Radioactive Waste Management Challenges and Opportunities in the United Kingdom

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Since 1956, 44 nuclear reactors have been built in the United Kingdom; 26 of which are Magnox Power Stations owned by the Nuclear Decommissioning Authority. Twenty-two NDA reactors are currently in decommissioning phase with the remaining four scheduled for decommissioning by 2010.

Estimates are 2 million m^3 of low level waste (LLW) and 350,000 m^3 intermediate level wastes (ILW) will be generated during decommissioning activities. Supporting an accelerated schedule poses both challenges and opportunities including transitioning from generation to final site clearance with a workforce inexperienced in decommissioning; insufficient in-country waste management treatment capabilities and disposal capacities; limited Company experience in waste management, decontamination, reclassification and innovative treatment technologies; and ongoing requirements for flexible regulatory strategy that both Regulators and Stakeholders accept.

Delivery of safe, innovative streamlined projects and global benchmarking of similar Defuelling & Decommissioning (D&D) activities has been initiated. As transition from power generation power to D&D occurs, emphasis will be on performing decommissioning work and utilising various waste management technologies and opportunities. Considerations include utilisation of different approaches to concrete remediation; installation of on-site low level waste storage facilities with repacking, size reduction and decontamination capabilities; inter-site waste transfers of waste for consolidated management; on-site disposal capability; implementation of more efficient waste characterisation and tracking management systems and tools; and new off-site waste management treatment/disposal capabilities.

THE UNITED KINGDOM IN PERSPECTIVE

To put things in perspective, the United Kingdom (UK) is 244,820 square kilometres; slightly smaller than the State of Oregon and is comprised of England, Scotland, Wales and the province of Northern Ireland. Great Britain is a relatively small island that forms the larger part of the UK terrritory and is made up of England, Scotland and Wales.

Great Britain is almost 227,000 square kilometres, which would make it the 12^{th} largest state in the United States. England itself is approximately the same size as Louisiana. Great Britain's population is 58 million people with a population density of 652 persons per square mile. The combined population of New York and California is 53.5 million people and the population density of those two states together is 245 persons per square mile. Finally, London is located as far north as Calgary, Canada and no one in England lives more than 75 miles from the sea.

INTRODUCTION

The United Kingdom (UK) is currently in the process of beginning to decommission the bulk of the first commercial nuclear power stations. Cleaning up the nuclear legacy is going to be a long-term project which will take many years and cost billions of pounds. The question at hand is will there be adequate waste management and treatment technologies, capabilities and disposal capacity to support the wastes generated from the decommissioning efforts.

Decommissioning and waste management strategies must be developed up front to identify ways to reduce the amounts of waste requiring disposal and optimising the disposition of all wastes expected to be generated in addition to identifying innovative decontamination and treatment technologies and alternate disposal routes to support the decommissioning efforts in the UK over the next several years.

BACKGROUND

At the end of 2005, there were 443 nuclear power stations in operation world-wide. Twenty-three stations remain operational in the United Kingdom (UK) in comparison to 103 in the United States. It is estimated that nuclear power provides between 20 and 25% of the UK's electricity with the majority remaining electricity being supplied by gas (37%) and coal (34%). Although worldwide there are twenty five nuclear power stations currently being constructed, (primarily in Japan, India, South Korea, China and Finland) there are currently no authorised "New Builds" in the UK.

One of the oldest types of commercial reactors constructed and operated in the UK is the Magnox Reactor. These reactors were so named because of the type of cladding used on the fuel (Magnox = magnesium non-oxidizing alloy). Magnox Reactors use natural uranium fuel and have a graphite moderator. Heat is transferred to steam raising units using carbon dioxide. Twenty-six Magnox Reactors have been constructed and operated in the UK since 1956. Only four reactors remain operational and still in the generation phase.

Prior to 2006, twenty-one NDA owned reactors had entered decommissioning; eighteen of which were Magnox Reactors. By the end of 2010, all 26 Magnox rectors will be in decommissioning. (Refer to Table 1).

Table 1: NDA Magnox Reactor Shutdown and Decommissioning Schedule

Location	**# Reactors**	**Type**	**Current Status**	**Date Open**	**Date Closed**	**Defuelling Complete**
England						
Berkeley	2	Magnox	Decommissioning	1962	1989	1992
Bradwell	2	Magnox	Decommissioning	1962	2002	2006
Calder Hall	4	Magnox	Defuelling	1956	2003	2010
Dungeness A	2	Magnox	Defuelling/ Decommissioning	1965	2006	2009
Hinkley Point	2	Magnox	Decommissioning	1964	2000	2004
Oldbury	2	Magnox	Generating	1967	2008	2011
Sizewell	2	Magnox	Defuelling/ Decommissioning	1965	2006	2009
Wales						
Trawsfynydd	2	Magnox	Decommissioning	1965	1993	1995
Wylfa	2	Magnox	Generating	1971	2010	2012
Scotland						
Chapelcross	4	Magnox	Defuelling	1959	2004	2009
Hunterston A	2	Magnox	Decommissioning	1964	1990	1995
Total Magnox	26					

NUCLEAR DECOMMISSIONING AUTHORITY (NDA)

In 2005, the Department of Trade and Industry (DTI) formed the Nuclear Decommissioning Authority (NDA) to focus on the management and clean-up of the UK's public sector civil nuclear liabilities. In addition they were tasked with providing the first ever UK-wide strategic focus on decommissioning nuclear reactors. Once formed, the NDA took over ownership of all nuclear sites that were being operated by British Nuclear Fuels Limited (BNFL) and the United Kingdom Atomic Energy Authority (UKAEA). Included were the 10

Magnox Power Stations (26 reactors) identified in Table 1 above. Figure 1 identifies the geographic location of Magnox power stations and other sites currently owned by the NDA.

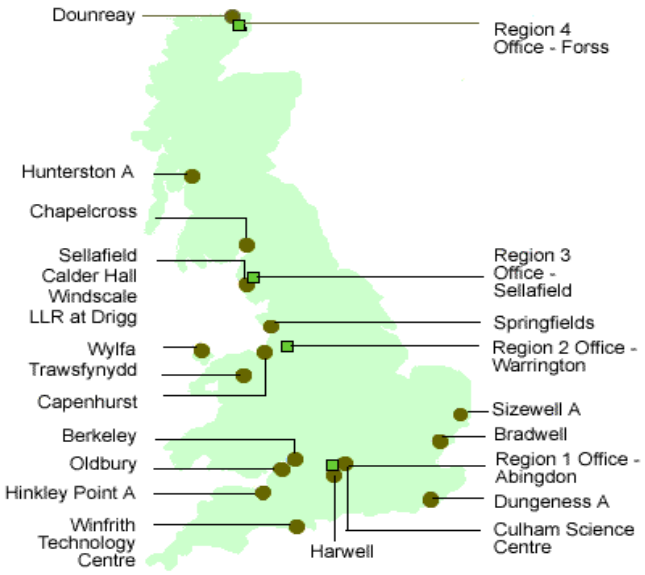

Figure 1: NDA Owned nuclear sites and offices

ANTICIPATED WASTE TYPES TO BE GENERATED

There are seven categories of waste that are expected to be generated as the result of decommissioning the Magnox reactors.

1. Low level radioactive waste (LLW)
2. Intermediate radioactive level waste (ILW)
3. High level radioactive waste (HLW)
4. Exempt Waste
5. Hazardous Waste
6. Clean Waste
7. Inert Waste

STAKEHOLDER INVOLVEMENT

Stakeholder involvement and views are an important part of developing waste management strategies. The current baseline decommissioning strategy has been shared with regulators and stakeholders as part of the sites on-going process of engagement. To realise future opportunities to optimise the management of waste, further engagement is required. This will be integrated so that regulators and stakeholders together are informed of the strategy as a whole. A Magnox Southern Region stakeholder engagement plan is being prepared so that stakeholders can be informed, provide their views and approvals can be sought to realise opportunities in a timely manner.

Table 2: Current Stakeholders

NDA	NDA is the owner of the Magnox Electric Southern Region sites. The NDA is responsible for developing and implementing a strategy for decommissioning in the UK.
Regulators	Environment Agency The Environment Agency is responsible for the regulation of the disposal of radioactive waste from the site and non-radiological environmental impacts.
	Nuclear Installations Inspectorate (NII) The NII is responsible for regulation of worker and public safety from operations at nuclear licensed sites.
	Office of Civil Nuclear Security (OCNS) OCNS is responsible for regulating all aspects of security at civil nuclear licensed sites.
	Department for Transport (DfT) The Radioactive Materials Transport Division of the DfT is responsible for regulating all aspects of transport of radioactive substances in the UK.
	Local Authorities Local Authorities have particular responsibilities with regard to planning, regulating non-radioactive discharges and contaminated land.
Nirex	Nirex is a body that in support of Government policy, develops and advises on safe, environmentally sound and publicly acceptable options for the long-term management of radioactive materials in the UK.
Local community	Those people who live locally to nuclear licensed sites.
Politicians	Government, MPs, MEPs who have an interest in nuclear licensed sites.
Natural England	Natural England is a Government body responsible for conserving and enhancing the natural environment. As most of the Magnox Electric Southern Region sites border areas of special environmental interest, Natural England is a key stakeholder.
Site Stakeholder Group (SSG)	The SSG is an independent body of representatives of the local area (local authorities and parish councils). It is alternatively known at some sites as the Local Community Liaison Committee (LCLC). It is sponsored by the NDA.

NATIONAL REGULATORY FRAMEWORK

The UK Government is the regulatory body for matters of overall policy related to waste management requirements. The government regulators operate in accordance with legal requirements and ensure that Government policy is being implemented. Producers and owners of waste must manage the waste in ways that meet both the legal and policy requirements. The UK Government's Policy on the management of radioactive waste is set down in a 1995 White Paper, Command 2919 and subsequent updates.

Unlike the directly prescriptive waste regulations in the United States and other countries, the UK Regulatory system is a non-prescriptive goal-setting regulatory regime. Although regulatory limits are set on the in-country disposal of waste in the authorisation issued under Radioactive Substances Act (RSA) 93, a key requirement regarding radioactive waste is for

the generator to use the Best Practicable Environmental Option (BPEO) and Best Practicable Means (BPM) to minimise discharges to the environment. There is always a regulatory expectation that by using BPM, discharges will be well below the authorised limits. In this way, the UK Government's policy of progressive reduction in discharges is implemented. Although what actually constitutes BPM is not prescribed by the regulators: the onus is on the Operator to have the experience and technical understanding to be able to demonstrate BPM themselves. This is a challenge for decommissioning sites in the UK.

The UK waste policy is based on the same basic principles as apply more generally to environmental policy, and in particular on that of sustainable development. Command 2919 defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Key issues for radioactive waste at nuclear licensed sites are:

- Radioactive wastes must be generated safely and appropriately managed and treated and not unnecessarily generated
- Radioactive waste must be safely disposed of at appropriate times and in appropriate ways and only at authorised facilities
- For interim storage of ILW, when the demands of safety are over-riding, waste must be treated as necessary to improve storage conditions
- Decommissioning should be undertaken as soon as it is practicable to do so and operators must produce decommissioning plans
- Radioactive waste should not be imported or exported from the UK unless:- (a) for recovery of re-usable materials (b) for treatment that will make its subsequent storage and disposal more manageable, in cases – where processes are at the developmental stage or where the quantities are too small to make the process viable in the country

In Great Britain, the RSA93 regulates the in-country disposal of radioactive waste. Control under the Act is exercised in England and Wales by the Environment Agency (EA) and in Scotland by the Scottish Environmental Protection Agency (SEPA). Where an application is made for disposal of radioactive waste on or from a site licensed under the Nuclear Installations Act 1965 (NIA), the Environment Agency is required to consult the UK Department for Environment, Food & Rural Affairs (DEFRA) Agency and the Health and Safety Executive (HSE) before deciding whether to grant an authorisation and, if so, subject to what Terms and Conditions.

The off-site shipment and authorised in-country disposal routes for radioactive waste from the Magnox sites are controlled under an authorisation (RSA License) issued to individual sites. The authorisation contains both general and site-specific information and requirements; stipulates where individual waste streams can go; and sets limits and conditions on disposals or transfers. The authorisations are issued by the EA and the SEPA. In granting or varying any authorisation, the Agencies must take into account the UK Government Policy. The accumulation of radioactive waste is managed under the Nuclear Site Licence and is regulated by the Nuclear Installations Inspectorate which is part of the Health and Safety Executive.

In April 2005, UK Nirex Limited was reconstituted as a Government owned waste management organisation with the responsibility to advise the Government and governed bodies on waste management options for radioactive materials; specifically ILW. Today, Nirex sets the national waste packaging standards; issues waste packaging specifications for the ILW; and provides policy for acceptance of ILW via a Letter of Compliance. Up until very recently, Nirex had been an independent body. On November 30, 2006, ownership shares in Nirex were transferred to the NDA in order to better align national strategies.

Waste Management Hierarchy Policy

In the UK, the accountability for responsible waste management lies with the generators and owners of the waste. Prior to generating a radioactive waste stream, a generator must prepare a Best Practicable Means (BPM) assessment. This assessment is performed to identify means of minimising waste creation and ensuring that options for recycling and re-use have been given preference over options for disposal. In addition, waste management routes and alternatives should be identified for each waste stream prior to generation.

The waste management hierarchy is a guide when determining the Best Practicable Environmental Option (BPEO) and BPM. It represents a chain of priority for waste management, extending from the ideal of prevention and reduction to the last resort of disposal. The waste management strategy amongst the Magnox Sites is to process operational and historical waste arisings in the most efficient manner, taking into account disposal options, whilst adhering to the principles of the waste hierarchy, corporate and government policies and regulatory requirements. Figure 2 sets forth the waste management hierarchy guidance.

Figure 2: Waste management hierarchy

Options to avoid, prevent or reduce waste should be considered primarily, as this is likely to be the most effective way to minimise waste generation and ultimately, waste disposal. Recycling and composting are lower in the waste management hierarchy, as these options both require additional energy and resources to reduce waste levels.

Whilst energy recovery from waste is also an option, the UK Government does not expect incineration to be considered before opportunities for recycling and composting have been fully explored. Note that composting of radioactive waste is generally considered as not applicable. Disposal of waste is the last resort, once all other options have been considered and should be done in such a way as to be sympathetic to the environment.

TYPES OF WASTES GENERATED AND CURRENT MANAGEMENT OPTIONS

As stated earlier, there are seven anticipated waste types that will be generated as the result of decommissioning Magnox Reactors. Radioactive and non-radioactive wastes are largely subject to separate legislation in the UK. Radioactive waste is defined in the Radioactive Substances Act of 1993 (RSA93) which includes a schedule of naturally occurring radioactive materials that at certain levels may be classed as exempt. All man-made radioactive materials are classed as radioactive. It should be noted that there is not a "mixed waste" category in the UK.

The following summarises the waste types expected to be generated from the decommissioning of Magnox Sites and current management options available.

Low Level Waste (LLW)

In the UK, Low level Waste (LLW) is a solid waste which is > 0.4 Bq/g but < 4000 Bq/g (4 GBq/te) for alpha emitting radionuclides and < 12 GBq/te for beta-gamma emitting radionuclides.

LLW represents the largest proportion of radioactive waste generated by the Magnox Sites. It is estimated that 2 million m^3 of LLW will be generated during decommissioning and cleanup activities. Note that this volume does not include the additional 20 million m^3 of LLW expected to be generated at Sellafield from the management of contaminated land. Most of the LLW currently being generated by Magnox is disposed of at the Low Level Waste Repository (LLWR) near the village of Drigg located in northwest England in the County of Cumbria. However at this time, the LLWR does not have sufficient projected capacity to accommodate future arisings of LLW expected to be generated by decommissioning the Magnox Sites, let alone the quantity of LLW expected to be disposed of by other UK generators.

It is currently estimated that 3.2 million m^3 of LLW disposal capacity is required in the UK to clear the current Magnox nuclear burden. The LLWR near Drigg has a remaining capacity of 35,000 m^3 and this capacity is projected to be used by mid-2008. Plans have been submitted for additional capacity at the LLWR, but planning permission has not yet been granted by the local Council. Even when permission is granted, the maximum possible remaining capacity at the LLWR near Drigg is 700,000 m^3. This is a shortfall for Magnox of almost 2.5 million m^3 of LLW. This shortfall has lead to the development of on-site disposal strategies at some of the Magnox sites. However, this strategy is subject to regulatory, stakeholder, and most importantly local planning commission acceptance.

In addition to the having the landfill capability at the LLWR near Drigg, some of the Magnox sites have onsite incineration capability for oils and combustible solids. Also, there are commercial incinerators licensed under RSA93 to incinerate combustible radioactive waste. Although one incinerator is currently authorised to process waste containing alpha emitting radionuclides, the acceptance level is very low.

A sub-category of LLW is referred to as Very Low Level Waste (VLLW). This is waste that due to its low level of radioactivity may be disposed of with normal refuse where it is dispersed with the additional refuse into a landfill. This is often used by the medical sector and universities and is not a disposal option that is currently widely available to the nuclear industry in the UK. However, the UK Government is currently consulting on this approach.

Intermediate Level Waste (ILW)

This is radioactive waste whose activity limits exceed the LLW criteria, but below the heat generating criteria of High Level Waste. ILW is sufficiently radioactive to require shielding and containment and special arrangements for its handling. These wastes consist mainly of metals, with smaller quantities of organic materials, inorganic sludges, cement, graphite, glass and ceramics. These mainly arise from the dismantling and reprocessing of spent fuel and are defined by the lack heat generation.

ILW is present at all of the Magnox Sites and arises from both site operations and decommissioning activities. In volume terms, the NDA expects to generate an estimated 350,000 m^3 of ILW as a result of decommissioning activities. At present, there is no disposal route currently available for ILW wastes in the UK.

To address this lack of disposal routes, the UK Government formed the Committee of Radioactive Waste Management (CoRWM) to recommend a strategy for the long-term management of UK higher activity solid radioactive waste. After 3 years of engaging

Stakeholders, members of the public and scientific community and reviewing options, a recommendation report was published in July 2006. The report recommended that geological disposal was the best option for this type of waste and that a continued commitment to the safe and secure interim storage of the waste was necessary. The underground geological disposal would utilise the rock structure to provide a barrier against radioactivity. The report also recommended that the Government should look to develop a partnership arrangement as a means of securing facility siting. Presently, most of the ILW waste is being held in interim storage at the sites where it arises.

It is worth noting that disposal of LLW (including VLLW), ILW and HLW requires a disposal authorisation issued under RSA93. This also includes any proposals to transfer waste to another site for processing.

High Level Waste (HLW)

This is radioactive waste with activity limits that exceed the LLW criteria and also produces significant amounts of heat such that the waste requires cooling.

The HLW waste arising from the Magnox Sites is primarily from the processing of spent fuel. Outside of the operating sites, there is an estimated 2,000 m^3 of HLW already in storage in the UK. Two-thirds of this waste type is currently being stored in storage tanks at Sellafield awaiting treatment. The other third has already been vitrified (immobilised in glass blocks) and placed in stainless steel containers. The un-encapsulated waste is currently identified as the most hazardous waste existing within the NDA purview.

Currently the NDA has a systematic approach to reduce the volumes of un-encapsulated wastes. It is anticipated that this will be completed by 2015. This timeframe is dependent on the performance of the vitrification plant and future decisions on reprocessing.

Exempt Waste

Exempt waste is a category of radioactive waste that is exempt from the requirements of a RSA93 Authorisation by use of an Exemption Order. This is usually through the Substances of Low Activity Exemption Order (SoLA) which states that for solid waste if the total activity above background is < 0.4 Bq/g, the waste is exempt (although still radioactive). This exemption does not apply to liquids.

Hazardous Waste

Hazardous wastes are regulated in the UK by the Environment Agency (EA) and the Scottish Environmental Protection Agency (SEPA) and defined as wastes with one or more hazardous properties that are hazardous to health or the environment. The UK Hazardous Waste Regulations also apply to a limited amount of radioactive waste. There is not a "mixed waste" category in the UK; wastes are either radioactive or hazardous, but not both. If wastes have both radioactive and hazardous characteristics, in most cases, the waste is managed primarily as radioactive waste although the hazardous content is considered. Wastes which can be excluded from the requirements of radioactive control and which demonstrate one or more hazardous properties are subject to the requirements of the Hazardous Waste Regulations.

Typically, hazardous wastes generated from Magnox decommissioning activities include the types of waste normally expected. These include fluorescent tubes, laboratory chemicals, batteries, oils, solvents, asbestos, hydro-carbon contaminated land and computer monitors. Currently, there are numerous facilities licensed in the UK that provide adequate treatment capabilities and capacity for the anticipated range of hazardous waste generated from Magnox decommissioning. However, the county is currently witnessing a reduction in the number and capacity of hazardous waste units. Like in other countries, reclaim, reuse and recycle of the materials are the preferred options and facilities exist to support this. Additionally, hazardous

wastes that cannot be managed any other way may require incineration or landfilling following pre-treatment.

Clean Waste

The UK produces around 330 million tonnes of clean (i.e. non-radioactive/non-hazardous) waste annually - a quarter of which is from households and business. The rest comes from construction and demolition, sewage sludge, farm waste and spoils from mines and dredging of rivers. Most of the clean waste generated from Magnox decommissioning includes building debris and insulation, metals and office waste. These wastes are recycled or reused when possible or sent offsite for disposal. In addition, clinical waste is generated from on-site medical facilities and sent offsite for incineration.

Inert Waste

Inert wastes in the UK are those wastes that do not physically or chemically break down. Inert wastes typically include concrete, glass and tiles. These may be non-radiological or radiological (above or below SoLA exemption limits). Depending on the physical, chemical or radiological characteristics (i.e below SoLA exemption limits), these wastes may be hazardous, non-hazardous or inert.

TRANSITIONING FROM POWER GENERATION TO DECOMMISSIONING

Transitioning from generating electricity at a nuclear power station to defuelling and decommissioning is a huge challenge. This coupled with moving from an owner operator to a contractor with a demanding customer and schedule set up by the Government and the challenges multiply many times.

Some of the challenges that we face during transition is an ageing work force, a skill mix that supported generation not decommissioning and processes and procedures for operating power stations – not removing them. However, each of these challenges are being successfully addressed - from bringing in experienced personnel from outside the Company with expertise in nuclear decommissioning and project management and re-training a highly-skilled workforce to meet the decommissioning programme. Additionally, new employment terms and conditions have recently been negotiated and proposed by the Company and Trade Unions to support this new mission. Throughout, we have continued to deliver our contracts safely.

As we look forward, more changes are on the horizon – the sale of British Nuclear Group Reactor Sites, separating the Magnox business into two site licence companies and ultimately, competition. The results of all of these should better support decommissioning activities at the Magnox Sites.

RADIOACTIVE WASTE MANAGEMENT STRATEGIES, CAPABILITIES AND INNOVATIONS

As noted above, there are very limited waste management treatment and disposal options available to manage radioactive wastes in the UK. Additional treatment facilities will need to be licensed and built and innovative technologies introduced if all of the wastes are to be managed in-country.

The following summarises some of the in-house strategies and innovative technologies being evaluated to support the radioactive waste management needs.

Integrated Waste Characterisation Plan

An integral part of managing the waste from decommissioning efforts is accurate characterisation and waste projections that are underpinned and bounded. As part of

preparing waste inventory projections, additional sampling, testing/analysis, modelling and fingerprinting of wastes may be required at several of the Magnox sites. This data will not only be used to determine the chemical, physical and radiological waste characteristics to support treatment and disposal optioneering, but will also support future waste projections by waste types. Over the next couple of years, personnel at the Magnox Sites will be developing characterisation plans to identify additional sampling and analysis required based on the Data Quality Objectives Process.

Low Level Waste - In-House Waste Management Capabilities

Each of the Magnox stations currently has some in-house capabilities or contracted services to support their waste management needs. A wide-range of techniques for decontamination and dismantling are currently being utilised to reduce the quantity and types of wastes being or projected to be generated. Additionally, sophisticated, remotely operated equipment is being used to reduce personnel dose during decommissioning work.

Decontamination practices are in use across the patch (Company). These practices include wiping/swabbing of lightly contaminated items, degreasing or chipping fixed contamination in oils or grease from steelwork or concrete items, cutting or grinding to remove small areas of fixed contamination in large items and the use of "chimney sweep" brushes to remove contamination from internal ducting walls. Chemical decontamination and paint stripping is also used. Additionally, some sites use ultrasonic baths, high pressure washing and sand/grit blasting.

A number of the Magnox sites also have in-house size reduction capabilities. Some of the sites have sorting, shredding and compaction (size reduction) means that are used to reduce the volume of waste requiring land disposal. In some cases, wastes are placed into bags or drums at the place of generation and are later sorted and segregated by trained personnel. Prior to offsite shipping, if the waste has not been sorted, it is passed through a bag monitor or in some cases x-rayed to ensure that the bag does not contain unauthorised items (e.g. batteries, aerosols, organic waste, etc.). Some sites have size reduction facilities that include the use of grinders, mechanical cutters and plasma cutters.

Dismantling methods currently in use include physical cutting using a variety of reciprocating and circular saws. The nature of the dismantling work depends on the nature and extent of radioactive contamination.

As noted earlier, some of the Magnox Sites currently have authorisation to operate small on-site incinerators to manage certain LLW. Oils and solid combustible wastes generated at the individual sites can be incinerated. For some sites, this option is critical in the overall waste management process. For example, at the Dungeness Power Station, approximately 14% of their 2006 low level waste inventory was incinerated onsite.

Some of the additional concepts being considered include cleanup contract incentives to reduce the quantity of waste being generated and for decontaminating radioactive waste to free release levels.

Low Level Waste Optioneering

Given the imminent capacity limitation of the LLWR near Drigg, priority will need to be focused on providing continuing LLW disposal route to high priority wastes. Additionally, alternative routes must be identified and license/authorisation changes initiated. Currently, with the requirement for public consultation, EA staffing constraints and ongoing relicensing efforts in other areas, it is anticipated that it will take a year to modify existing RSA authorisations to include additional offsite waste management capabilities.

Magnox personnel are continually identifying opportunities for prevention, minimisation, re-use, and recycling or energy recovery of low level waste. One of the options in evaluation is

opportunities for reusing and recycling materials that arise on sites through decommissioning activities. Disposal trials have been conducted by two of the Magnox Sites to evaluate the option to ship contaminated metals out of county in support of a contaminated metal disposition strategy. UK metallic waste arisings are estimated at 17-21% of the total future arisings. Although not in country, current technologies exist that has the potential to reduce the metal volumes by up to 90%. Trials to test the effectiveness of these technologies have been and continue to be conducted and evaluated to develop the overall strategy for dealing with contaminated metals being generated by the Magnox Sites.

As discussed earlier, another option being considered is the on-site disposal of low level radioactive wastes. Working closely with regulatory agencies and local Stakeholders, Magnox personnel are evaluating the options and issues surrounding local disposal and potential solutions are being developed.

A large quantity of radioactive waste currently being generated is tritium-contaminated asbestos. The radiological half life of tritium is 12 years. Studies are currently underway to evaluate decay rates to support future disposal options. One option to manage this waste is on-site decay with ultimate disposal in a clean landfill.

Packaging efficiencies are also currently being reviewed to identify areas for improvement. Additionally, current waste profiles and facilities' waste acceptance criteria are also being evaluated to identify additional opportunities.

Intermediate Level Waste - In-House Waste Management Opportunities

The UK Government has determined that higher activity waste (i.e. ILW) will be managed long-term through geological disposal. This decision was reached through an innovative stakeholder engagement process and published in the July 2006 report by the Committee on Radioactive Waste Management (CoRWM). The NDA has the responsibility for planning and implementing geological disposal. This involves placing radioactive waste in facilities deep underground where the rock structure provides a barrier against the release of radioactivity. Current projections are that geological disposal will not be available for at least thirty years.

Chemical dissolution is an opportunity that has already been successfully demonstrated at the Magnox Dungeness A Site. This process dissolves metal in a weak carbonic acid solution and retains the bulk of the radioactivity as a residue whilst discharging the dissolved metal to sea as a very weak solution of magnesium bicarbonate. The residue is easily managed in a similar manner to other slurry form wastes. Extensive trials have also been carried out on the chemical destruction (wet oxidation) of low level waste organic based resins. Lastly, experience with high temperature processes in the UK is limited to incineration of low level waste. This concept now needs to be extended to deal with ILW.

Intermediate Level Waste Optioneering and Alternatives

Until a long-term management solution is available, ILW will need to be temporarily stored in a passively safe form, possibly for several decades. It has never been the intent that interim storage facilities be considered as providing a long-term management solution since they are not being designed or built to fulfil such a function.

As part of several internal optioneering workshops, Magnox personnel have in general, identified very few opportunities for prevention, minimisation, re-use, recycling or energy recovery of intermediate level waste. The majority of the material will be destined for off-site disposal. As stated above, the current strategic focus for this type of waste is to ensure passive safe storage as soon as possible. The current plan is to retrieve and promptly encapsulate the ILW for interim storage until a geological disposal facility becomes available. Retrieval and encapsulation facilities are being designed around production of disposable packages based on the specification and guidance provided by Nirex. On-site storage

facilities have been or are currently being considered, designed, constructed and operated at some of the Magnox Reactor sites.

In addition to encapsulation, there are a number of alternate innovative treatment options currently being evaluated which will also achieve passive safe storage, and may provide more cost effective solutions with better safety and/or environmental performance. One of the options is mechanical size reduction. Shredding or compaction of ILW to reduce eventual disposal volume (by two fold or more for metallic items) can be done without changing the characteristics of the wastes. This process is already being used in the management of low level wastes in the UK - however, is has yet to be demonstrated that such an approach on ILW meets Nirex specifications (and therefore disposable).

Evaluations are ongoing of past characterisation data (in some cases over a decade old) to confirm that the wastes are actually ILW. Recharacterisation efforts are being initiated for wastes where new information is available. Resampling and analysis is being conducted when deemed appropriate. Additionally, revaluation and validation of previous assumptions is also being done.

The use of high temperature and chemical processes is also being considered. Although these technologies will provide volume reduction, the key advantage is to change the waste characteristics to facilitate interim storage and final disposal.

Other innovative solutions are also being considered, including co-packaging of solid and/or slurry wastes. Some of the metals currently in ILW inventory may meet out-of-country waste management facilities acceptance criteria and may be eligible to be reused as metal shielding once melted.

SUMMARY

As outlined above, hundreds of thousands of cubic metres of radioactive, hazardous and clean wastes will be generated as the result of decommissioning Magnox Power Stations. As discussed above, for some of the wastes, there are clear treatment/disposal routes. For other waste streams, adequate in-country capacity may be lacking. And finally, for some waste streams, no identified treatment/disposal route has yet been identified.

High-level wastes generated from spent fuel reprocessing are not an issue for the Magnox sites as these wastes are treated and stored at Sellafield in accordance with the Magnox Operating Programme (MOP). Intermediate level wastes are currently being stored on-site pending the identification of innovative treatment technologies or national disposal options. Currently, solid low level wastes are primarily disposed of at the LLWR near Drigg with focus on volume reduction and packaging efficiency. Capacity at the LLWR near Drigg may not be available after mid-2008.

The Magnox sites currently have access to limited on-site and offsite commercial incineration capabilities for low level liquids. There are ongoing efforts to authorise additional capability; however, it is most likely that treatment and disposal capacities will lag the need, creating the potential for a legacy of stored wastes.

To date, several waste management, treatment and disposal options are being reviewed and trials initiated. However, not all waste streams have adequate or fully acceptable final disposition paths identified. The identification of new or innovative opportunities is needed.

Although we remain hopeful that authorisation for additional capacity at the low level repository will be granted, there may still be a lag between the days the doors close and reopen with additional capacity. These options to support radioactive waste management can in no way support the decommissioning programme's timescales, waste types and projected volumes.