documents/summary_report_from_nda_national_stakeholder_group_nsg_april_2006.pdf)

<sup>29</sup> A list of members can be found at

<http://www.envcouncil.org.uk/docs/List%20of%20NSG%20members.pdf>

## 6 Conclusions and recommendations

The UK's decommissioning plans are advanced and probably better documented than elsewhere in Europe, mainly because UK was a pioneer in nuclear power and has many retired nuclear facilities that need to be decommissioned. The UK government's Nuclear Decommissioning Authority (NDA) was set up in 2005 to take over the sites previously owned by BNFL and the UKAEA and is expected to manage the decommissioning of British Energy's sites.

The total cost of decommissioning Britain's civil nuclear facilities is currently estimated to be in excess of £75bn, although it is widely expected that this figure will rise. The cost estimates are dominated by two sites, Dounreay and Sellafield, which account for about 75 per cent of the total liability. These sites have two things in common: large amounts of plutonium were handled there and they were both sites of accidents that led to the release of radioactive material.

British governments have continued to avow the 'polluter pays' principle as a basis of their environmental policy, which implies that funds to decommission facilities should be provided by consumers of the output of these plants. Despite this, funding has been mismanaged and as a result, after more than 25 years of contributions, there is only about £800m in identified funds to pay for a liability in excess of £75bn. In the new arrangements for any future nuclear power plants, the 'polluter pays' principle is conspicuously absent from the list of principles that will underlie future arrangements.

A segregated fund (NDF) for British Energy's power plants was set up when British Energy was created in 1996. However, the scope of the fund was inadequate - it did not cover stage 1 - and British Energy collapsed in 2002. This illustrates that even a segregated fund, which relies on contributions from consumers over the expected life of the plant, is not a guarantee that adequate funds will be available when needed.

British Energy was rescued at huge expense to British taxpayers. The NDF has been renamed the NLF and expanded to include some fuel waste management costs. British Energy will make contributions to the fund, but these are related to their ability to pay, not to the scale of the liability. The contributions are also heavily dependent on the profitability of British Energy. Should this company find itself in financial difficulties again, an eventuality that is by no means unlikely, the fund could again be at risk of falling far short of the requirements. Expanding the fund to include some spent fuel disposal costs might seem a good way to ensure these costs are covered. However, in practical terms, the effect of this change might be simply to allow the Treasury to access it earlier than it would have otherwise been able to postponing the time when taxpayer funds were needed. As the NDF only covered stages 2 and 3, most of the funds would not have been accessible for 70 years or more.

By international standards, the UK timescales for decommissioning are extraordinary, with completion of final clearance for nuclear power plants not expected to be completed until up to 130 years after plant closure. NDA has an objective to reduce this to 25 years, which will increase undiscounted costs and massively increase discounted costs. While the NDA has a supervisory role over plans to decommission British Energy's plants, it is not clear whether it is able to require British Energy to reduce the timescales for its plants, which on current plans assume site clearance is not completed until nearly 100 years after plant closure.

The Nuclear Decommissioning Authority might be a useful (not perfect) model for other countries for managing decommissioning once the facilities have closed. It creates an agency that was not party to the creation of the liabilities and is not a commercial concern. It therefore has no prior interest in minimising cost estimates or lengthening time-scales in

order to reduce the present value of its liabilities or to bolster its technical reputation. The NDA has contributed to transparency by published a vast amount of useful and accessible material on its decommissioning plans and the estimated costs through the 'Lifecycle Baselines' it publishes for each of its main facilities. The NDA may, in due course, suffer 'capture' by the nuclear industry or it might feel the need to cut costs to demonstrate its management skills but, to date, NDA has improved the transparency of the decommissioning Process significantly.

Ironically, the failure of British Energy and the transfer of most of its decommissioning liabilities to the taxpayer also removed the incentives on British Energy to reduce the decommissioning liabilities for short-term commercial reasons, albeit at the expense of having to abandon the 'polluter pays' principle.

It is difficult to determine to what extent the recent steep increases in decommissioning cost estimates are the result of the removal of the commercial pressures to reduce forecast liabilities and how far the increases are the result of more detailed planning of decommissioning.

While facilities are still in operation, the operator will have much more intimate knowledge of the facility and must play the lead role in planning and estimating the cost of decommissioning. However, British experience does seem to underline the importance subjecting plans and cost estimates to regular independent scrutiny to prevent commercial interests distorting plans.

The British government is now contemplating building up to ten nuclear plants. In October 2006, the British government was still developing its plans on how decommissioning would be provisioned for any new plants. It will be important to ensure that any measures adopted are likely to be more effective than the previous efforts in Britain to make the 'polluter pay' and ensure that those that have to decommission the nuclear plants that current consumers will benefit from are endowed with adequate funds to carry out the task even if, unavoidably, they will have to do the potentially hazardous job. Somewhat surprisingly, in the list of principles that would under lie a decommissioning, the polluter pays principle is not listed.<sup>30</sup>

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<sup>30</sup> The principles the government listed are: There should be an upfront assessment of decommissioning costs; Full responsibility for decommissioning costs to be retained by the private sector operator(s); Protection will be given to the public sector regarding credit risk and reduced reactor life; The framework should be robust and transparent through time; These principles will form the basis of arrangements which will apply consistently to all new build operators and reactor types. <http://www.dti.gov.uk/files/file31890.pdf>

## 7 References

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UK Government (2002) 'A better quality of life: a strategy for sustainable development for the UK' (Cm 4345, The Stationery Office, London, ISBN 0-10-143452-9.

## **Annex Organisations involved in nuclear power in UK**

### **British Energy**

In 1996, all 7 AGR stations and the then complete PWR (Sizewell B) were privatised in a new company, British Energy. This ran into financial difficulties in 2002 and the company was eventually re-launched in 2005 after massive government assistance with liabilities and costs.

### **British Nuclear Fuels Limited (BNFL)**

British Nuclear Fuels Limited was set up in 1973 as a nationally owned organisation to own and operate the UK's fuel production, waste disposal and other activities. Subsequently it acquired the nuclear vendor businesses of Westinghouse (1998) and ABB (1999). In 2005, ownership of its sites was passed to the Nuclear Decommissioning Authority and the company began to be broken up. The reactor vending, servicing and fuel manufacture functions were sold as the Westinghouse division to Toshiba in 2006 and the British Nuclear Group (BNG), which carries out the work at the reactor and fuel cycle facilities (excluding fuel manufacture) is expected to be privatised in 2006.

### **Central Electricity Generating Board (CEGB)**

Until 1990, the publicly owned CEGB owned and operated virtually all power stations in England and Wales, including the commercial, civil nuclear plant. At the time of its break-up in 1990, it owned 8 operating Magnox nuclear stations, 5 operating Advanced Gas-cooled Reactor (AGR) stations and was building a Pressurised Water Reactor (PWR).

### **Committee on Radioactive Waste Management**

The Committee on Radioactive Waste Management (CoRWM) is an independent committee appointed by the UK Government. Its task is to review the options for managing those UK radioactive wastes for which there is no agreed long-term solution. CoRWM was asked to consult and to make recommendations to the UK Government in 2006.

### **Magnox Electric**

In 1996, the 9 civil Magnox stations were transferred from Nuclear Electric and Scottish Nuclear to a new, publicly owned company, Magnox Electric. In 1998, this was absorbed into BNFL along with its two dual purpose Magnox stations.

### **Ministry of Defence**

The Ministry of Defence owns a number of other military nuclear facilities (e.g., submarine bases)

### **Nuclear Decommissioning Authority**

The Nuclear Decommissioning Authority was created in 2004 to own all the UK's civil nuclear sites except those owned by British Energy, and to manage their decommissioning.

### **Nuclear Electric**

In 1990, all the CEGB's nuclear power plants were transferred to a new publicly owned company, Nuclear Electric, which operated them until 1996.

**Nuclear Installations Inspectorate**

The Nuclear Installations Inspectorate (NII) is the government body responsible for regulating the safety of nuclear installations. It is located within the government's Health and Safety Executive (HSE), which itself is sponsored by the Department of Work and Pensions.

**Scottish Nuclear**

In 1990, all the SSEB's nuclear power plants were transferred to a new publicly owned company, Scottish Nuclear, which operated them until 1996.

**South of Scotland Electricity Board (SSEB)**

Until 1990, the publicly owned SSEB owned all the commercial civil nuclear power plants in Scotland, including one retired Magnox station and two operating AGRs.

**United Kingdom Atomic Energy Authority (UKAEA)**

The United Kingdom Atomic Energy Authority, owned by the UK government, was set up in 1954 to oversee the UK nuclear research programme, both civil and military including the fusion programme. It built, owned and operated all nuclear facilities, except for the purely civil power stations until it was split up in the early 1970s.

Then, weapons research, fuel production, isotope production and radiological protection were transferred to other organisations: in 1971, the Atomic Weapons Research Establishment (AWRE), later Atomic Weapons Establishment (AWE) for weapons production; in 1973, British Nuclear Fuels Limited (BNFL) for fuel production and other activities; URENCO for uranium enrichment Amersham International (1983) for isotope production, privatised in 1982 and taken over by General Electric in 2004; Nuclear Installations Inspectorate (NII), set up in 1960 as part of the government's Health and Safety Executive, to regulate the safety of the UK nuclear sites.