Nuclear Decommissioning Authority

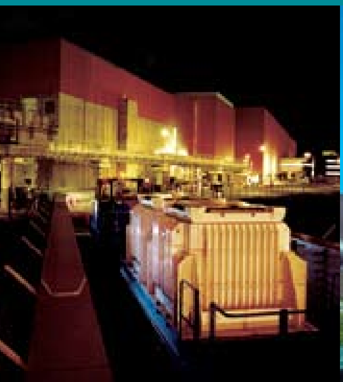
Magnox North

Magnox South

Sellafield Ltd

The Magnox Operating Programme (MOP8)

Please see MOP8 addendum, attached to the back of this document



Prepared on behalf of the NDA

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Foreword

The Nuclear Decommissioning Authority (NDA) welcomes the publication of the eighth update to the Magnox Operating Programme (MOP8). This is the third programme to be published under the NDA's ownership of the civil nuclear assets and, in line with our policy of openness and transparency, is published in a form suitable for release to a wide audience and for the first time published as an NDA document.

The NDA continues to seek safe underpinned programmes of work which realistically reflect what is achievable with the resources and plant available. And this year, considerable efforts have been made by our contractors to examine plant performance and ensure continuing hazard reduction going forward. The programme reflects achieved reprocessing rates and acknowledges the challenge this presents to previously declared milestones.

Interdependences between the lifetime plans for the Site Licence Companies are recognised and built into the programme. It presents an exemplar in terms of cross site integration required to deliver the NDA mission and balances demands across the NDA estate.

The logistical and process challenges discussed in these pages illustrate the complexity of the process. It is a tribute to the professional dedication of all involved across a number of Site Licence Companies to recognise the challenges facing the programme and their efforts to deliver a safe, optimised and cost effective programme as we strive to clean up our nuclear legacy.

The emerging picture and implications of the MOP were shared and discussed with stakeholders at the National Stakeholder Group meeting in November 2007 and also referenced in the NDA's draft 3 Year Business Plan which was the subject of consultation between November 2007 and January 2008.

Brian Burnett
SLC Programme Director, NDA
February 2008

Executive Summary

Chapelcross new flask building

The Magnox Operating Programme (MOP) is an integrated programme covering all business areas associated with the cost-effective management and safe disposal of spent Magnox fuel and, as such, supports the Nuclear Decommissioning Authority (NDA) strategy of managed reduction of potential hazards. This document has been prepared on behalf of the NDA by the MOP management team.

Eleven Magnox power stations were built in the UK, with a total of 26 Magnox reactors. All but four of these reactors are now shut down and 10 reactors have been completely defuelled. To defuel, spent fuel must be removed from the reactors and stored in the sites' ponds or dry stores before being shipped to Sellafield in flasks, where it is reprocessed. The logistics of moving significant quantities of spent fuel from diverse sites using a limited number of flasks, road transporters and rail flatrols are complex. Additionally, the programming of fuel for reprocessing must take account of the balance between:

- Fuel supply
- Electricity generation and refuelling requirements
- Station defuelling and decommissioning plans
- The constraints governing operation of the reprocessing and ancillary plants at Sellafield.

The MOP manages these complex interactions.

The MOP Mission is to:

- Optimise the Magnox closure programme making best use of the assets associated with management of the Magnox fuel cycle and enabling national and international environmental obligations to be supported
- Be challenging to deliver the MOP schedule in a safe, efficient and innovative manner.

This document outlines the strategy and processes associated with the delivery of the MOP mission statement. Inherent is a focus on the management both of operational aspects of the plan and of programme and radiological risks. The document describes:

- The scope of the MOP (Section 1)
- The history of the MOP and its achievements (Section 2)
- The chosen strategy for delivery of the MOP schedule, key milestones and associated assumptions (Section 3)
- Identified risks to the plan, associated mitigation and contingency plans (Section 4)
- The management processes that implement the MOP strategy (Section 5)
- The nature of the Magnox business and the environment in which it operates (Appendix B).

Significant MOP Achievements

The first MOP was launched in 2001, at which time both operational and transportation difficulties had

Executive Summary

resulted in undesirably high levels (1600 tonnes) of spent fuel in station ponds and the Fuel Handling Plant (FHP) at Sellafield. The cladding of some fuel, known as legacy fuel, had corroded impacting on pond contamination levels and resulting in substantially reduced decanning and reprocessing rates. The MOP approach to integrated strategic planning and prioritisation has led to significant improvement in all of these areas. By the end of August 2007 these included:

- Wet fuel in ponds reduced from 1600 tonnes in 2001 to 1250 tonnes in August 2007. This includes a reduction in corroded legacy fuel from around 600 tonnes to 325 tonnes
- A total of 4596 tonnes fuel shipped to Sellafield, involving 2551 movements of flasks by rail or road in each direction, all completed without incident
- Around 4500 tonnes fuel reprocessed
- 90TWh of electricity generated, avoiding the emission of 80 million tonnes of carbon dioxide
- 25% increase in the average flask payload, thus reducing the total number of transport journeys
- Modelling tools and techniques have been deployed at Sellafield to provide confidence levels for completion of the MOP and to enable development of a targeted improvement plan for Magnox Reprocessing.

Safety and the Environment

Since one of the main objectives of the MOP is to enable the UK to meet its international environmental and safety commitments, it is implicit that the MOP should be the Best Practicable Environmental Option (BPEO) strategy for bringing the Magnox programme to a close, and use Best Practicable Means (BPM) to implement that strategy. Government policy is that reprocessing is the BPEO for spent Magnox fuel. In delivering the MOP, all operations will be carried out safely, managing the risks inherent in any industrial process. Improvements to the process will facilitate reactor defuelling which will contribute directly to hazard reduction and enable sites to move more efficiently into full decommissioning mode. The main regulatory interfaces are:

Environment Agency	OSPAR commitments
	BPEO BPM strategy
	Radioactive discharges from Sellafield and reactor sites
Scottish Environmental Protection Agency	Radioactive discharges from Chapelcross site
	BPEO BPM strategy
Nuclear Installations Inspectorate	Industrial and nuclear safety of all operations
	Safety of fuel and waste in storage
Department for Transport	Safety of fuel during transport
Office of Civil Nuclear Security	Security of nuclear installation and materials

Individual sites are responsible for environmental and safety issues on their site and the safety of fuel shipped from that site. The role of the MOP is to identify the best programme and to optimise activities across all sites delivering that programme.

Electricity Generation

Continuing to operate Magnox power stations necessarily involves loading additional fuel into reactors and an increase in the total amount of spent fuel to be managed at Sellafield facilities. This does incur additional costs, liabilities and risk but it also generates income for the NDA to fund clean-up (and contributes to UK electricity supply needs). Without this income the scope of work for the NDA scheduled over the next three years would be significantly impacted.

Managing the MOP

The MOP, as the overall strategy, defines the key deliverables for the whole Magnox fuel cycle, covering the headline lifetime targets relating to fuel manufacture, electricity generation, fuelling and defuelling of reactors, and reprocessing of spent fuel. It sets the parameters and environment in which each facility operates, ensuring the Lifetime Plan (LTP) of each facility contributes to the overall strategy. It provides the flexibility to manage the whole cycle, compensating for under-performance, capitalising on acceleration possibilities, and managing risks across sites.

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Flask being loaded on to a transporter

The detailed scope, schedule and cost for the delivery of the MOP is contained in the individual Site Licence Companies' LTPs. The MOP describes the strategic targets and why we use the assets. LTPs describe the tactical targets and how we use the assets. The following features are important in ensuring delivery:

- The MOP sets out the high level steps required to reprocess all spent Magnox fuel, with lower level targets being contained in LTPs
- There is a demonstrated link between MOP targets and LTP targets for fuel manufacture, generation, defuelling, transport and reprocessing
- A process exists to evaluate the impact of changes on the overall MOP strategy, and to prompt any required action.

Achieving the MOP objectives requires many risks to be managed. The consequences of the risks mainly affect site schedules and overall NDA programme costs. Some of the risks could additionally have an impact on safety or the environment. For most of the period of the MOP, the reprocessing performance is a key risk to stations completing defuelling to their programmed dates. Sites are also potentially vulnerable to loss of skilled staff and to deteriorating plant condition. Towards the end of the MOP, when Wylfa and Calder Hall are defuelling, poor defuelling performance by these two stations could affect the completion of Magnox reprocessing. Responsibility for managing the risks generally rests with the sites. However, the MOP team also maintains an overview to ensure that cross-site effects are recognised and appropriate mitigation is in place.

Major MOP changes since issue 7

Following the introduction of the MOP, significant strides were made in improving performance. Achievement of the MOP key milestones was therefore considered reasonably practicable. However, following an extended outage at Sellafield in 2005, there have been a series of issues adversely affecting the performance of the Magnox Reprocessing plant and the associated plants on which it depends. Despite this, the programme flexibility and appropriate application of MOP management processes has ensured continuing progress towards the delivery of the MOP mission. In particular:

- The fuel cycle continued to generate income to help with the cost of NDA clean-up. Sizewell and Dungeness operated very successfully until their declared closure dates of December 2006. Oldbury and Wylfa continue to contribute to the UK electricity supply
- The Sizewell and Dungeness fuel usage closely matched their fuel orders and only a small amount was returned to Springfields for reuse
- The P50 (50% confidence) target for the transfer of fuel between stations and Sellafield in 2006/07 was exceeded
- Projects designed to improve the defuelling capability at Calder Hall and Chapelcross are being delivered

Executive Summary

- Bradwell defuelling was completed ahead of schedule in August 2006, successfully removing another power station from the MOP
- All undamaged fuel has been removed from Wylfa dry cell stores 4 and 5. This represents a significant hazard reduction achievement for the site
- Following the cessation of generation at Sizewell and Dungeness the hazard from spent fuel in storage has been further reduced. At Sizewell the pond has been emptied of fuel and good progress is being made with reducing the Dungeness pond stock.

The lower than planned reprocessing of spent fuel at Sellafield has resulted in the total amount of fuel remaining to be reprocessed at the end of April 2007 being 1000 tonnes greater than had been assumed in MOP6, which had been prepared two years earlier.

Reprocessing capability is the key constraint on MOP delivery. As part of the process to create the programme for MOP8, detailed modelling and assessments have been performed to establish greater confidence in the reprocessing programme based on improved underpinning of expected plant performance. This facilitates robust station defuelling and resource plans. The significant change in the MOP8 programme when compared with previous issues is the declaration of a P80 (80% confidence) estimated end date for Magnox reprocessing of January 2016, compared with the end of 2012. This prudent planning assumption underpins MOP8. At the same time improvement plans are being prepared and enacted to pull the end date forward.

The original commitment of an end date of "around the end of 2012" for completion of Magnox reprocessing was derived to permit Post-Operational Clean-Out (POCO) of the reprocessing plants within the timescale for OSPAR (Reference 1) commitments to be met. Subsequent work to implement Technetium 99 (Tc99) abatement means that, despite the later end date, the reprocessing sector targets in the UK discharge plan can still be met.

There are obvious consequences of the reprocessing planning assumption for all of the constituent parts of the MOP, and in response:

- The risk of spent fuel being stored much longer in ponds has been mitigated by instigating new wet fuel stock controls
- Station defuelling logic and key dates have been re-optimised
- Direct Rail Services (DRS) support in transporting fuel is required for longer than previously planned
- Risks and opportunities across both the MOP and the wider NDA portfolio have been revisited.

DRS train

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Wet Fuel Stock Policy

The amount of wet fuel stored currently in FHP ponds is higher than foreseen in previous MOP schedules. Magnox fuel cannot be stored wet indefinitely and there is concern that a major or prolonged reprocessing outage could lead to deterioration of fuel condition during storage. This would result in slower reprocessing and potentially to increased discharges.

A wet fuel limit has therefore been introduced to limit the risk posed by the level of wet fuel in storage. A number of scenarios were studied as the stated aim was risk reduction but too stringent a reduction plan and final limit would serve to extend the time required for reprocessing and potentially increase the overall risk to the MOP.

A limit of 800 tonnes ±50 tonnes is therefore being implemented to be reached by April 2010, as shown in the graph, with the following aims:

- The limit of about 800 tonnes reached by April 2010 will progressively reduce risk whilst restricting the detrimental effects to sites and the reprocessing end date
- The control levels give a graded application of measures allowing reasonable time for recovery whilst ensuring interested parties are informed and have the opportunity to give their views.

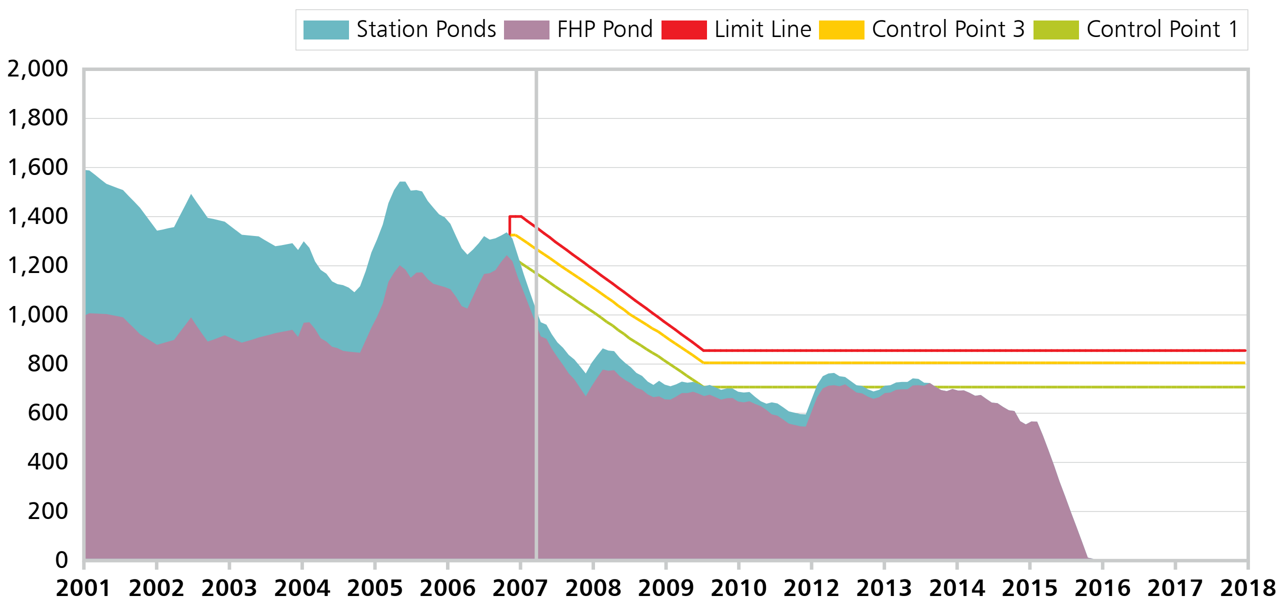
Optimising the Defuelling Schedule

The station defuelling periods have then been set to ensure that defuelling at each site can be achieved with 80% confidence provided that the assumed reprocessing plan is achieved. The schedule is constructed around a steady state performance for both reprocessing and defuelling. However, experience has demonstrated that significant variations are to be expected in both. For this reason, sites will retain the capability to perform at above the average requirements to ensure that temporary shortfalls in performance can be recovered.

In optimising the schedule, the key considerations have been to:

- Optimise reduction of potential hazard
- Minimise risks from wet fuel in the event of further breakdown
- Ensure that the fuel delivery sequence will not impede reprocessing
- Minimise risk of constraining FHP activities due to lack of fuel

MOP 8 Projected Wet Fuel Stock Reduction



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- Ensure that all spent fuel is reprocessed
- Protect against adverse effects on staff and equipment caused by extended timescales
- Maintain funding for decommissioning programme through electricity generation
- Minimise costs.

The resulting defuelling schedule is shown in Section 3.2.

Main Conclusions

Continued application of MOP management processes has maintained progress towards the delivery of the MOP mission despite a series of issues adversely affecting the performance of Magnox Reprocessing and its associated plants since publication of MOP7.

Government policy is that reprocessing spent Magnox fuel is the BPEO. The NDA contractors charged with delivering and managing the MOP have adopted a prudent forecast of future reprocessing performance consistent with the principles established in the NDA Programme Control Procedures (PCPs). This forecasts that Magnox fuel reprocessing will be complete around January 2016. The planned defuelling dates for the Magnox power stations have been prioritised and re-phased so as to enable the fuel to be removed from all of the stations, transferred to Sellafield and reprocessed by this date. Despite extension of the MOP end dates UK commitments under the OSPAR convention can still be met.

The speed at which stations can be defuelled is constrained by a number of practical and resource issues, including the availability of storage capacity at the FHP at Sellafield and the capability to handle the necessary skips and flasks. This is now controlled in line with a Wet Fuel Stock Policy to help reduce the risk of fuel corrosion.

Continued operation of stations to a phased and structured closure programme increases the total amount of fuel that must be managed. The option exists to remove this additional liability from the MOP by immediate closure of all stations. However, the additional good spent fuel that arises from generation is not difficult to manage and handling it does not significantly increase the risk of failing to complete reprocessing around 2016. Income from electricity generation makes an important contribution to funding clean-up work.

The rate at which skips of "legacy" fuel can be drawn from the FHP pond for reprocessing is constrained primarily by the additional radioactive waste management problems associated with reprocessing that fuel and the need to remain within authorised discharge limits. There needs to be a steady flow of good fuel being decanned and fed to the reprocessing facility in parallel with the legacy fuel. Otherwise the plant would simply be operating at a greatly reduced capacity – below the minimum daily throughput levels necessary to enable continuous efficient operation of the reprocessing plant. A

Wylfa fuelling machine

steady flow of good fuel is also needed for the purpose of blending with fuels of different isotopic composition.

Working to the current MOP strategy (and reprocessing all Magnox fuel) remains very much the best available option. However the NDA is conducting a review of fallback options should the reprocessing plant fail in such a way that recovery is not viable. The nature of this contingency planning was shared with stakeholders at the NDA's NSG meeting in November 2007 but, in brief, the following options were identified: developing wet fuel drying capability and long term dry storage of irradiated fuel and alternative reprocessing options for Magnox fuel. The NDA is conducting detailed work to review these options before undertaking further engagement with stakeholders. [1]

[1] This paragraph is an update. The original text has been amended to include reference to contingency options under consideration and discussion with the National Stakeholder Group. It has been agreed with the document signatories.

1. Introduction & Scope

The Magnox Operating Programme (MOP) is an integrated programme across eight sites which supports the Nuclear Decommissioning Authority (NDA) strategy by delivering the safe and cost-effective closure of the Magnox business and management of the associated liabilities. This document has been prepared on behalf of the NDA by the MOP management team.

1.1 Magnox Generation and the Fuel Cycle

Magnox nuclear power stations utilise the energy of nuclear fission to heat steam to high pressure and drive turbines to generate electricity that is supplied to customers via the national grid.

Magnox fuel, manufactured at Springfields, is supplied to the power stations. The fuel is loaded into the reactors, where it generates energy through nuclear fission. Spent (irradiated) fuel is discharged from the reactors, and despatched to Sellafield where it is reprocessed into products suitable for long term storage or re-use. This process is known as the Magnox Fuel Cycle and its key components are illustrated in Figure 1.1 below. The reactors are defuelled (all fuel is removed from them) after generation ceases.

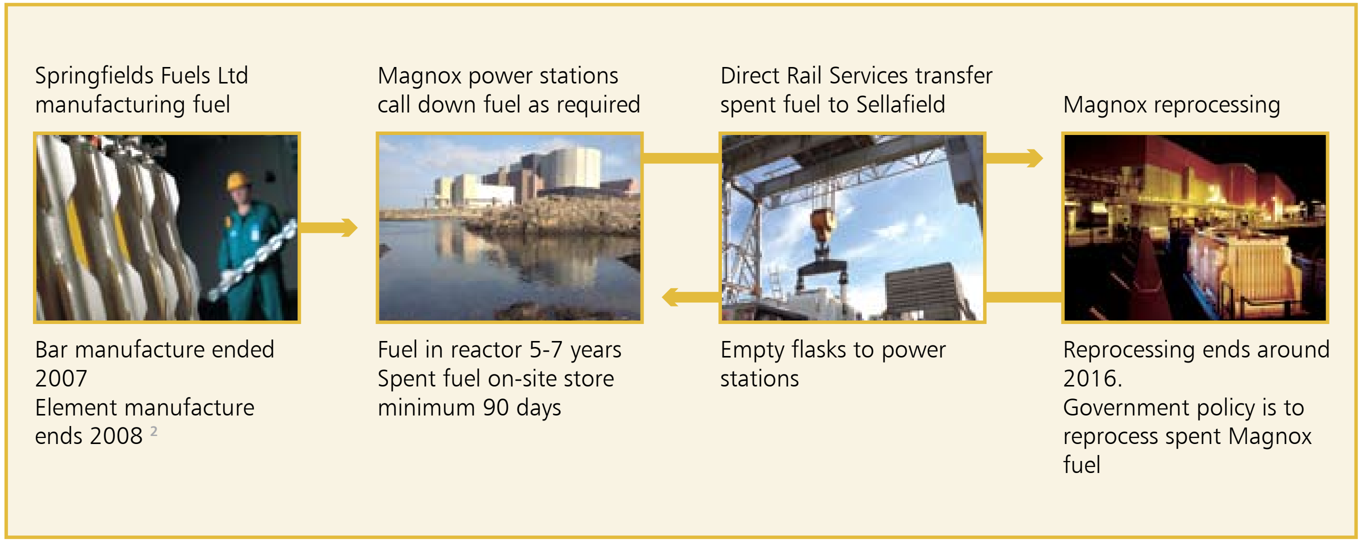


Figure 1.1 Magnox Fuel Cycle
The Magnox fuel cycle is described in more detail in Appendix C and further information on the plants and activities are in the sites' Lifetime Plans (LTPs).

[2] Februrary 2008 update: Element manufacture planned to continue to 2009

1.2 The MOP Mission Statement:

The MOP Mission is to:

- Optimise the Magnox closure programme making best use of the assets associated with management of the Magnox fuel cycle and enabling national and international environmental obligations to be supported
- Be challenging to deliver the MOP schedule in a safe, efficient and innovative manner.

Supporting High Level Objectives:

- The target level for incidents involving nuclear and conventional safety is zero
- The strategy must take into consideration Best Practicable Environmental Option (BPEO) methodology, and delivery processes must apply principles of Best Practicable Means (BPM)
- Minimise spent fuel liabilities enabling safe completion of reprocessing as soon as practicable
- Manage the impact of interacting businesses on the delivery of the Magnox programme
- Optimise economic return to the NDA from electricity generation, utilising the Magnox assets.

1.3 The MOP

This document outlines the strategy and processes associated with the delivery of the MOP mission statement. Inherent is a focus on the management of both operational and risk

1. Introduction & Scope

Sizewell A fuelling machine

aspects of the plan. The document describes:

- The scope of the MOP (This section)
- The history of the MOP and its achievements (Section 2)
- The chosen strategy for delivery of the MOP schedule, key milestones and associated assumptions (Section 3)
- Identified risks to the plan, associated mitigation and contingency plans (Section 4)
- The management processes that implement the MOP strategy (Section 5)
- The nature of the Magnox business and the environment in which it operates (Appendix B).

MOP8 sets target dates based on the conditions that applied at 31st August 2007.

1.4 Optimising the Fuel Cycle

From a UK wide perspective, there are benefits and disadvantages in the generation of electricity through nuclear power. At a high level these may be summarised as:

UK Benefits:
- Significant and diverse contribution to generation capacity
- Reduction in carbon dioxide emissions
- Creation of employment and socio-economic support to the local community
- Assets, capacity and expertise exist to facilitate UK-wide remediation solutions
- Provides expertise and capacity for potential sale in export markets.

UK Disadvantages:
- Assets and plant employed need to be decommissioned and made safe. They represent a long term liability
- Each new fuel element loaded into a reactor increases the liability for processing and long term storage
- Products and wastes in long term storage represent an ongoing liability.

The optimisation of the nuclear fuel cycle is, as is usually the case when maximising value, a question of defining an appropriate balance between these benefits and disadvantages. The value of the cycle is not solely dependent on maximising generation from the stations prior to closure. The potential exists to use the depth of experience and mature plant and processes to make a significant contribution to the full span of UK energy strategies, from generation to remediation.

The way the components of the fuel cycle help to optimise nuclear strategies is indicated in Table 1.4.

1. Introduction & Scope

Fuel Manufacture:	• Develop appropriate investment strategies and fit for purpose solutions • Manufacture fuel in an efficient, appropriate “just in time” process.
Stations:	• Optimise economic contribution • Maximise flask turn-round and payload • Manage reactor outages and defuelling programmes effectively • Engage with NDA and UK Government generation strategy to maximise contribution.
Sellafield:	• Minimise outages and programme slippages • Maximise daily rates when operating • Maximise efficient use of shared assets in support of British Energy operations and UK remediation plans • Manage impact of interacting plants and processes • Manage long term storage of products.
Magnox Operating Programme:	• Manage across boundaries and contracts • Contribute core skills, expertise and existing assets into development of UK wide remediation strategies • Integrate scheduling, using common processes and resources • Optimise defuelling activities and manage defuelling resource • Provide advice to NDA on maximising remaining generation income to support decommissioning programmes

Table 1.4 Contribution to Optimisation

The MOP Scope

The current scope of the MOP covers all Magnox fuel:

- In the final reactor cores of six Magnox stations
  - Calder Hall
  - Chapelcross
  - Dungeness A
  - Oldbury
  - Sizewell A
  - Wylfa
- In associated station stores (Ponds/Dry Cells) at these stations
- In the Fuel Handling Plant (FHP) at Sellafield
- To be discharged from reactors during refuelling operations at Oldbury and Wylfa until the end of generation
- In transit between stations and Sellafield
- In two skips of fuel from Studsvik in Sweden.

Considerations of including additional materials within the MOP Envelope (e.g. Dounreay blanket material and/or fuel in other legacy ponds at Sellafield) will be managed through the gatekeeper process.

1.6 MOP Endpoint

The end point of this plan will be:

- All Magnox fuel elements removed from reactor sites
- All Magnox fuel elements removed from FHP
- All Magnox fuel elements either reprocessed or in process
- All equipment associated with Magnox fuel will have an identified route for long term use, decommissioning and/or disposal.

1.7 Scope Amendment / Gatekeeper Process

The scope and schedule for the MOP requires precise definition and resource loading to enable successful delivery. It is recognised that the assets used to deliver the MOP could be used to deal with other material in order to further the aims of the overall NDA remediation programme.

Requests for the inclusion of further “Non-MOP” materials or activities are subject to the “Gatekeeper Process”, which involves full evaluation of the potential effect on the MOP, so that the NDA is able to make an informed decision on the way forward.

1. Introduction & Scope

Some of the questions that need to be answered in order to effectively incorporate new activities are listed below:

- Does the proposed activity impact on other NDA objectives/interests (positive/negative)?
- Can the activity be completed without impacting on MOP delivery?
- How does the proposal help achieve the primary objectives of the NDA programme?
- Are there alternatives to undertaking the activity and have they been considered?
- Is the most effective approach being used to complete the activity?
- Is the timing/sequence of the activity right?
- Is there an economic case for proposal?
- Does it meet regulatory requirements?

2. History of the MOP

Magnox reactors were the first type of nuclear reactor used for the commercially viable generation of electricity. For over forty years the Magnox fleet has made a significant contribution to electricity generation and generated income for its owner.

2.1 Magnox Stations, their History and Status

Eleven Magnox power stations were built in the UK, with a total of 26 Magnox reactors. Five of the power stations (ten reactors) ceased generation some time ago and have been defuelled completely and are being decommissioned. Another four power stations (12 reactors) have ceased generation, and are preparing to defuel. The last two power stations (4 reactors) are still operational.

In May 2000 latest closure dates were announced for the Magnox power stations. These were set to meet the constraints of periodic safety reviews and the need to defuel all the Magnox reactors within the time constraints of Magnox Reprocessing.

Table 2.1 identifies the fleet of Magnox power stations in the UK and indicates the current status of each reactor site. Figure 2.1 illustrates the contribution of Magnox power stations to UK generation since the start of MOP in 2001.

Station	Date of First Synchronisation	Date of End of Generation (Actual or Plan)	Reactors Defuelled? (Yes/No)	Electricity Exports up to August 2007 (TWh)	Future Electricity Exports (TWh)
Calder Hall	1956	March 2003	No	54	Nil
Chapelcross	1959	June 2004	No	60	Nil
Berkeley	1962	1989	Yes	43	Nil
Bradwell	1962	March 2002	Yes	60	Nil
Hunterston A	1964	1990	Yes	57	Nil
Trawsfynydd	1965	1991*/1993	Yes	72	Nil
Hinkley Point A	1965	1999*/2000	Yes	103	Nil
Dungeness A	1965	December 2006	No	120	Nil
Sizewell A	1966	December 2006	No	110	Nil
Oldbury	1968	December 2008	No	118	2
Wylfa	1971	December 2010	No	200	17
TOTALS				**997**	**19**

Table 2.1 Status of the Magnox stations

* Date of cessation of generation; second date is announcement of closure

(In addition to the UK reactors, Japan and Italy each had a Magnox reactor which sent its fuel to Sellafield for reprocessing. These stations have closed and their fuel has already been reprocessed)

2. History of the MOP

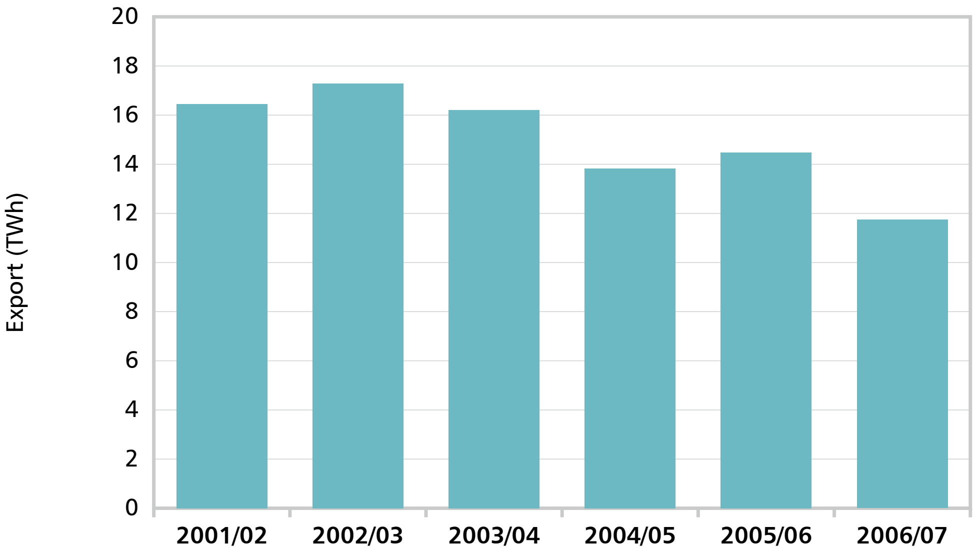


Figure 2.1 Electricity exported to the National Grid by Magnox Power Stations

Licensing and ownership of Magnox power stations has had a complex history, particularly in the preparations for privatisation of the electricity supply industry in March 1990. This is detailed in Appendix A. Appendix B describes the current business environment.

2.2 History of Reprocessing

The present Magnox Reprocessing plant at Sellafield came on line in 1964, receiving spent fuel from all Magnox stations and converting it into products suitable for safe long-term storage or re-use. It is still in operation, and it remains UK Government policy to reprocess spent Magnox fuel.

In 2001 BNFL wrote to the Environment Agency committing BNFL to complete reprocessing of all Magnox fuel by around 2012 and informing the Agency of revised closure dates for Oldbury and Wylfa. 2012 was selected as the target date for completing reprocessing in order to provide confidence that Post-Operational Clean-Out (POCO) of the Magnox Reprocessing plants will have been completed, and associated discharges ceased, well before 2020. This is important in the context of the UK's national strategy for reducing discharges and the objective of the UK and other contracting parties to the OSPAR Convention (Reference 1) of achieving near zero additional radionuclide concentrations in the marine environment in the North East Atlantic, North Sea and the Irish Sea by 2020. The main agreements focused on discharges from reprocessing where Technetium 99 (Tc99) was the primary species of interest and excluded discharges from Historic Wastes. There was no specific reference to reprocessing end dates. In July 2003 Sellafield successfully implemented a modification to divert waste streams containing Tc99, thereby substantially reducing the amount discharged from reprocessing. This positive contribution to environmental impact reduction means that the reprocessing section targets in the UK discharge plan can still be met even if reprocessing continues well beyond 2012.

Following the biennial outage of the reprocessing plant in 2005, decanning and reprocessing of spent fuel restarted 6 months later than planned as a result of delivering plant improvements. Consequently, decanning and reprocessing fell 466 tonnes below the 2005/06 plan. This reduction in reprocessing is illustrated in Figure 2.2 overleaf. During the outage, fuel deliveries from reactor sites continued at a level exceeding the declared P50 (50% confidence) programme by diverting resource from decanning to cleaning and release of fuel skips in FHP. This reduced the hazard from fuel stored at reactor sites, particularly Wylfa, Chapelcross and Bradwell. The combination of reduced decanning while maintaining deliveries to FHP increased the stocks of fuel in the FHP pond. Reprocessing of legacy fuel was affected, with little corroded fuel being reprocessed in the 2005/06 year. However, despite these outcomes the MOP continued to be deliverable within the previously declared 2012 timescale with some of the planned decanning rescheduled to the end of the programme where there was contingency. However, the changes significantly increased the forecast stocks of wet fuel, and made it unlikely that the site defuelling programmes could all be achieved to the MOP6 timetable. Consequently, the MOP team reviewed the options, and recommended that the defuelling programme at Calder Hall be slowed in order to reduce stocks of wet fuel, and improve confidence in completing defuelling at sites where it is on the critical path to decommissioning. The NDA Board gave consent to this significant revision of the Calder Hall LTP on 13 June 2006.

2.3 History of the MOP

Prior to January 1998, the interface between Magnox Electric plc (or its predecessors) and Sellafield for receipt, storage and reprocessing was through a commercial reprocessing contract. As indicated in Appendix A, the Government made Magnox Electric plc a wholly owned subsidiary of BNFL in 1998, recognising that a purely commercial/contractual arrangement was no longer in the best interests of the UK, and expected savings to arise from a more integrated organisation.

The MOP was originally formulated by Magnox Electric and BNFL and launched in June 2001 to optimise the remaining Magnox lifetime programme for fuel manufacture, generation, defuelling, fuel movements and reprocessing. It has fostered a closer working relationship and continuously improves the level of co-operation and planning between the principal delivery organisations.

The MOP has been reviewed and reissued periodically and regular

Figure 2.2 Magnox Fuel Reprocessed at Sellafield

meetings are held to co-ordinate activities, monitor progress and respond to threats and opportunities.

2.4 Achievements of the MOP to date

When the MOP was launched in 2001, three of the Magnox stations (Berkeley, Trawsfynydd and Hunterston) had shut down and been defuelled (all their spent fuel had been sent to Sellafield for reprocessing). One station (Hinkley Point A) had shut down, and was preparing to defuel. The other seven stations were still operational, contributing to the UK electricity supply, but planned closure dates for them had been announced. About 1600 tonnes of spent fuel had been removed from reactors and was being stored wet in station ponds or at Sellafield,

2. History of the MOP

awaiting reprocessing.

Since the launch of the MOP in June 2001 up to August 2007, the following have been achieved:

- 2530 tonnes of new fuel manufactured and delivered to the operating stations to support continued generation
- Total new fuel requirements defined, allowing Springfields to optimise their closure and decommissioning plans
- Three power stations (Bradwell, Sizewell A and Dungeness A) operated safely to their planned closure dates
- Two other power stations (Calder Hall and Chapelcross) operated safely until their closure, which was slightly ahead of their original planned closure dates
- These five stations, and the two still operating (Oldbury and Wylfa) together generated 90TWh of electricity, so avoiding the emission of up to 80 million tonnes of carbon dioxide
- Two stations (Hinkley and Bradwell) each completed defuelling of their two reactors 3-4 months ahead of schedule. This required the removal and shipping of 1186 tonnes of fuel
- The two fuel storage ponds at Chapelcross and Dry Store Cells 4 & 5 at Wylfa emptied of spent fuel, except for a small amount of damaged fuel in Dry Store Cell 4 requiring special arrangements [3]
- A total of 4596 tonnes of spent fuel moved from the operating and closed power stations to Sellafield. This required the 2551 movements of fuel flasks by rail or road in each direction, all of which were completed without incident
- Around 4500 tonnes of fuel reprocessed at Sellafield
- The total stock of wet fuel awaiting reprocessing reduced from 1600 tonnes in 2001 to 1250 tonnes in August 2007. This includes a reduction in the stock of corroded legacy fuel from around 600 tonnes to 325 tonnes
- Steps taken at all the power stations to increase the efficiency of loading fuel into transport flasks. The average flask loading had increased by 25%, so reducing the number of transport journeys required
- A series of modelling tools and techniques deployed at Sellafield in order to provide confidence levels for completion of the MOP and to enable analysis areas for targeted improvement
- A Magnox Reprocessing improvement plan developed at Sellafield to target the areas identified by the models.

[3] February 2008 update: Subsequent planned verification checks found a single fuel element in Dry Store Cell 5 which will shortly be removed.

3. The MOP Schedule

3.1 The Purpose of the MOP, its Principles and Inputs

3.1.1 Overview

The MOP is a fully integrated programme which facilitates the management of complex interfaces between disparate but linked sites within the NDA UK portfolio. The programme maps the flow of fuel through the Magnox Fuel Cycle and is key to both the achievement of the MOP Mission and the optimisation of the fuel cycle.

The effectiveness of the MOP is built on well defined management processes which provide the flexibility required to re-optimise the fuel cycle within changing circumstances.

A robust integrated programme is essential for both the effective measurement of MOP progress and the appropriate application of the MOP processes.

3.1.2 Principal Inputs to the MOP Strategy

The strategy principles underpinning the achievement of the mission statement are summarised in Table 3.1.2:

Principle	Action and Input to Programme
Safety and care for the environment are paramount.	All regulatory requirements and commitments will be met Operations will be BPEO/BPM UK Government OSPAR commitments will be met.
To remove risk from the process, as much fuel as possible must be removed as quickly as possible.	The Magnox Reprocessing plant should operate at maximum capacity, and fuel should be shipped to Sellafield to match that capacity It is recognised that reprocessing capability is the key constraint on MOP delivery Reprocessing rates must be within the Highly Active Liquor (HAL) and discharge authorisation constraints.
The defuelling period for each site should be as short as possible, to remove hazards, reduce costs and shorten the time to Care and Maintenance.	Station defuelling programmes should be optimised within MOP capability to support them.
Before the start of defuelling, a station should: • Maximise the income from generation • Prepare for a speedy transfer from generation to defuelling and to decommissioning • Make preparations for defuelling at the highest rate reasonably achievable.	The MOP key dates implement this logic.

Table 3.1.2: MOP strategy principles

3.1.3 Status against MOP7 Programme and the Consequence for MOP8

Despite a number of issues around the performance of Magnox Reprocessing and its associated plants (which are listed in Appendix B.5) the programme flexibility and appropriate application of MOP management processes have ensured continuing progress towards the delivery of the MOP mission.

In particular:

- The fuel cycle continued to generate income to help with the cost of the NDA clean-up programme. Sizewell and Dungeness successfully operated until their declared closure dates. Their performance in their last year of operation was exceptional and both stations generated more in the calendar year 2006 than in any year since 1994. Oldbury and Wylfa continue to contribute to the UK electricity supply
- The Sizewell and Dungeness fuel usage closely matched their fuel orders. All but nine tonnes of the available fuel was used. (The excess was returned from Dungeness to Springfields and reused to make fuel for Oldbury)
- Despite less than planned decanning,

innovative work at both FHP and stations meant that the P50 target for the transfer of fuel between stations and Sellafield in 2006/07 was exceeded removing hazard from across the UK
- Projects designed to improve the defuelling capability at Calder Hall and Chapelcross are being delivered
- Bradwell defuelling was completed ahead of schedule in August 2006, successfully removing another power station from the MOP
- All fuel was removed from Wylfa dry cell store 5 in December 2006, and all undamaged fuel was removed from dry store cell 4 in March 2007. [3]

However the lower than planned reprocessing of spent fuel at Sellafield resulted in the total amount of fuel to be reprocessed at the end of April 2007 being 1000 tonnes greater than had been assumed in MOP6. A detailed re-evaluation of Magnox Reprocessing forecasts was undertaken as described in Section 3.1.5 below.

These revised reprocessing assumptions have consequences for all of the constituent parts of the MOP, in particular:

- The effect of spent fuel being stored much longer in ponds needs to be understood and mitigation put into place
- Station defuelling logic and key dates have to be re-optimised
- Direct Rail Services (DRS) support in transporting fuel will be required for longer than previously planned
- Risks and opportunities across both the MOP and the wider NDA portfolio need to be revisited.

The following sections expand on the key issues and the optimisation process.

3.1.4 Fuel to be Reprocessed

Section 1.5 lists the fuel that is to be reprocessed within the scope of the MOP. In April 2007 there were just under 5900 tonnes of spent Magnox fuel to be reprocessed. This was broken down as follows:

Dry Fuel already irradiated	4027 tonnes
Wet fuel already irradiated	1315 tonnes
New fuel that is assumed will be irradiated*	Up to 540 tonnes

*In the event of there being surplus unused fuel at the end of generation, it will be returned to Springfields Fuels Ltd rather than being reprocessed.

3.1.5 Capability to Reprocess the Fuel

As part of the process to create the programme for MOP8, detailed modelling and assessments have been performed of reprocessing performance to date, operational risks going forward and the potential impact on the MOP of continuing under-performance.

As a result of this work, a conscious decision has been taken to set a more realistic and less optimistic reprocessing programme to underpin MOP8 in order to facilitate robust station defuelling and resource plans.

The significant change in the MOP8 programme when compared with MOPs 1 to 7 is the declaration of a P80 (80% confidence) end date for Magnox Reprocessing of around January 2016, compared with “around the end of 2012”. Despite this planning assumption, improvement plans are being prepared and enacted to pull the end date forward.

At the start of the MOP, the FHP pond at Sellafield contained around 600 tonnes of corroded fuel (often referred to as “legacy fuel”). Legacy fuel is more difficult to process than “good” fuel. By April 2006 260 tonnes had been successfully reprocessed, but the remaining fuel has proved even more difficult to process. Longer fuel preparation time in the sub-ponds and in the decanner cells along with high activity challenges to Site Ion Exchange Plant (SIXEP) meant that the predicted rates for reprocessing needed to be reassessed. For planning purposes it has been assumed that the quantity of corroded fuel in FHP will be reduced

3. The MOP Schedule

at a uniform rate over the whole duration of the MOP. It remains an aim to reduce the quantity as quickly as can be achieved without jeopardising the overall reprocessing rate. New and innovative methods of fuel preparation are being explored continually with the aim of safely speeding up the processing as much as is practicable.

The radionuclides present in spent Magnox fuel vary depending upon how heavily the fuel has been irradiated, and upon whether the Uranium content of the fuel has been enriched. Safety case requirements in the Magnox Reprocessing plant and downstream plants restrict the possible radionuclide composition of fuel. Some fuels need to be blended so that the combined characteristics satisfy the requirements. In addition, legacy fuel requires good fuel (specifically good Magnox swarf) to mix with swarf/sludge from corroded fuel to meet the Magnox Encapsulation Plant (MEP) Conditions for Acceptance. Consequently, the FHP pond needs to retain a stock of good fuel to maintain optimum performance.

3.1.6 Defuelling sites

Most sites will defuel their reactors and despatch fuel to Sellafield using their existing fuel routes. The fuel routes have been reviewed to identify investments needed to ensure reliable performance during defuelling. In addition, Chapelcross and Calder Hall modified their fuel routes to enable standard skips and flasks to be used for transport to FHP.

Previous defuelling stations have experienced operational issues that have slowed or stopped defuelling for several months. Sites have reviewed their own risks, and modelled performance. The defuelling windows in the MOP8 schedule are designed to ensure that sites are 80% confident of completing by the end date provided that reprocessing rates are achieved, and that the identified fuel route investments are made.

Although the site defuelling programmes are based on the P80 reprocessing schedule, sites need to be capable of responding to requests to increase their defuelling rate or bring forward the start of defuelling if:

- Magnox Reprocessing exceeds the P80 programme
- The site has fallen behind schedule
- Another site has fallen behind its defuelling schedule.

Each site has considered the potential for this and how long it would take to implement such a change.

3.1.7 Environmental and Safety Issues

Environmental and safety issues are managed and licensed on a site by site basis and detailed discussion of these is outside the scope of the MOP. However the MOP has an influence on hazard reduction and on discharges because it determines the order in which sites defuel and the amount of fuel that will be stored wet (Appendix D).

The amount of fuel stored in FHP and station ponds is currently higher than had been foreseen in previous MOP schedules. Because Magnox fuel cannot be stored wet indefinitely, if a reprocessing outage lasting several years were to occur, corrosion would, in time, result in fuel failures. This would further complicate and slow the decanning process, and potentially challenge discharge levels. In the most extreme case an alternative method of dealing with the fuel would be required. In order to limit the potential effect of such an event, new wet fuel stock controls have been put in place. These are designed to reduce the quantity of wet Magnox fuel awaiting reprocessing from the April 2007 level of 1300 tonnes to 800 tonnes by April 2010. This will limit the wet fuel hazard in the event of a prolonged shutdown of Magnox Reprocessing.

Removing all fuel from sites is a major contributor to hazard reduction at stations.

3. The MOP Schedule

Flask at Wylfa railhead

In addition, at stations with ponds, discharges will be reduced when the station pond is taken out of service. Overall, it is preferable to have completed defuelling and taken the ponds out of service at a few sites rather than having only partly defuelled several sites.

At Sellafield the emphasis is on earliest possible completion of reprocessing, and particularly on removing the corroded legacy fuel to reduce discharges.

The principles described above are designed to ensure:

- Operations are conducted in a manner which promotes and supports the safety of workers and members of the public
- Operations are in compliance with national and international regulations and legislation
- The strategy is BPEO and operations use BPM (Appendix B.10)
- Liabilities and hazards across the Magnox spent fuel cycle are progressively reduced.

3.1.8 Costs

Continuing to operate Magnox power stations necessarily involves loading additional fuel into reactors and an increase in the total amount of spent fuel to be managed at Sellafield facilities. This does incur additional costs, liabilities and risk but it also generates income to fund clean-up (and contributes to UK electricity supply needs). Without this income the scope of decommissioning work scheduled over the next three years would need to be reduced.

The changes to reprocessing and defuelling schedules will affect site work scope and costs, but the precise effects require detailed consideration of the MOP8 schedule. This will be done during production of LTP08.

3. The MOP Schedule

3.2 Optimising the Programme

3.2.1 Optimisation Principles

The order of station defuelling has been optimised based upon the amended MOP performance assumptions, as described earlier. The key constraints are the potential unavailability of any of the suite of plants at Sellafield on which reprocessing depends, the restrictions imposed by reducing wet fuel stocks to 800 tonnes, and the defuelling capabilities of the sites.

In optimising the schedule, the key considerations have been to:

- Optimise hazard reduction balancing the risks associated with wet storage, dry storage and reprocessing (Appendix (B.10)
- Minimise risks from wet fuel in the event of further breakdown (Appendix (D)
- Ensure that the fuel delivery sequence will not impede reprocessing (Appendix C)
- Minimise risk of constraining FHP activities due to lack of fuel (Appendix C)
- Ensure that all spent fuel is reprocessed
- Protect against adverse effects on staff and equipment caused by extended timescales
- Maintain funding for decommissioning programme through electricity generation
- Minimise costs.

Defuelling priorities

1. Chapelcross

Chapelcross reactors 3 and 4 contain enriched fuel which takes longer to reprocess, and cannot be co-reprocessed with Oldbury/Wylfa low enriched fuel (LEU). To avoid a negative impact on the reprocessing rate, Chapelcross has been scheduled to defuel well ahead of Oldbury and Wylfa. The original reactor defuelling sequence has also been changed and defuelling of reactors 3 and 4 has been brought forward to remove constraints.

2. Dungeness A

Each reactor at Dungeness A is in a separate building and discharges its fuel into its own pond. Thus, emptying one reactor/pond would allow decommissioning of those buildings to progress. The plan will be to defuel reactor 1 as quickly as possible given the supply of flasks to the station, and to defuel reactor 2 utilising any additional capacity.

3. Sizewell A

Sizewell A has a common reactor pilecap and common pond so there is less benefit from defuelling one reactor ahead of the other. It is scheduled to follow Dungeness when permitted by the wet fuel stock controls.

4. Oldbury

Oldbury contains both natural and LEU in both reactors and has two types of fuel cladding, resulting in four different fuel types to manage. The LEU cannot be co-reprocessed with Chapelcross enriched fuel and so should be shipped after the Chapelcross fuel has been reprocessed. Also, because the station is scheduled to generate until December 2008 it will not be ready to start defuelling as early as Sizewell.

5. Wylfa

Wylfa is scheduled to generate to December 2010 subject to review in 2009. It has the largest reactor cores with a combined total of 1100 tonnes of fuel to move. As it is one of the last stations to defuel, there needs to be a high degree of confidence in its defuelling capability. Because of the close linkage between Sellafield reprocessing rate and Wylfa defuelling at the end of the MOP, the rate of defuelling is likely to fluctuate considerably. Wylfa has primary and secondary defuelling routes and MOP8 assumes that both will be available for use during defuelling.

6. Calder Hall

Fuel has been stored in-reactor safely for several years at Calder Hall. Because the reactors are on the Sellafield Site there would be relatively little reduction in site costs on removing all fuel. Moving fuel from Calder to FHP uses on-site transport, so the station can be used to mitigate against risks to inter-site transport. Defuelling Calder in parallel with Wylfa helps to mitigate against risks from Wylfa fuel route breakdowns.

3.2.2 Defuelling Schedule

The MOP8 defuelling schedule reflects the priorities above. It assumes that Magnox reprocessing will complete around the end of January 2016. The station defuelling periods are then set to ensure that defuelling at each site can be achieved with 80% confidence. The schedule is constructed around a steady state performance for both reprocessing and defuelling. Experience has demonstrated that significant variations are to be expected in both. For this reason, sites need to retain the capability to perform at above the average requirements to ensure that temporary shortfalls in performance can be recovered. The overall programme is shown in Figure 3.2.2. The key dates and quantities are shown in Tables 3.2.2a and 3.2.2b.

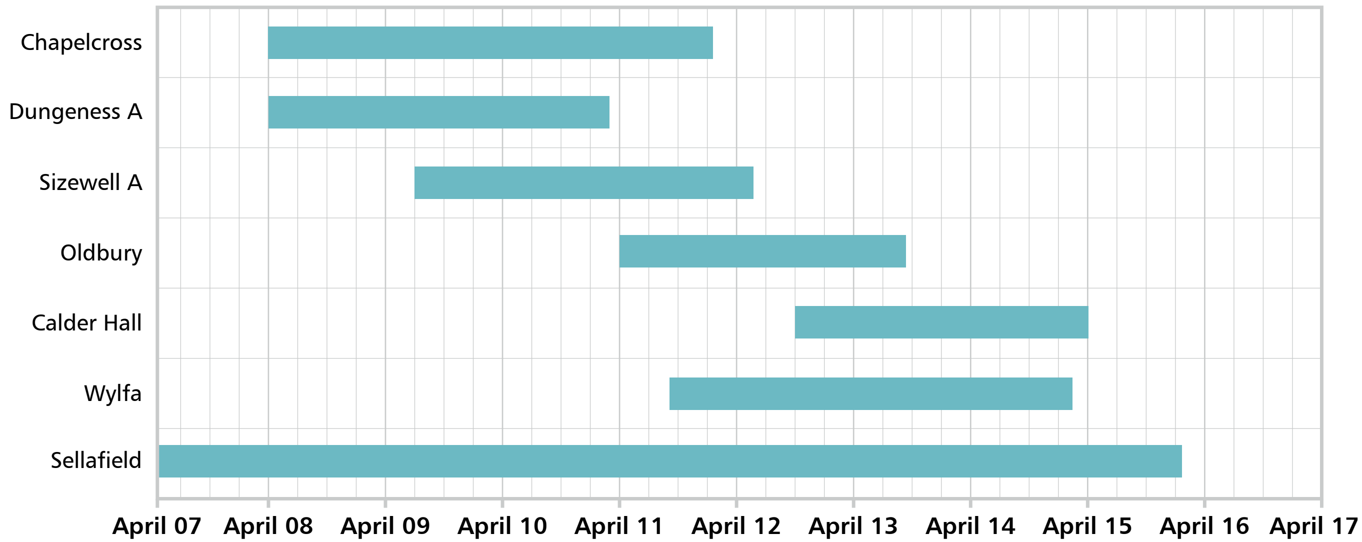


Figure 3.2.2 MOP8 Defuelling Schedule

Site	Start Bulk Defuelling	Last Fuel Off-site
Calder Hall	October 2012	May 2015
Chapelcross	April 2008	August 2011
Dungeness A	April 2008	March 2011
Oldbury	April 2011	September 2013
Sizewell A	July 2009	June 2012
Wylfa	August 2011	January 2015
Sellafield	completes reprocessing around January 2016	

All the dates are P80 estimates and the intention is to complete defuelling and reprocessing sooner.

Table 3.2.2a MOP8 Key Programme dates

3. The MOP Schedule

	Calder Hall	Chapelcross	Dungeness A	Oldbury	Sizewell A	Wylfa	Total
2007/8	0	10	46	37	51	130	274
2008/9	0	98	191	30	10	102	431
2009/10	0	140	263	50	130	141	724
2010/11	0	140	163	16	223	121	663
2011/12	0	50	0	203	223	201	677
2012/13	53	0	0	254	41	364	711
2013/14	187	0	0	104	0	423	713
2014/15	192	0	0	0	0	324	516
2015/16	14	0	0	0	0	0	14
Total Lifetime	447	437	663	693	679	1806	4724

Table 3.2.2b Planned Annual Fuel Deliveries to Sellafield (in tonnes/annum)

Operation of Magnox Reprocessing into the financial year 2015/16 would require the supporting plant operating for longer than has previously been planned. All such dependencies will be taken into account in producing LTP08.

Compared to previous MOP issues, the stations are significantly later in starting and completing defuelling. The changes have a particular impact on:

- When decommissioning/hazard reduction activities can begin at sites
- What workforce skills need to be retained and for how long
- How best to manage sites and people while awaiting the later start date for defuelling
- Extended lifetime requirements for equipment and services (e.g. trains/railheads)
- Overall programme costs.

The Magnox North and Magnox South Executives have reviewed the proposed MOP changes and identified potential options for reducing the adverse effects of the programme delays. These will be included during the production of LTP08.

The impact of delayed defuelling at Calder Hall is less of an issue than at other stations because the workforce can be redeployed to other, similar, work across the Sellafield site. However there is a short-term challenge for the Sellafield decommissioning strategy, as current projects are now likely to cease before the next wave of substantial plants become available for decommissioning.

It was announced in September 2007 that proposals for the establishment of a National Skills Academy for the nuclear sector has been accepted by the Department for Innovation, Universities and Skills; the organisation will have its Head Office in West Cumbria and will assist employers in addressing future skills gaps. This should assist in mitigating the impact of delayed defuelling on the availability of suitable trained and experienced staff for the subsequent decommissioning activities.

3.3 Economic Justification

The 1995 submission to the Environment Agency for Radioactive Substances Act reauthorisation of nine sites from Magnox Electric to BNFL included an economic review to confirm the economic benefits outweighed the environmental disadvantages.

During the re-authorisation process, the Environment Agency asked BNFL to state the Company's policy on whether it would operate uneconomic stations. BNFL responded as follows:

"Subject to safety and environmental compliance, BNFL will continue to operate the power stations for as long as the revenues earned exceed avoidable costs.

3. The MOP Schedule

It is company policy to close down:

- An individual Magnox power station if it becomes uneconomic to continue to operate the station, and
- The complete tranche of Magnox power stations if it becomes uneconomic to continue to operate the tranche."

Subsequent to this statement Hinkley Point A, Bradwell, Calder Hall, Chapelcross, Dungeness A and Sizewell A have been closed.

Such decisions would now be made by the NDA based on advice from the Site Licence Companies (SLCs). (The NDA receives the revenue from the electricity generation which then contributes to meeting the costs of clean-up.)

The economic assessment is based on the avoidable cost of continued operation compared with the anticipated income from electricity sales if the stations generate to their planned closure dates of December 2008 for Oldbury and December 2010 for Wylfa. The avoidable cost was calculated as the difference between:

- The Base Case – the lifetime cost of the fuel cycle if Oldbury and Wylfa generate to the end of their operational life, and
- The Scenario Case – the lifetime cost of the fuel cycle if all stations were to close at midnight on 31st March in the year the assessment is being carried out.

All costs associated with operations prior to the reference date are excluded on the basis that, in economic terms, they are "sunk" and unavoidable costs. Depreciation and decommissioning costs are deemed to be unavoidable on the same basis (i.e. they relate to expenditure that has already been incurred or, in the case of decommissioning, they are a necessary expenditure that cannot be avoided).

The key assumptions that underpin this review are:

- Accounting results and projections are of limited value because of the large element of "sunk" costs, hence the avoidable cost methodology is employed, i.e. the value of continued operation is the difference between future income and "avoidable" costs
- "Base Case" is all costs of operating stations and the relevant Springfields and Sellafield plants to the end of the current MOP schedule
- Future income is a function of generation to the end of generating lifetimes, and assumed price
- The calculation includes the Net Present Value (NPV) / Cash effect of advancing decommissioning at Oldbury and Wylfa and/or any additional care and maintenance prior to decommissioning
- Early closure of Magnox Reprocessing would result in a shift in operating costs which could then be reallocated to other clean-up activities on the Sellafield site.

The methodology and results were subject to an exhaustive independent review by Ernst and Young in December 1998 which broadly accepted the methodology and the results obtained at that time. The Environment Agency went on to declare that the continued operation of the Magnox power stations was justified and new Radioactive Substance Act authorisations were implemented in December 2002.

The economic review has been performed in each year since then as part of the MOP management processes, employing the same avoidable cost methodology used in the 1998 review.

The most recent calculation undertaken for closure at the end of this financial year gave a Net Present Value of continued operation of £418m using an 8% discount rate. (The calculation uses a P50 estimate of future generation and an 8% discount rate to remain consistent with previous NPV calculations.)

It is therefore concluded there are a number of benefits to continuing to operate power stations to their planned closure date, provided this does not significantly delay the end of Magnox reprocessing.

The conclusion of the NPV model is insensitive to discount rate, as shown by Figure: 3.3.a.

The price of electricity is an important variable in these calculations. Following a dip in price in 2002, the price increased substantially in 2005 and 2006 before declining to its present level between £30 and £40/MWh, as shown in Figure 3.3.b.

Whilst future predictions of electricity prices are uncertain, the underlying costs of coal and gas indicate that electricity price is unlikely to fall to a point that would undermine the economic justification. The current levels reflect the long-term costs of generation identified in the Royal Academy of Engineering Report (Reference 2) giving further confidence that prices are unlikely to fall significantly over the long-term.

The insensitivity of the NPV to the discount rate and the forecast electricity prices ensure that the NPV benefit of the MOP remains robust.

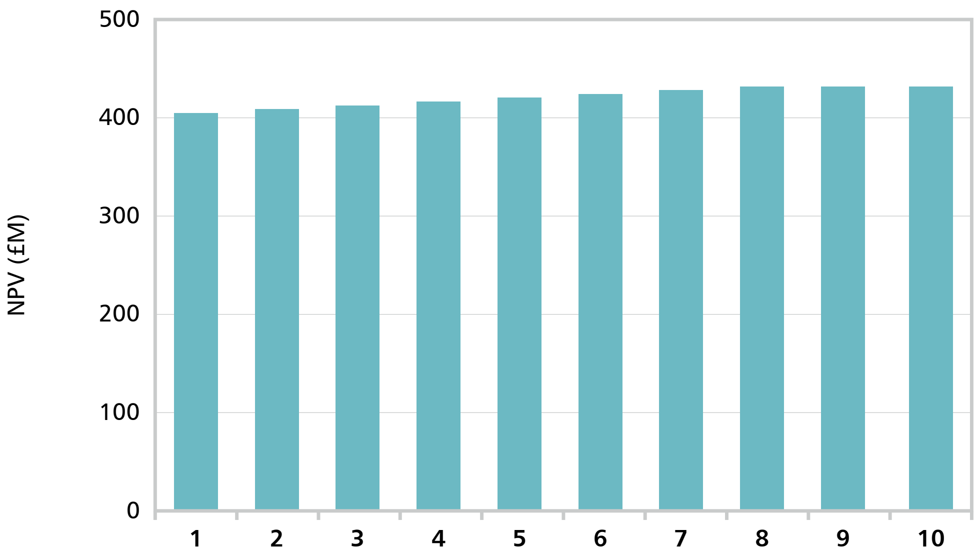


Figure 3.3.a Variation of NPV with Discount Rate

Figure 3.3.b Prices for Electricity 2001 to 2007

4. Risks to MOP and Contingencies

A flask move at Sellafield

Achieving the MOP objectives requires many risks to be managed. The consequences of the risks mainly affect site schedules and overall NDA programme costs. Some of the risks could additionally have an impact on safety or the environment.

Under the NDA Programme Controls, responsibility for managing most risks generally rests with the sites. SLCs and the North and South regions of Magnox Electric keep risk registers to help manage high level and generic risks. The MOP team also maintains an overview to ensure that cross-site effects are recognised and that mitigation is in place at an appropriate level. The high level generic MOP programme risks are listed in Table 4a together with their probability and impact classified in accordance with NDA procedure PCP10 (Reference 3) based on their impact on programme costs and site schedules. Table 4b lists MOP opportunities.

These risks are reviewed periodically by the MOP team. Sites may have several site level or plant level risks that contribute to a single MOP risk. This is particularly the case at Sellafield where a large number of downstream plants and site services can affect Magnox Reprocessing. These plant level and site level risks are managed under the site risk management procedures.

Decanning and reprocessing fuel is the key activity linking all the sites. Stoppages or reduced performance can affect the ability of the power stations to refuel or defuel. Whether the problem is caused by internal issues, downstream plant or external influences, the overall effect on the MOP is similar. For most of the period of the MOP, the reprocessing performance is the key risk to stations completing defuelling to their programmed dates. A work-stream is underway at Sellafield to build upon the existing risk management process further enhancing and strengthening it. Towards the end of the MOP, when Wylfa and Calder Hall are defuelling, poor defuelling performance by these two stations could delay the completion of Magnox reprocessing.

The most severe risk would result from total loss of reprocessing capability. The MOP8 Reprocessing Schedule is underpinned by newly developed models at Sellafield which analyse current and historic performance and use that data to predict future performance. A key strength of these models is their ability to map the process across the numerous plant interfaces at Sellafield, covering both reprocessing facilities and supporting downstream plants.

The information on "risk areas and pinch points" thus generated is forming the basis of further work aimed at identifying key unmitigated risks to the MOP and assisting in the process of focussing improvements across the whole cycle.

The MOP is predicated on the Magnox Reprocessing route being UK national policy and assumes that it will be available for as long as it is needed.

4. Risks to MOP and Contingencies

There is currently no technically underpinned alternative to this reprocessing route, but as part of the MOP management and risk mitigation processes potential alternatives are continually under active review by both NDA and Site Licence Companies.

Table 4a – Main MOP Risks

Event - Risks	Potential Root Causes	Impact Description	Impact Level	Probability	Controls In Place	Mitigation
Major failure of any of the plants or services at Sellafield on which decanning depends, resulting in prolonged outage of decanning/ reprocessing	Decanning depends on a number of ageing facilities	Long interruption to decanning/ reprocessing, or possibly permanent end to decanning/ reprocessing	Critical	Possible	Asset care plan and major Sellafield Site projects	1) Reducing the quantities of wet-stored fuel (as planned) will reduce the environmental risk 2) Magnox Options work on alternative disposal routes
Rate of decanning / reprocessing at Sellafield falls below plan	The performance of reprocessing plants and their interfacing plants is below historical availability Some fuel is unexpectedly difficult to decan or reprocess	Need to reduce rate of defuelling to minimise quantity of wet fuel Completion of defuelling of some power stations is delayed Completion of reprocessing is delayed	Significant	Possible	Asset care plan and major Sellafield Site projects	1) Reducing the quantities of wet-stored fuel (as planned) will reduce the environmental risk 2) Magnox Options work on alternative disposal routes
		Not all the fuel is reprocessed	Critical	Unlikely	Asset care plan and major Sellafield Site projects	Consider early end to generation (but fuel quantities small so little benefit)
All available Plutonium storage space at Sellafield is filled before the new store is ready	New Plutonium store project is not ready before Jan 09	Reprocessing would have to stop until the new store is available	Significant	Unlikely	Recover new Plutonium Store schedule	Refurbishment of existing stores to take the expected arisings
Additional materials introduced to MOP	NDA require Magnox Reprocessing to take other material (e.g. Dounreay blanket material)	Magnox fuel reprocessing is likely to take longer or the other material displaces Magnox fuel from being reprocessed	Significant	Unlikely	The MOP gatekeeper process will be applied to identify the likely impact of additional materials and recommend the best option to the NDA	Would be agreed as part of gatekeeper process
Moratorium on spent fuel transport	Could arise from a transport incident anywhere in the world	Cannot move fuel by road or rail until resolved	Significant	Very Unlikely	Careful attention to spent fuel movements	1) Maintain ample buffer stock of fuel in FHP 2) Advance/accelerate defuelling of Calder Hall 3) Advance/accelerate defuelling of Chapelcross if the moratorium affects only rail transport

4. Risks to MOP and Contingencies

Event - Risks	Potential Root Causes	Impact Description	Impact Level	Probability	Controls In Place	Mitigation
Chapelcross, Dungeness or Sizewell encounter a problem which slows or stops defuelling	Difficulty in discharging fuel Equipment breakdown	Slippage in spent fuel delivery programme to FHP	Significant	Unlikely	Site defuelling plans have included "lessons learned" from earlier defuelling sites	Increase rate of defuelling from unaffected reactors of Dungeness, Sizewell, or Chapelcross
Chapelcross and Calder Hall Fuel Route Transition Projects encounter a major problem	This is a major new installation, which may experience unexpected problems, for example interfacing with existing equipment	Delayed start to defuelling from Chapelcross and Calder Hall	Significant	Very unlikely	Project Risk Management	1) Increase rate of defuelling Dungeness or Sizewell for Chapelcross 2) Calder Hall defuelling plans to include "lessons learned" from Chapelcross defuelling
Oldbury ceases generation before December 2008	NII do not accept graphite safety case Major plant failure	Reduced NDA income	Significant	Possible		1) Unlikely that defuelling could be advanced significantly 2) Arrangements for staff deployment post shutdown being developed in case needed ahead of plan
Oldbury encounters a problem which delays/slows defuelling	Difficulty in discharging fuel Equipment breakdown	Slippage in spent fuel delivery programme to FHP Delay to completion of defuelling of the site	Significant	Unlikely	Site defuelling plans have included "lessons learned" from earlier defuelling sites	Increase rate of defuelling from unaffected reactor at Oldbury, or at Wylfa or Calder Hall
Wylfa ceases generation before March 2010	Major plant failure Strategic decision to limit additional irradiated fuel	Reduced NDA income	Critical	Unlikely		Shut down/defuelling safety case being developed early in case needed ahead of plan
Extension of Wylfa generation up to December 2010	Decision to take the option to generate for longer in support of NDA objectives	Short delay to the completion of defuelling of Wylfa, compared to ceasing generation at the end of March 2010	Significant	Likely	Site review of defuelling risks and opportunities	Review Wylfa end of generation date
Wylfa encounters a problem which slows defuelling	Difficulty in discharging fuel Equipment breakdown	Delays completion of defuelling at Wylfa Places Wylfa on the critical path for the completion of reprocessing at Sellafield	Significant	Possible	Site review of defuelling risks and opportunities	1) Project to make diverse discharge route (DDR) available for defuelling 2) Increase rate of defuelling Calder Hall
Loss of suitably qualified and experienced (SQEP) staff from reactor defuelling teams or from central technical support	Age profile of staff and normal staff turnover, exacerbated by delays to defuelling plan dates	Slows or stops defuelling	Significant	Likely	Site manpower planning	1) Recruit and train additional staff 2) HR development package for relevant staff 3) National Skills Academy Nuclear

4. Risks to MOP and Contingencies

Table 4b - Main MOP Opportunities

Event - Opportunity	Potential Root Causes	Impact Description	Impact Level	Probability	Controls In Place	Opportunity
Decanning / reprocessing exceeds plan	The performance of reprocessing plants and their interfacing plants exceeds historical availability	Can accelerate defuelling programmes and the MOP end date	Marginal (If small amounts/ periods) Significant (if larger amounts/ periods)	Possible (if small amounts/ periods) Unlikely (if larger amounts/ periods)	1) Maximising decanning within equipment limits and other constraints (e.g. legacy fuel) 2) Active management of identified risks associated with plant) 3) Implementation of the Magnox Improvement Plan	1) Increase rate of defuelling reactors already defuelling and hence early completion of defuelling 2) Advance date of start of defuelling other reactors 3) Add other materials into the MOP 4) Early remediation of FHP pond 5) Increase in SIXEP capacity for earlier remediation of Sellafield legacy ponds and silos 6) Significant cost savings to allow investment in other remediation opportunities
Oldbury ceases generation before December 2008	NII do not accept graphite safety case Major plant failure	Small reduction in fuel to be reprocessed	Marginal	Possible		1) Slight reduction in reprocessing risks 2) Natural uranium from unirradiated fuel can be sold
Wylfa ceases generation before March 2010	Major plant failure Strategic decision to limit additional irradiated fuel	Small reduction in fuel to be reprocessed	Marginal	Unlikely		1) Slight reduction in reprocessing risks 2) Natural uranium from unirradiated fuel can be sold
Extension of Wylfa generation up to December 2010	Decision to take the option to generate for longer in support of NDA objectives	Additional income from ~4 TWh additional generation	Critical	Likely	Site review of defuelling risks and opportunities Review Wylfa end of generation date	Income for NDA from additional generation

5. Implementing the MOP Strategy

Section 3 of this document describes the chosen strategy for the MOP. This section aims to describe how the strategy will be implemented, focussing on the role and interface between the MOP and individual site's LTPs.

5.1 The Relationship of the MOP Strategy to LTPs

LTPs describe the scope, schedule and cost of all the work that will be done for each site. It is therefore essential that they are fully aligned with the requirements of achieving the MOP.

The MOP defines certain key milestones that are fed into the site LTPs. Achieving these key milestones to time, quality and cost will ensure that the benefit of the MOP is realised. Accountability for delivering the LTPs is vested in the site management.

The MOP team also defines certain tactical targets that are fed into the LTPs to facilitate delivery of the key milestones. Central co-ordination of the milestones and targets takes into account the complex interactions between the sites.

The key milestones are:

Reactor sites:	• Generation end • Defuelling start • Defuelling end.
Sellafield:	• Reprocessing plant outage start/end • FHP pond cleared of legacy fuel • Last fuel loaded into dissolver.

The key metrics are:

Reactor sites:	• Tonnes of fuel dispatched each year • Level of wet fuel stock • Pond/store inventory at year end • Annual generation.
Sellafield	• Tonnes of fuel reprocessed per year • Tonnes of legacy fuel reprocessed per year • Level of wet fuel stock • Number of flasks dispatched per year.

With these arrangements, the MOP document is not a detailed implementation plan, but directs the site plans to achieve the MOP mission as indicated in Figure 5.1.

The strategy, as well as providing clear milestones, also links electricity generation forecasts to spent fuel transfers from stations and ultimate conversion of the liabilities to a safer form for storage. This high level direction is interpreted into lower level tactical targets for implementation and delivery of the lifetime strategy.

It should be noted that whilst there is a predominant downward influence depicted in Figure 5.1, there is a key upward influence associated with changes at site level which have the potential to change the MOP strategy.

5. Implementing the MOP Strategy

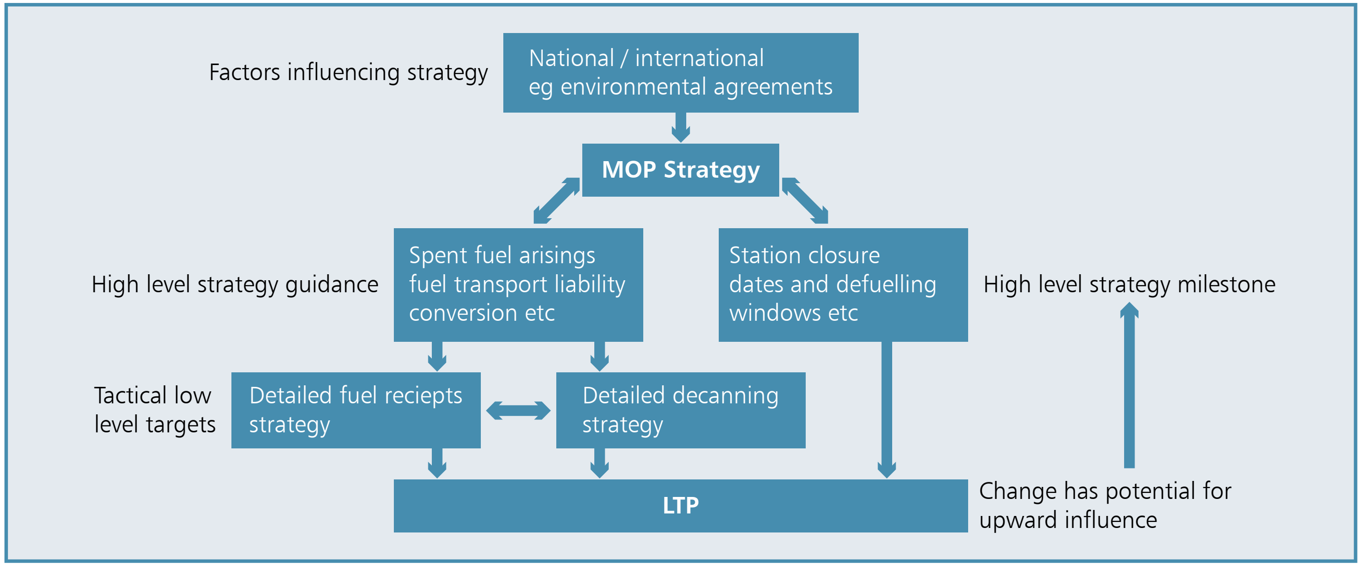


Figure 5.1 The Hierarchical Dissemination of Business Strategy from MOP down to LTPs

5.2 Change Processes

5.2.1 Changes to Key Targets

The approved key metrics listed in section 5.1 are annual operational targets held, and managed on behalf of NDA, by the MOP team. Due to the complex interactions between all the sites, each site's ability to meet its targets is dependent on both its own performance throughout the year and that of other sites.

Each year, the MOP team reviews the position across all the sites contributing to the MOP, and proposes priorities in consultation with senior management and the NDA. When agreed, the MOP team updates the key milestones and metrics. These are incorporated into LTPs, and the NDA approve annual performance targets annually based on them.

The management of the annual targets has close linkages with the day to day management of fuel logistics. The 13-week Flask Allocation Plan is drawn up quarterly to meet each site's required performance levels and in this way the overall MOP strategy drives the detailed implementation of the plan. Where issues arise that are likely to impact delivery of the targets, sites report them as trends to NDA and raise change control requests for NDA approval if appropriate. This process is controlled by the MOP Management Procedure (Reference 4).

6. References

1. OSPAR is the Oslo - Paris Commission which adopted a convention in 1992 for the protection of the marine environment in the North East Atlantic, North Sea and the Irish Sea.

2. "The Costs of Generating Electricity" Royal Academy of Engineering, 10th March 2004.

3. "Baseline Management System – Risk Management" Doc No PCP10 Rev 1, 27th June 2006, Nuclear Decommissioning Authority.

4. "Magnox Operating Programme Management Procedure", ME/M/22 Issue 2 2006.

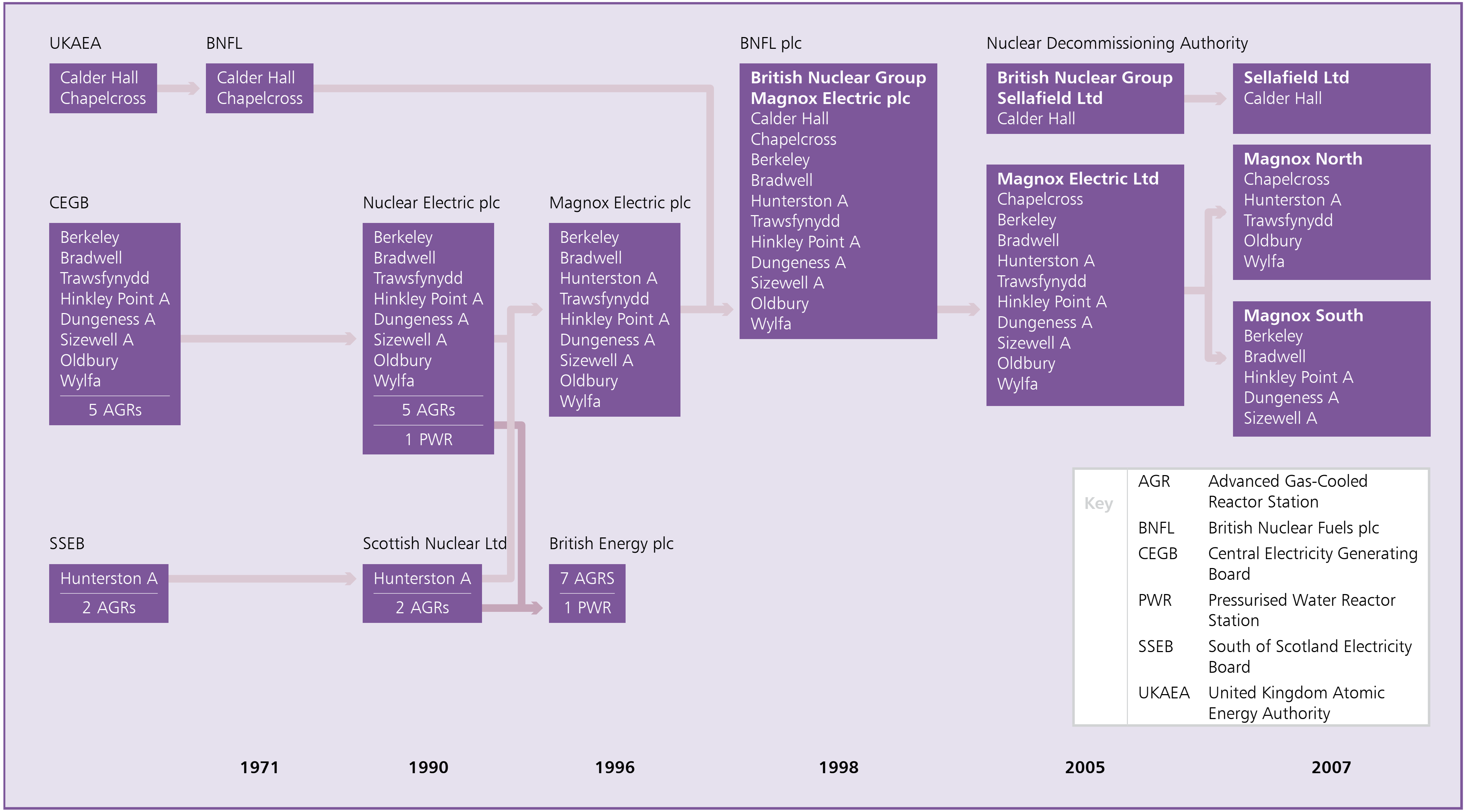
5. NDA Strategy, March 2006, www.nda.gov.uk.

6. "Managing the Nuclear Legacy", UK Government White Paper, Cm5552, July 2002.

7. "Regulations for the Safe Transport of Radioactive Material" IAEA Safety Standards Series No. TS-R-1, 2005.

Appendix A - Industry Background

Licensing and ownership of Magnox power stations has had a complex history. Figure A.1 below summarises the changes.



Appendix A - Industry Background

The ownership of the Nuclear Licensed sites was transferred from BNFL plc and Magnox Electric plc to the NDA on 1 April 2005. The transition of the previous plant owners to Management and Operations (M&O) contractors has had a major impact on the way that the MOP is managed. Appendix B.6 gives more details.

The four main organisations charged with delivering the MOP are now:

Organisation	Function	Parent Body Organisation
Springfields Fuels Ltd	Manufacture of new nuclear fuel (Magnox and Advanced Gas-cooled Reactor, AGR)	Toshiba / Westinghouse
Magnox Electric Ltd	Electricity generation Defuelling and decommissioning of reactor sites	Energy*Solutions*
Sellafield Ltd	Operates the Fuel Handling Plant and Magnox Reprocessing Plants and other plants and processes at Sellafield	BNFL
Direct Rail Services (DRS)	Rail company transporting nuclear fuel flasks (Magnox and AGR)	Subsidiary of the NDA

Ownership of the MOP has also been transferred from BNFL to the NDA; the MOP is included in individual LTPs and operated by Magnox Electric Ltd and Sellafield Ltd on behalf of the NDA.

The NDA Strategy (Reference 5) approved in March 2006, calls for the Magnox reactor sites to be managed by two separate SLCs: Magnox North Ltd and Magnox South Ltd. It has been agreed that Magnox North will manage the MOP on behalf of Magnox South, and this has been written in to the documentation prepared for separation of the SLCs.

Appendix B - Business Environment

The MOP aims to establish a single integrated and cohesive strategy for the whole of the Magnox business, aimed at effective delivery of its primary objectives.

B.1 Context

There is a range of fundamental technical, operational, commercial, political and regulatory considerations that bound the scope of the MOP. This appendix briefly considers some key factors that define the environment within which the Magnox businesses operate in order to explain the parameters which influence the chosen strategy.

B.2 The Priority is Clean-Up

The Government has made clear (Reference 6) that its (and therefore the NDA's) priority is to deal with legacy wastes and redundant facilities. Activities that are more commercial in nature may be justified but only if they are compatible with wider objectives for clean-up, the cost-effective discharge of liabilities, and the generation of additional income to accelerate clean-up. The NDA issued their strategy document (Reference 5) in March 2006, and this is now the overarching document within which MOP will operate.

B.3 Political Factors

The original commitment of an end date of around 2012 for completion of Magnox reprocessing was derived to permit POCO of the Magnox Reprocessing plants, and for the associated discharges to cease, well before 2020, i.e. within the timescale for OSPAR (Reference 1) commitments to be met.

This is important in the context of the UK's national strategy for reducing discharges and the objective of the UK and other contracting parties to the OSPAR Convention of achieving near zero additional radionuclide concentrations in the marine environment in the North East Atlantic, North Sea and the Irish Sea by 2020.

The main agreements focused on discharges from reprocessing where Tc99 was the primary species of interest and excluded discharges from Historic Wastes. There was no specific reference to reprocessing end dates. Subsequent work to implement Tc99 abatement means that the Tc99 discharges resulting from reprocessing are very significantly reduced. This positive contribution to environmental impact reduction means that, despite the later reprocessing end date being used for MOP8, the reprocessing section targets in the UK discharge plan can still be met. Indeed, modelling indicates approximately a year of contingency between the MOP8 planned end date and the sector targets being challenged.

There are stakeholder issues that will have to be managed arising from this change, which will be achieved via implementation of the associated NDA stakeholder communications plan. This is in support of the routine NDA/stakeholder dialogue meetings that take place.

A DEFRA review of progress towards meeting UK OSPAR commitments is underway with intent to go to public consultation in Spring 2008 and to have a revised strategy in place for the OSPAR Ministers meeting in 2010. DEFRA requests for information concerning future discharges have been met using LTP07 as the reference and projected discharges and doses have also been produced, recognising the possible extension of the MOP.

Although Magnox reprocessing is now spread over a longer period, the total quantity of fuel to be reprocessed has not increased and hence the total discharges from reprocessing operations will not be increased.

B.4 Regulatory Environment

The requirement to ensure the health and safety of workers and the public and the need to ensure the protection of the environment are important and underpin every aspect of the Magnox business.

Accordingly, all activities covered in the MOP

Appendix B - Business Environment

are carried out in compliance with stringent regulatory controls and in consultation with the relevant regulators. The need to remain within stringent discharge limits, comply with safety cases, and ensure total compliance with Site Licence requirements places a tight operational boundary on the MOP.

B.5 Reliance on Availability of Downstream Plants and Facilities

Delivery of the MOP is dependent on smooth operation of all the relevant Sellafield-based Magnox fuel management facilities.

Magnox Reprocessing Operating Unit encompasses the following plants on the Sellafield Site:

- Fuel Handling Plant (FHP)
- Magnox Reprocessing Plant
- Site Ion Exchange Effluent Plant (SIXEP)
- Magnox Uranium Finishing and Medium Active Salt Free Evaporation
- Magnox Plutonium Finishing and Storage.

Other major plants and services required for the reprocessing of Magnox fuel under the direct control of other strategic business groups are:

- The Magnox Encapsulation Plant (MEP)
- Site Services (including utilities, road and rail transport)
- HAL Evaporation, Storage and Vitrification
- Services from the Low Active Effluent Plants
- Solid waste management services (ranging from miscellaneous beta-gamma waste and plutonium contaminated material to low level waste)
- Analytical Services.

The ability to operate all these facilities to their fullest capacity is dependent on the continued smooth operation of all the above plants and services including those operated by other business groups within Sellafield Ltd.

B.6 Contract Arrangements

On the 1st April 2005 the NDA took ownership of all the sites and assets previously owned by BNFL (and UKAEA), and let M&O contracts for the operation of these assets to deliver the NDA's objectives, including management and development of the MOP. The M&O contractors prepare LTPs which detail the work required (scope, schedule and cost) in detail for year one and in less detail for subsequent years. The costs, quantities and timescales are at a P50 level for the first year (i.e. actual is equally likely to be above or below plan) and at P80 for subsequent years.

Following NDA approval, the work is carried out by the contractor and funded by the NDA. During the course of executing the work circumstances will change, the LTPs can be changed by either the contractor or NDA raising a Change Control Request (CCR), providing both parties agree the changes. In order to drive the contractor towards site goals, the NDA agree "performance based incentives" with the contractor. These specify the scope schedule and cost that the contractor must deliver to earn an incentive fee. They are normally taken from objectives and milestones in the site LTPs. The work required to manage the MOP is specified in the LTPs, thus the MOP is owned by the NDA but developed, maintained and managed by Magnox Electric Ltd and Sellafield Ltd on behalf of the NDA.

When the MOP was established the four organisations involved (Springfields Fuels, Magnox Electric, DRS and Sellafield) were all organisations within the BNFL Group of companies. DRS is now a wholly owned subsidiary of the NDA, and Springfields is part of the Westinghouse Group which has been sold to Toshiba. DRS and Springfields are still contributing to the MOP, and their involvements are managed via:

- a contract between Magnox Electric Ltd and DRS
- a Joint Internal Procedure (JIP) between Magnox Electric Ltd and Springfields Fuels Ltd.

Appendix B - Business Environment

The NDA strategy has set out a timetable for competing the M&O contracts with sites being bundled and competed. The contracting strategy will bring further changes to the MOP framework, but not to the MOP objectives or strategy.

Future arrangements will be developed together with the NDA and other stakeholders. In the future, as now, all LTPs will be aligned to MOP delivery.

B.7 Regulatory and Site Interfaces

The overall strategy for the management of spent fuel is contained within the NDA Strategy, approved by the Government. The role of the MOP is to implement the NDA strategy safely and with care for the environment. Individual sites contributing to the MOP are subject to formal regulation through Site Licence conditions (NII) and Discharge Authorisations (EA/SEPA), and the movement of radioactive materials is regulated by the Department for Transport.

The MOP is optimising the management of spent fuel across all sites and it is sometimes necessary to discuss the MOP as a whole with all the regulators and there is regular ongoing dialogue.

B.8 Phasing the Station Closure Programme

Immediate closure of the remaining operating stations (Oldbury and Wylfa) would reduce the total quantity of fuel to be managed in the future by up to 540 tonnes. While this would reduce pressure on the Magnox (and AGR) fuel management facilities it would not enable the overall timetable for defuelling of stations and reprocessing the fuel to be brought forward substantially. Furthermore, continued operation of the Magnox power stations has a number of benefits:

- Contributes to security and diversity of electricity supplies in the UK
- Provides continued employment and investment in the local areas
- Avoids the use of fossil-fuel power stations that would emit the quantities of gases shown in Table B.8, if they were used to produce equivalent amounts of electricity
- Maintains staff in a "Suitably Qualified and Experienced" (SQEP) state ready to defuel
- Maintains fuel route equipment in an operational state ready to defuel
- Provides an income stream which will help offset the costs of clean-up.

The financial benefit is quantified in Section 3.3.

Transmission lines

Appendix B - Business Environment

Power Station	Remaining Lifetime saving (tonnes)		
	Sulphur Dioxide	Nitrogen Oxides	Carbon Dioxide
Oldbury	20,000	6,000	1,700,000
Wylfa	170,000	51,000	14,600,000
Total	190,000	57,000	16,300,000

Table B.8 Emissions Savings through continued Magnox generation.

Ceasing generation early does not necessarily enable a reactor to commence defuelling early. The process of agreeing a strategy for shutting down, defuelling and decommissioning a reactor and reaching agreement with the NII on the associated safety cases needs to be worked through fully before defuelling can commence. This process takes around three years to complete and requires the allocation of significant resources. A phased station closure programme allows this preparatory work to be carried out in a structured way making sensible use of available resources, enables additional income to be created through the sale of electricity, and makes a significant contribution to UK electricity generation. In any event, infrastructure limitations mean it would not be practicable to resource defuelling of more than two or three stations at a time so little would be gained from shutting down both generating stations early.

Therefore, as discussed in section 3.3, it remains economically beneficial to continue operating the Magnox stations to currently planned operating lifetimes and operate a phased closure programme to 2010.

B.9 Government Policy on Reprocessing

The management of spent Magnox fuel has a potentially substantial impact on the environment, and it is appropriate to ask whether reprocessing is BPEO for spent Magnox fuel. This has been the subject of a number of Government and independent reviews, in particular by the Radioactive Waste Management Advisory Committee. As a result reprocessing of Magnox fuel has been agreed to be BPEO and it is UK National Policy to reprocess spent Magnox fuel, while ensuring BPM is applied to all processes.

B.10 Develop and Implement BPEO and BPM Strategies

BPEO/BPM are used to minimise impact on environment, and minimise dose to workers.

Both Magnox cladding and uranium metal corrode in water giving a potential for the release of fission products and consequently an increase in the radioactive content of storage pond water. If this activity is not controlled / removed it could ultimately result in a radioactive discharge to the environment. Additionally, high levels of radioactivity in water could result in increased operator doses. It is, therefore, important that all possible steps are taken to maintain fuel integrity during storage by managing pond stock levels, fuel age distribution, water condition and isotopic concentrations.

Storage conditions in station ponds and FHP pond are discussed in Appendix C. MOP metrics include both fuel quantities and pond water activity levels. These are subject to weekly scrutiny by the MOP team and considered in the planning process.

Following the cessation of generation at Sizewell and Dungeness the hazard from spent fuel in storage at stations has been further reduced. At Sizewell the pond has been emptied of fuel and good progress is being made with emptying the Dungeness pond. During defuelling these ponds will only hold minimum operational levels significantly reducing the hazard potential.

The discharge of radioactivity from fuel storage and reprocessing at Sellafield is closely monitored and optimised. A key facility is

Appendix B - Business Environment

SIXEP which removes activity from liquors from a number of Sellafield facilities, and use of SIXEP must be optimised between Magnox Reprocessing and site remediation activities. Further discussion of SIXEP operations follows in Appendix C.

Discharges of Tc99 were reduced during 2003 by diverting the concentrate from the medium active evaporator into the high active evaporator, hence diverting Tc99 to a waste stream which will be vitrified. In parallel, and following a successful trial, Tc99 is being removed from the medium active concentrate discharge stream using tetraphenyl-phosphoniumbromide (TPP). This implements an OSPAR undertaking and the reductions are in line with national and international expectations and the wishes of Government and the Environment Agency.

B.11 Safe Transport of Spent Magnox Fuel

Spent Magnox fuel is transported in transport flasks type M2 in accordance with IAEA requirements (Reference 7). The design authority for the 40 type M2 flasks is Magnox Electric Ltd. The type 1197 flask that was previously used for Chapelcross fuel has been phased out of service.

Each location has a "Flask Champion" who acts as the focal point for flask operations. The Flask Champions routinely meet to share information and best practice, and identify generic issues for consideration; although Magnox and AGR flasks are different in detailed design, British Energy staff are part of the Flask Champion network to ensure best possible information exchange.

An example of joint working is the Flask and Flatrol Contamination Task Force that was instrumental in driving down the levels and frequency of notification reports through procedural changes and engineered improvements. The frequency of such events is now below the historical frequency; the incidence is regularly monitored through the MOP management process, and any reports are investigated to establish if lessons can be learned.

B.12 Nuclear Security

In order to ensure safety of workers and public with respect to external threats, operations at reactor sites, at Sellafield, and the transport of nuclear fuel are carried out within the requirements of the Office of Civil Nuclear Security (OCNS). There are currently no issues that have a fundamental effect on the MOP.

B.13 Managing British Energy Fuel

As well as receiving Magnox fuel, FHP at Sellafield receives, dismantles and stores British Energy (BE) AGR fuel prior to transferring to THORP for reprocessing. Dismantling AGR fuel assemblies at FHP greatly increases the quantity of fuel pins that may be stored in the same size container. There is insufficient room available at THORP storage facilities for AGR fuel to be delivered direct without first being dismantled.

The schedule for delivering Magnox fuel to FHP is carefully planned to make maximum use of available resources and deliver most effective progress towards handling lifetime fuel arisings. The timetable for deliveries of AGR fuel, on the other hand, is determined by the contract terms agreed between BNFL and BE. The delivery schedule takes no account of the competing needs of Magnox fuel deliveries and therefore precludes the most effective scheduling of total fuel receipts at FHP. Any discussions about the optimisation of resources and capacity at FHP would be a contractual matter for Sellafield Ltd, BE and the NDA.

Appendix C - MOP and the Magnox Fuel Cycle

The Magnox fuel cycle is described briefly in section 1. Magnox fuel, manufactured at Springfields, is delivered to the power stations to meet demand. The fuel is loaded into the reactors, where it generates energy through nuclear fission. Spent (irradiated) fuel is discharged from the reactors, and despatched to Sellafield where it is reprocessed into products suitable for long term storage or re-use.

This appendix provides more detail of the activities, and identifies those activities which are particularly significant for the MOP strategy. The activities covered are:

Activity	Table
New fuel requirements	C1
New fuel supply	C1
Discharge fuel from reactors	C1
On-site fuel storage	C2
Transport spent fuel from reactor sites	C2
Transport logistics	C2
Fuel receipt	C3
Preparation of skips for return to station	C3
Fuel to pond	C3
Fuel preparation for decanning	C4
Decanning	C4
Uranium bars to reprocessing	C4
SIXEP	C5
MEP	C5

Appendix C - MOP and the Magnox Fuel Cycle

Table C.1

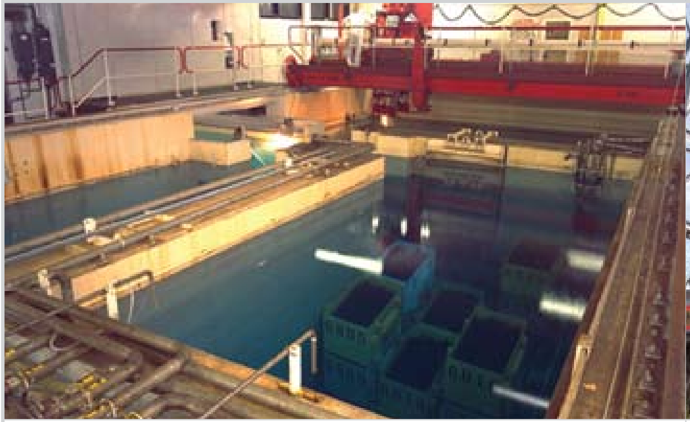
New Fuel Requirements	New Fuel Supply	Discharge Fuel from Reactors
		

• End of generation dates agreed to maximise NDA income while not prejudicing defuelling
• New end of life fuel cycles introduced to:
  • Reduce new fuel required, and hence:
  • Reduce spent fuel for reprocessing, and
  • Reduce fuel route activity in final months of generation allowing fuel route modification and refurbishment in preparation for defuelling
  • Improve match between fuel quality and reprocessing technical constraints
• Final order for total fuel placed December 2004
• Breakdown by element type finalised March 2005
• Monitor fuel usage, making minor adjustments to order.
	• Plant closure and decommissioning programme optimised for fixed, final fuel order
	• Manufacture of uranium bars completed
	• Manufacture of completed elements continues at reduced rate. This:
	  • reduces requirement to store completed elements on reactor sites
	  • maintains SQEP staff to advise on potential future fuel problems
	• Deliver fuel to reactors sites as required by generation programme
	• Unused fuel will have the Magnox cans removed and the uranium recovered.
		• During refuelling spent (irradiated) fuel is replaced by new unused fuel
		• During defuelling spent fuel is removed, at approximately four times the rate of normal refuelling
		• Need to demonstrate that on completion of defuelling no fuel elements are left in the reactors
		• Fuel is discharged to cooling ponds (Dungeness, Sizewell, Oldbury) or dry storage (Wylfa)
		• Calder Hall and Chapelcross discharge fuel directly into a transport flask (no on-site storage)
		• May need to package fuel in such a way that interaction with reprocessing constraints is minimised.

Strategic inputs to MOP • New, innovative fuel cycles have removed ~300 tonnes of fuel from manufacture and reprocessing requirements.	**Strategic inputs to MOP** • Plant closure programme has been optimised • SQEP staff retained • Unused fuel will not be reprocessed, but recovered at Springfields.	**Strategic inputs to MOP** • Fuel routes need to work faster during defuelling than refuelling • Defuelling need to be optimised both for rate and fuel property interaction with reprocessing constraints.

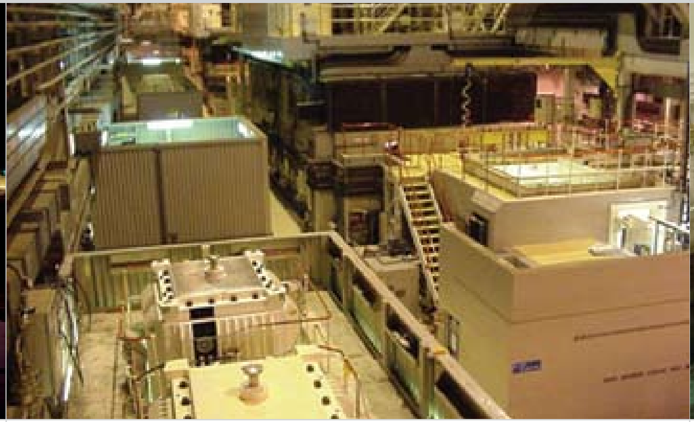
Appendix C - MOP and the Magnox Fuel Cycle

Table C.2

On-Site Fuel Storage	Transport spent fuel from reactor sites	Transport Logistics
		
• For pond storage, control and monitor water chemistry to maintain fuel integrity • Monitor quantity of fuel, to ensure adequate contingency for future discharges • For pond storage, monitor age of fuel and avoid excessive wet storage quantity and/or duration • If fuel should fail in reactor pond storage, ship to FHP where abatement facilities are more efficient • If fuel route equipment breaks down, deliveries will be rescheduled to take fuel from a different site, correcting for the change later in the plan.	• Flask delivery plan specifies delivery programme • Receive transport flask with empty skip • Identify fuel to be shipped, check constraints and safety case limits (e.g. minimum 90 day cooling). Normally oldest fuel first • Dungeness, Sizewell, Oldbury – replace empty skip with skip containing spent fuel • Chapelcross, Calder Hall, Wylfa – load fuel directly into skip in flask • Load as many elements as possible into skip • Carry out pre-despatch operations and monitoring before flask despatch.	• 10 road transporters for flask movements • 40 M2 spent fuel transport flasks • 51 Flatrols (rail transport wagons jointly owned with British Energy) • Engines and rail crew provided by DRS under contract • Railheads owned by Network Rail and leased to DRS • Track closures and diversions may be required to facilitate railway track maintenance and upgrade.
Strategic inputs to MOP • Maintaining fuel integrity is a critical activity • The fuel delivery plan (reactors to Sellafield) must take into account quantities, and ages, of fuel in storage • The Flask Plan will respond to short-term perturbations to optimise delivery while meeting the strategic objectives.	**Strategic inputs to MOP** • MOP Flask Plan determines delivery schedule • Increasing flask payload reduces the number of flask transports (and associated handling activities) for the same amount of fuel moved.	**Strategic inputs to MOP** • Transport infrastructure must be maintained until the end of the MOP delivery programme • Network Rail actions to maintain / improve the network are unlikely to have any significant effect on spent fuel deliveries.

Appendix C - MOP and the Magnox Fuel Cycle

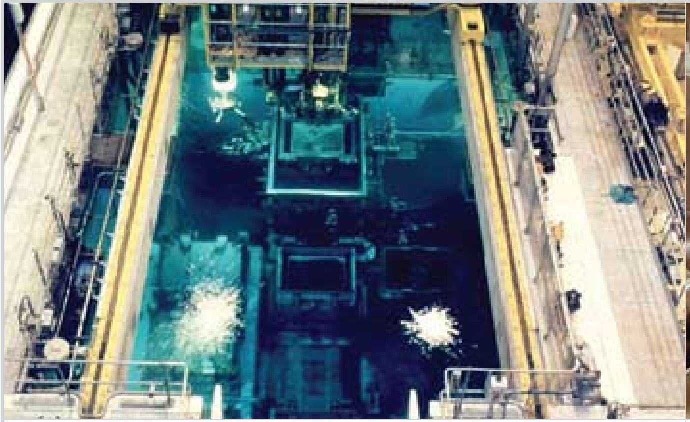
Table C.3

Fuel receipt	Preparation of skips for return to station	Fuel to pond
		
• Flasks of fuel received into 1 of 3 inlet cells • Receipt checks carried out • Skips of spent fuel removed from flasks and put into empty containers prior to pond storage • Empty skips removed from containers and placed in flask ready for return to stations	• Empty skips selected according to station requirement • Skips washed • Checks carried out to confirm that despatch criteria are met, e.g. free from debris, paint condition etc.	• Fuel stored in skips in containers • To control pond water activity the container's contents are isolated from the bulk pond by creating an ullage at the top of the container • Containers have to be re-ullaged periodically to maintain the ullage.
Strategic inputs to MOP • Before receiving a skip of spent fuel elements, it is necessary to have a container with an empty skip – so the storage capacity is limited by the number of containers • If all the skips are full there is a direct linkage between decanning rates and flask receipt rates (the way to empty a skip is to decan the contents) • Inlet Cell operations are close to the critical path • Increasing flask payloads allows more fuel to be delivered for the same number of handling operations • AGR fuel movements must be included in the overall programme.	**Strategic inputs to MOP** • Skip despatch criteria include both physical condition and contamination assessment • The need to match short/long skips to stations makes a strong link between the decanning plan and the fuel delivery plan • Operational strategies are being evaluated to avoid difficulties when short skips are no longer required in service • Monitoring procedures have been implemented which reduce the incidence of contaminated skips received at stations.	**Strategic inputs to MOP** • Pond storage is ultimately limited by the number of available containers • Total pond capacity is rated at 1400 tonnes, although not all of this is utilised. Stock is controlled through the Wet Fuel Stock Policy (Appendix D) • Re-ullaging reduces the contribution to FHP pond activity from corroded fuel in storage • Prevent the formation of new legacy fuel (by maintaining current specifications for ullaging and caustic solution) • Ensure fuel now being received is not stored so long that it is added to the "legacy" category.

Appendix C - MOP and the Magnox Fuel Cycle

Table C.4

Fuel preparation for decanning

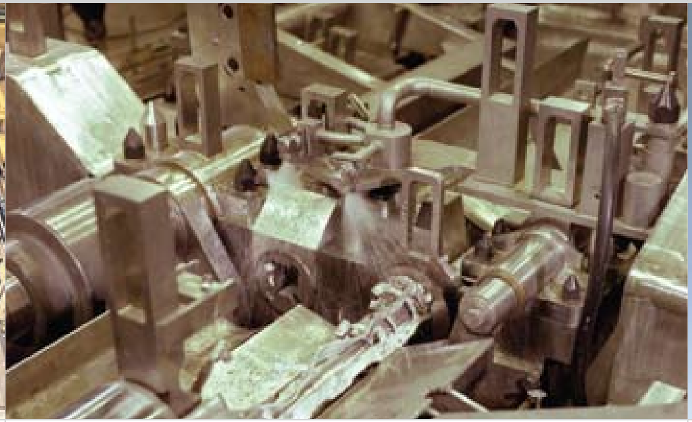


- Containers moved from main pond to 1 of 3 sub-ponds
- Containers flushed to limit activity release to main pond
- Container contents purged to flush free activity to SIXEP to limit activity release to the pond
- Container lids removed
- Confirm the fuel identity through skip/ container number
- Skips and contents washed as required
- Containers and skips moved to 1 of 2 decanner ramps.

Strategic inputs to MOP

- A longer preparation time is required for legacy fuel
- High activity challenge to SIXEP from pond water activity and fuel preparation liquors when reprocessing legacy fuel
- Higher quantities of solid waste to SIXEP from sludge arisings when processing legacy fuel
- Preparation of legacy fuel for decanning is time consuming.

Decanning



- Decanning plan matches fuel in pond with reprocessing technical limits
- Containers moved up decanner ramp into decanner cell
- Fuel elements removed from skip and placed on strip line
- End fittings cropped at end of each element
- Element forced through a die to remove outer Magnox cladding (known as swarf).

Strategic inputs to MOP

- Within the Magnox Reprocessing suite of plants, decanning is the critical path
- Reprocessing technical limits are factored into the delivery plan
- Legacy fuel will be decanned and reprocessed as quickly as practicable.

Uranium bars to reprocessing

- Uranium bars loaded into magazines
- Full magazines loaded into internal transfer flasks
- Flasks transferred to the reprocessing plant via internal site rail
- Fuel elements ejected into a dissolver
- Dissolved elements undergo chemical separation
- Plant safety cases specify the required fuel mixes based on irradiation levels and enrichments.

Strategic inputs to MOP

- Very low or very high irradiation fuel requires special treatment
- Station defuelling plans are being developed to limit the number of skips with very low or high average irradiations
- Throughput should be maintained at 3 tonnes/day and above, a rate that cannot be achieved by decanning legacy fuel on its own.

Appendix C - MOP and the Magnox Fuel Cycle

Table C.5

SIXEP	Magnox Swarf to MEP
	
SIXEP comprises three main areas: • The Sea Discharge Treatment Plant (SDTP) - designed to remove solids and soluble radioactive caesium and strontium from pond water purges prior to discharge to sea • Storage of spent sand from the sand filters and spent clinoptilolite from the ion exchange columns. Storage of sludge from FHP operations and from the first generation storage pond • FHP Pond cooling - fission product decay heat produced during the storage of Magnox and AGR fuel is removed from the re-circulated FHP pond water in the closed loop cooling plant.	• Magnox swarf collected in decanner cell and transferred to encapsulation and storage. The following checks are carried out: • Uranium content – to meet the Conditions for Acceptance which will limit the uranium content in each encapsulated drum as required by the safety case • Hydrogen evolution rate, which is limited by the safety case for Magnox swarf bin transfer There is a very limited buffer capacity and decanning operations can be halted by: • Breakdowns in MEP • Excessive hydrogen evolution from corroding Magnox swarf.
Strategic inputs to MOP • SIXEP operation is critical to legacy fuel reprocessing • Legacy fuel processing and elevated FHP pond water activity creates a high activity challenge to SIXEP. Despite good SIXEP performance the SIXEP discharges are elevated, and are predicted to remain higher until the legacy fuel has been processed. The SIXEP BPEO and BPM assessments have been updated for legacy fuel processing, and supporting programmes of technical work are in place to optimise operations and assess the options to enhance SIXEP • A SIXEP operating strategy has been developed. It takes into consideration the MOP, legacy fuel requirements and the requirements of the Sellafield Site Remediation Project. It is an overarching strategy pulling together workstreams and recommended best operational practice for SIXEP. In this sense it is a companion to the MOP defining how Magnox irradiated fuel can be reprocessed without prejudicing Sellafield Site remediation.	**Strategic inputs to MOP** • Breakdowns/outages/delays in MEP operations quickly halt decanning • To more easily meet the MEP Conditions for Acceptance on sludge in swarf it is current practice to decan a good fuel skip before and after each legacy skip.

Appendix D - Wet Fuel Stock Policy

D.1 Benefit of applying a wet fuel stock limit

The amount of fuel stored in station and FHP ponds has risen to higher levels than foreseen in previous MOP schedules having peaked at about 1500 tonnes. Magnox fuel cannot be stored 'wet' indefinitely and there is concern that, in the event of a major / prolonged reprocessing outage, corrosion failures could start to occur complicating the decanning process and potentially increasing discharges. To limit the amount of wet stored fuel the MOP managers decided not to commence bulk defuelling of closed reactors until a procedure was in place to manage the amount of Magnox fuel in wet storage.

If no wet fuel limit is applied, the available pond capacity at FHP and at the stations could be used to bring forward the completion of removing fuel from the reactors, and potentially to advance the date of removing all spent fuel from station sites. This programme benefit needs to be weighed against the benefit of applying a wet fuel stock limit which is the reduced risk of fuel corroding in ponds. With no limit the total amount of wet fuel would be likely to reach 1300-1400 tonnes at times during the MOP period.

If a catastrophic failure of Magnox Reprocessing were to occur, an alternative route would be required to deal with wet fuel before it corrodes. A review of potential alternative ways of dealing with wet and dry spent Magnox fuel is in progress, and will identify available options and timescales.

Whatever approach is used there will be a requirement to:

- recognise that an alternative route is required to deal with Magnox fuel
- design and build the facility
- operate the facility to process all the wet fuel before it corrodes.

D.2 Derivation of the Wet Fuel Stock Limit

With decanning and reprocessing operating at maximum capability, the only way to further reduce the amount of wet stored fuel is to reduce the rate of wetting fuel. It would cause severe operational difficulties if the level of wet fuel stocks were to be reduced too quickly. Fuel route equipment works most reliably when it is regularly exercised, and without regular experience fuel route staff will lose their familiarity with the equipment and procedures and hence lose their SQEP status.

If the eventual level of wet fuel stocks is too low then operational buffers will be inadequate for smooth, efficient and compliant operations. For example:

- At Oldbury fuel must be stored in the station pond for a minimum of six to nine months to allow the decay heat to reduce before shipping
- At Sellafield the decanning schedules require blending of different fuels to remain within safety and administrative limits.

A number of scenarios were examined to look at the impact of both the rate of reduction and the long term maximum wet fuel stock levels. The impacts considered included safety, environmental and financial issues. Following comparison of the scenarios a wet fuel stock limit of 800 tonnes ±50 tonnes to be reached by April 2010 was selected.

To try and avoid repeated damaging "stop-start" operations a planning philosophy has been introduced which should allow sufficient time to amend the flask plan by use of increasingly restrictive "Control Points". The actions to be taken at each control point are shown in Figure D.2a.

Appendix D - Wet Fuel Stock Policy

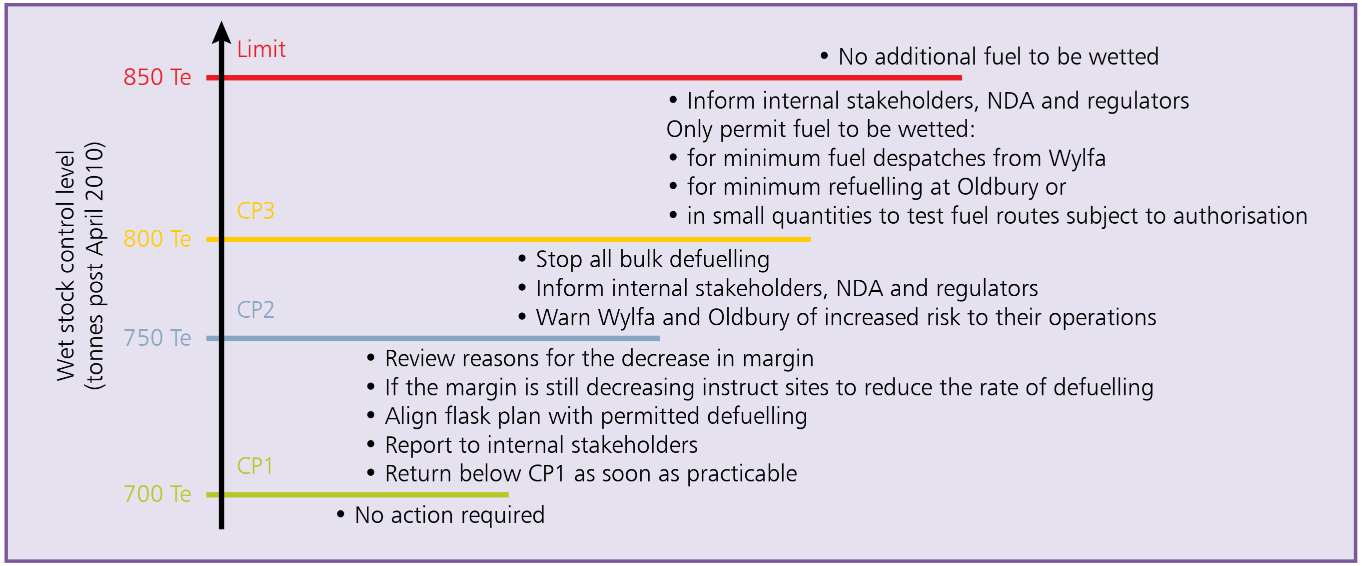


Figure D.2a – Wet Fuel Stock Control Point Actions

The result of this planning philosophy is that wet fuel stocks should normally be more than 100 tonnes below the limit and the initial rate of wet fuel stock reduction will be faster than the limit would suggest. A projection of the wet fuel stocks levels associated with the MOP8 delivery schedule is shown in Figure D.2b.

Appendix D - Wet Fuel Stock Policy

MOP 8 Projected Wet Fuel Stock Reduction

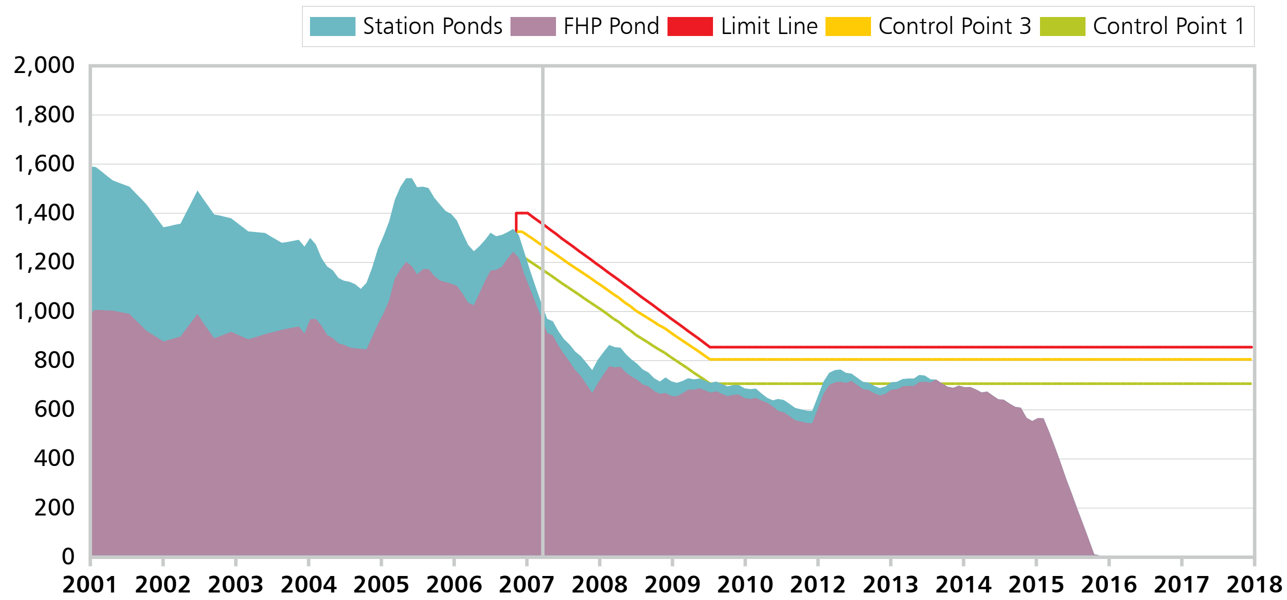


Figure D.2b – Projected MOP8 stock levels compared to the Wet Fuel Stock control points

D.3 Wet Fuel Stock Control Summary

1. The limit of about 800 tonnes reached by April 2010 will progressively reduce risk whilst restricting the detrimental effects to sites and the reprocessing end date

2. The control levels give a graded application of measures allowing reasonable time for recovery whilst ensuring interested parties are informed and have the opportunity to give their views before the final limit is reached.

Appendix E - Glossary of Terms and Abbreviations

Abbreviations

AGR	Advanced Gas-cooled Reactor (reactor type owned by BE)
BE	British Energy
BPEO	Best Practicable Environmental Option
BPM	Best Practicable Means
CCR	Change Control Request
DRS	Direct Rail Services (a subsidiary of the NDA)
FHP	Fuel Handling Plant at Sellafield
HAL	Highly Active Liquor
LEU	Low Enriched Uranium fuel (typically U235 increased from 0.7% to 0.8%)
LTP	Lifetime Plan (LTP08 is the LTP for 2008)
M&O	Management and Operations
MEP	Magnox (swarf) Encapsulation Plant at Sellafield
MOP	Magnox Operating Programme (MOP8 is the 8th edition of the MOP)
MWh / TWh	Megawatt hour / Terawatt hour
NDA	Nuclear Decommissioning Authority
NPV	Net Present Value
P50	50% confidence in achieving or bettering estimate
P80	80% confidence in achieving or bettering estimate
PCP	NDA Programme Control Procedure
POCO	Post-Operational Clean-Out
SLC	Site Licence Company
SIXEP	Site Ion Exchange Plant at Sellafield
SQEP	Suitably qualified and experienced person
Tc99	Technetium 99 – a radioactive isotope present in spent fuel.

Definition of Terms

Flask	Spent Magnox fuel transport flask – robust steel container into which the skips holding the fuel are loaded for transport from the stations to Sellafield. The flasks currently used are type "M2".
Flatrol	A special purpose railway wagon used to transport spent fuel flasks.
Legacy Fuel	Spent Magnox fuel that has been stored under water for a long period and has severely corroded cladding, seriously reducing achievable decanning and reprocessing rates.
Pond	A purpose-built indoor facility filled with water, used for storing spent Magnox fuel. The water provides cooling and a barrier to radiation from the fuel.
Skip	An open container used for storing spent fuel in station and Sellafield ponds and for transport in a flask.
Spent Fuel	Magnox fuel after it has been removed from a reactor and requires reprocessing.
Ullage	A nitrogen bubble used to isolate the contents (spent fuel) of containers in the FHP pond from the bulk pond.
Wet Fuel	Spent Magnox fuel that has been immersed in water in a pond or flask. Fuel is transported wet and remains wet in the FHP until it is reprocessed. If it remains wet for a long period the cladding may corrode – see legacy fuel.

Notes

MOP 8 Schedule

Site	Start Bulk Defuelling	Last Fuel Off-site
Calder Hall	October 2012	May 2015
Chapelcross	April 2008	August 2011
Dungeness A	April 2008	March 2011
Oldbury	April 2011	September 2013
Sizewell A	July 2009	June 2012
Wylfa	August 2011	January 2015
Sellafield	completes reprocessing around January 2016	

All the dates are P80 estimates and the intention is to complete defuelling and reprocessing sooner.

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Magnox North

Magnox Operating Programme
MOP8 Revision 1

Addendum 1 to MOP8 (ME/P/001)

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Introduction

The Magnox Operating Programme (MOP) is described in MOP8 which was published in February 2008. MOP8 was based on the position in August 2007. A review of the schedule has been carried out based status at the end of August 2008. The approach described in MOP8 has proved successful in managing the MOP and there is no requirement to issue a revised version of the MOP8 document. In particular, the approach has achieved a major reduction in the amount of wet fuel stored in the UK (from 1300 Te in September 2007 to 850Te in September 2008).

There was, however, a need to review the dates used for planning purposes in the lifetime plans. The MOP P80 schedule has therefore been adjusted to take into account:

- performance since August 2007
- the latest Magnox Reprocessing schedule and P80 forecast end date
- updated fuel usage forecasts
- active commissioning of the Calder Hall fuel route before the start of bulk defuelling

Reprocessing Performance

The revised forecast for completion of reprocessing is now March 2016 based on the MOP8 fuel loading assumptions, a delay of two months from the published MOP8 end date of January 2016. The reprocessing forecast takes into account the fact that decanning in 2007/08 was 164Te less than assumed in MOP8. The revision in site defuelling windows in the updated MOP8 schedule is mainly the result of this shortfall. Reprocessing performance in 2008/09 is forecast to match MOP8 assumptions.

The MOP8 schedule is based on a P80 reprocessing forecast to ensure that cost estimates in Lifetime Plans are also at P80. A programme of improvements is in place to achieve higher reprocessing rates.

New Fuel Loading

MOP8 was based on the position in August 2007. In order to ensure that the reprocessing demand should not be underestimated, high estimates of future fuel loadings were used. Actual usage since the MOP8 schedule was designed has been lower. Oldbury loaded less fuel than assumed in MOP8, primarily because R1 has not operated during this period. Wylfa reactors also loaded less fuel than assumed in MOP8 because of a number of plant issues that reduced the availability of the reactors.

MOP8 assumed that Oldbury would cease generation on 31st December 2008. However, the case for continued generation has now been made and is supported by government and Regulators. The station could generate another 3TWh of electricity, and the fuel needed for this has been retained in MOP8.

The shortfall in refuelling compared to MOP8 and the additional fuel that would be used by Oldbury are both around 70Te, so the net effect of these changes is to keep the total reprocessing requirement the same as for MOP8.

Station Prioritisation

The optimisation principles identified in Section 3 of MOP8 have been reviewed and are still valid. There are two minor issues potentially affecting prioritisation:

- There is little benefit in carrying out a 10 Te defuelling trial ahead of starting defuelling Sizewell A and so the capacity has been released to Dungeness A.

- Further review of the MOP8 Calder Hall defuelling programme has identified a significant risk of defuelling overrunning due to the long period of non-operation of the new plant and operating procedures. The MOP8 Rev1 schedule includes an allowance for small deliveries from Calder ahead of its scheduled defuelling start date to allow for earlier active commissioning.

Based on the underlying assumptions above the defuelling dates have been changed as indicated in Table 1.

Site	Start bulk defuelling (P80)			Last Fuel Off-site (P80)		
	MOP8	MOP8 Revision 1	Change (months)	MOP8	MOP8 Revision 1	Change (months)
Calder Hall	Oct 2012	Oct 2012	0	May 2015	May 2015	0
Chapelcross	Apr 2008	Aug 2008	4	Aug 2011	Nov 2011	3
Dungeness	Apr 2008	Apr 2008	0	Mar 2011	Jun 2011	3
Oldbury	Apr 2011	Jun 2011	2	Sep 2013	Feb 2014	5
Sizewell	Jul 2009	Jul 2009	0	Jun 2012	Aug 2012	2
Wylfa	Aug 2011	Aug 2011	0	Jan 2015	Mar 2015	2

Table 1 - Revised station defuelling dates based on P80 reprocessing schedule

Site capability requirements

It is important to the NDA that Magnox stations are in a position to respond to the expected improvements in the reprocessing rates, either by increasing deliveries from sites or by starting to defuel earlier than the P80 programme. Sites are also likely to need to operate at a higher delivery rate if they, or an earlier station, encounter problems during defuelling. The requirements on stations are listed in Table 2. (These capability requirements are unchanged from those issued in the LTP07 guidance last year.)

Site	MOP8 Rev 1 Readiness Requirements	
	Start	Max Flasks/wk
Calder Hall	Jul-12	3
Chapelcross	N/A	3
Dungeness	N/A	4
Oldbury	Sep-10	3
Sizewell	Mar-09	4
Wylfa	Jul-11	10

Table 2 –Defuelling readiness dates/defuelling rates

Potential Wylfa Generation Extension

The MOP8 assumption that Wylfa will cease generation on 31st December 2010 is unchanged. Sufficient fuel will be available to continue to generate some time beyond this and work is ongoing to pursue this option. A case for extending Wylfa's generation beyond 2010 would need to justify any additional fuel put into the MOP and demonstrate that Sellafield Ltd is able to reprocess the fuel.

Conclusion

To a first order, MOP8 is a valid and achievable programme. Revising the schedule is beneficial to align site and site licence company lifetime plans to a P80 position. Because the changes are comparatively minor, the main MOP8 document will not be re-issued at this time.

Magnox North

Magnox Operating Programme
MOP 8 Revision 2

Addendum 2 to MOP 8 (ME/P/001)

Endorsed by	*Endorsed by*	*Endorsed by*
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Approved by

N Baldwin

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Introduction

The Magnox Operating Programme (MOP) is described in MOP 8, which was published in February 2008, and MOP 8 Revision 1, published as an addendum in January 2009. MOP 8 was based on the programme in August 2007, and Revision 1 was based on the updated position at the end of August 2008. The schedule has been reviewed and this second addendum to MOP 8 details the MOP status and schedules as at the end of March 2010. The schedules in this Addendum 2 replace those for MOP 8 Revision 1 described in Addendum 1.

Highlights of Programme Performance since MOP 8 Revision 1 was published.

The key elements of the Programme performance since the publication of MOP8 Revision 1 are summarised here:

- Springfields Fuels Ltd completed the planned production of Magnox fuel elements in December 2009. This marked the end of the safe and successful production of around 5.5million Magnox fuel elements at the site since 1955, in support of electricity generation from Magnox power stations

- A number of issues have arisen concerning fuel transport flasks which have required pro-active management and stakeholder engagement. As a result of these issues the total quantity of fuel delivered from stations to Sellafield between August 2008 and March 2010 was less than in the MOP8 Revision 1 Schedule.

- A number of operational issues with the reprocessing facilities at Sellafield and associated downstream waste plants, combined with lower than anticipated spent fuel deliveries, has resulted in total reprocessing being below the MOP8 Revision 1 Schedule.

- The continuing collaborative working between the constituent Site Licence Companies through the application of well established MOP processes has enabled the impact of these issues on the final delivery of the MOP to be minimised. The net programme position is that 370 fewer tonnes were reprocessed up to the end of March 2010 than was anticipated in MOP8 Revision 1

- The impact of the above three issues is that the MOP8 Revision 1 target of March 2016 is more difficult to achieve than previously forecast.

- Opportunistic work has been undertaken to accelerate the mitigation or removal of risk in the remaining lifetime of the MOP, for example:
    - Work to accelerate the defuelling of Calder Hall and to remove the need to co-process Calder and Wylfa fuel, thus removing a potential pinch point in the final years of the MOP.
    - Plant modifications and technical work which has improved the capability at Sellafield for the decanning of legacy (corroded) Magnox fuel, to give the best possible opportunity to remove this risk to MOP completion.
    - Acceleration of the future programmed Sellafield outages for a number of MOP and non-MOP Plants to remove future risk and allow a buffer of reprocessable fuel to be created.

  - o Work to accelerate the statutory maintenance of fuel flasks, to maximise the number of flasks in service and thereby bring the MOP back on schedule

- Work has continued on the design of a possible contingency option that could be used to deal with spent Magnox fuel, in the event of either catastrophic or chronic failure of the Magnox reprocessing route, such that that MOP in its current form cannot be completed.

- In addition specific work-streams have been undertaken to maximise the contribution of the "MOP Assets" to the NDA Mission, for example:
  - o Generation optimisation at Oldbury and Wylfa to use all available fuel and generate additional income for the NDA clean-up mission.
  - o The planned receipt of a small amount of material from Dounreay for treatment at Sellafield. This plan has yet to be fully underpinned and developed. [1]
  - o A study to review what other UK clean-up activities can be supported by plant currently used for the MOP.

As a result of the programme performance described above, the dates used for planning purposes in the lifetime plan schedules have been adjusted in this addendum to the MOP to take into account:

- Performance since August 2008
- The latest Magnox reprocessing schedule and scheduled end date
- Continuing generation at Oldbury and Wylfa using existing Magnox fuel not previously included in the MOP8 reprocessing plans.
- Active commissioning of the Calder Hall fuel route before an earlier start of bulk defuelling

Key areas of the programme are reviewed below.

New Fuel Loading

The fuel cycles continue to be managed to optimise the use of new fuel, and both Oldbury and Wylfa have end-of-generation fuel cycles designed to optimise the amount of electricity which can be generated with the available fuel. At no point will the fuel cycles preclude an earlier end to generation should the MOP require it. Implementation of these cycles has resulted in a small change to the incidence of fuel usage (and hence spent fuel discharged) but that is easily accommodated in the MOP schedules.

Generation Optimisation at Oldbury and Wylfa

At the time of writing MOP 8 Revision 1, Oldbury had received agreement to continue generating beyond the MOP 8 assumption of December 2008, and Wylfa end of generation was assumed to be December 2010. MOP 8 Revision 1 assumed that just over 100 tonnes of Magnox fuel would remain unused and have to be recycled. Subsequent reviews of generation potential have shown that it will be possible to use all the fuel already manufactured for Oldbury and Wylfa to generate for longer and then to defuel the reactors in line with reprocessing schedules.

---

[1] Final approvals of business case and subsequent programme change to include this material in the plan have yet to be achieved and as such, it is included here as a planning assumption

Extensions to previously stated generation end dates will be subject to appropriate regulatory and government approval. No further fuel is to be manufactured.

The benefits of continuing to generate at Oldbury and Wylfa stated in MOP 8 Revision 1 remain valid. In addition, continued generation avoids the need to recycle or dispose of unused nuclear fuel, and maintains people, plant and systems at Oldbury and Wylfa in an operational state until close to the start of their defuelling phase.

The environmental impact of generating for longer at Oldbury and Wylfa has been considered and the conclusion is:

- The additional discharges and dose increases are low,
- There will be no significant increase to the rate of generation of radioactive wastes, and there is sufficient capacity for storage of expected waste arisings,
- No additional non-radiological consents are required.

Provided Oldbury and Wylfa continue to satisfy all safety and environmental requirements it is anticipated Oldbury and Wylfa will each continue to generate until

- The fuel cycle has exhausted supplies of fuel to continue generating, or
- The site needs to stop generating to allow defuelling to start to meet MOP schedules, or
- The site reaches its Periodic Safety Review end date[2],

whichever is the earliest

The MOP is especially sensitive to completion of defuelling at Wylfa because it is scheduled to be the last station to complete defuelling. Magnox North, through MOP management procedures involving all affected Site Licence companies, will carry out regular reviews to ensure that Wylfa ceases generation early enough to allow sufficient time for defuelling (based on a pessimistic estimate of defuelling duration). MOP 8 Revision 2 has reduced the planned margin between the end of Wylfa defuelling and the end of reprocessing to 3 months. This is an adequate margin to avoid Wylfa defuelling delaying the end of reprocessing.

Spent Fuel Transport

There have been a number of issues that limited the number of fuel flasks available for service, or led to a stoppage of fuel movements for a time. This has impacted the fuel deliveries to Sellafield, which have been less than the plan in MOP 8 Revision 1

A recovery plan is in place, which includes demanding targets to accelerate flask maintenance, to reduce the number of operational issues affecting flask availability, and make optimum use of the available flasks by speeding up the turnround of flasks at Sellafield and the station sites. The MOP8 Revision 2 schedule is a stretch programme that depends on achieving a delivery of around 750 Tonnes during 2010/11 and at least 800 Tonnes in the following three years. The actions underway in the recovery plan are designed to facilitate this, but it is recognised that these targets are very challenging and their achievements is not certain.

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[2] Currently Oldbury June 2011, Wylfa September 2014.

Reprocessing

The target date for completion of reprocessing remains March 2016 but this is now more challenging than envisaged in MOP 8 Revision 1 because:

- Reprocessing up to March 2010 was 370Te below the MOP8 Revision 1 schedule
- 108Te has been re-introduced into the reprocessing envelope to support continued generation at Oldbury and Wylfa
- A small amount of material from the Dounreay Fast Reactor is now expected to be reprocessed using the Magnox reprocessing facilities.

The quantity of additional fuel for continued generation at Oldbury and Wylfa plus the material from Dounreay is small compared the total of approximately 4,600Te of Magnox fuel included in MOP8 Revision 2 for reprocessing in the next six years.

The NDA competition for management of the Sellafield site has now been completed and the new Parent Body Organisation, Nuclear Management Partners, has developed a plan to increase the reprocessing rate to the level required to reprocess all fuel by March 2016. The fuel delivery schedule is designed to ensure that there will be enough fuel to support the reprocessing plan.

If the performance improvement is not achieved, then the forecast end date for reprocessing, based on previously assumed reprocessing rates, would be March 2017. The slower reprocessing rate would also mean that defueling at some sites would be delayed. This underlines the benefit of achieving the planned improvements at Sellafield. The forecast of March 2017 assumes that there are no events or issues that significantly interrupt spent fuel transport or reprocessing.

Acceleration of reprocessing is recognised as a key aspect in accelerating MOP delivery, but cannot be achieved in isolation. Ongoing interface management is required to ensure that the flexibility exists across the entire programme (from station de-fuelling to fuel transfers) to maximise the programme benefits of any such improvements

Wet Fuel Stocks

MOP 8 explained that a limit of 800Te had been introduced to cap the total quantity of wet Magnox fuel; this was to reduce the potential impact of sudden and prolonged interruption to reprocessing. Following two years of operating within this limit it has become apparent that the limit is too low and the buffers in site storage and storage in the FHP pond are too small. The operations of defuelling reactors and filling transport flasks are rate-limited, so it takes some time to recover from any interruption; for this reason each station needs to hold a small buffer stock. In addition, a minimum stock is required in the FHP pond to allow fuel types to be selected for campaigns and for blending. Interruptions in spent fuel transport have proved a particular problem.

The limit for the total quantity of wet fuel has been raised to a maximum of 1,000Te which will allow the schedules to maintain a larger margin to both upper and lower limits. There is no short-term expectation the limit will be reached, but the contingency is considered valuable and will reduce overall MOP delivery risks. The MOP 8 Revision 2 schedules make use of the increased limit.

Station Prioritisation

Section 3.2 of MOP 8 identified optimisation principles to decide the relative priorities of defuelling the stations. These principles have been reviewed and are still valid. There are only two minor issues affecting prioritisation:

- The assumption of a later start to Wylfa defuelling (as a result of generation optimisation) means that bulk defuelling of Calder Hall should start earlier to help assure a steady flow of spent fuel to FHP.
- The MOP 8 Revision 2 schedule includes an allowance for small deliveries from Calder Hall ahead of its scheduled bulk defuelling start date to allow for earlier active commissioning. This will help to prove the route and improve confidence in defuelling.

Based on the underlying assumptions above, the defuelling dates have been changed as indicated in Table 1.

MOP "End-Date"

The MOP end point remains the completion of reprocessing of all Magnox fuel. However there are considerable benefits when all spent Magnox fuel has been removed from the power station sites and is on the Sellafield site:

- Cross-site working is no longer required and delivery of the final stages is entirely within the control of Sellafield Ltd,
- The transport infrastructure (flasks, flatrols, train services) is no longer required for the MOP

For this reason completion of defuelling Magnox sites by December 2015 is now recognised as an important milestone.

Site	Start bulk defuelling			Last Fuel Off-site		
	MOP 8 Revision 1	MOP 8 Revision 2	Change (months)	MOP 8 Revision 1	MOP 8 Revision 2	Change (months)
Calder Hall	Oct 2012	April 2012	-6	May 2015	Nov 2014	-6
Chapelcross	In Progress			Nov 2011	April 2012	+5
Dungeness	In Progress			Jun 2011	Jan 2012	+7
Oldbury	Jun 2011	Jan 2012	+7	Feb 2014	Feb 2014	0
Sizewell	In Progress			Aug 2012	Feb 2013	+6
Wylfa	Aug 2011	Jan 2013[3]	+17	Mar 2015	Dec 2015	+9

Reprocessing completes	Mar 2016	Mar 2016	0

Table 1 – Summary of MOP 8 Revision 2 schedules

[3] Wylfa will initially start to defuel the final reactor cores into the dry storage cells. Fuel from the final reactor cores is not shipped to Sellafield until 180 days after the reactor has ceased generation.

Site Capability Requirements

The Magnox stations need to be able to start to defuel as planned and deliver fuel to Sellafield at a rate sufficient to meet the planned schedules. But it is also important that Magnox stations are in a position to respond to the expected improvements in the reprocessing rates, either by starting to defuel earlier than the dates above, or by increasing the rate of deliveries from sites. Sites are also likely to need to achieve higher delivery rates than the average assumed in the schedules if they, or a preceding station, encounter problems during defuelling. For example, the schedules require Wylfa to achieve a sustained average of 6 flasks per week during defuelling, but the site needs to have the capability to deliver up to 10 flasks per week. The capability requirements on stations and Sellafield FHP are listed in Table 2.

Site	MOP 8 Rev 2 Readiness Requirements	
	Start bulk defuelling	Max. Flasks/week
Calder Hall	April 2012	3
Chapelcross	N/A	3
Dungeness	N/A	4
Oldbury	July 2011	3
Sizewell	N/A	4
Wylfa	April 2012	10
Sellafield FHP	N/A	14

Table 2 –Defuelling readiness dates/defuelling rates

Conclusion

The objectives laid down in MOP 8 remain valid and the overall reprocessing programme is still considered to be achievable. However experience since MOP 8 Revision 1 and a small increase in the amount of material to be reprocessed mean that meeting the schedule will require improved performance in both fuel delivery and reprocessing rates. Plans are being implemented to bring these improvements about.

If improved performance is not achieved it is judged that the completion of reprocessing may be delayed to around March 2017, with corresponding delays in the completion of defuelling at the power station sites. Whilst the MOP was and is managing and mitigating risks, it must be recognised that there will remain the potential for an event or issue to significantly interrupt spent fuel transport or reprocessing, and delay completion further.