Berkeley NPP

• Twin Magnox Reactors
• Operating 1962 – 1989
• First UK commercial reactor to enter decommissioning
• Currently managed on behalf of the Nuclear Decommissioning Authority by Energy Solutions Inc.
• Boilers deplanted in 1997
• Full care & maintenance status by 2021
• Final site clearance in 2070’s
Berkeley Boilers

• 8 boilers (heat exchangers) per reactor
  – Length: 21 meters
  – Diameter: 5 meters
  – Weight: 310 tonnes

• Total activity of ~40 GBq/boiler

• Dose rates up to 50µSv/hr

• One boiler sized reduced on site in the 1990’s

• Remaining 15 stored horizontally

• Lifetime plan was for boilers to remain until 2070’s
Studies
Graduate Study 2010 – Treat Now?

- Government LLW Policy, 2007
  - Presumption to Early Solutions
- National Low Level Waste (LLW) Strategy, 2010
- For LLW metals the Best Available Technique is to treat/recycle
- Noticeable change to the site skyline
- Provides base load for supply chain
- Remains LLW if stored to final site clearance on site, so why not do it now?
  - Storage saddles in need of replacement,
  - Undue loading of reactor basement walls
- Funding available “in year”
Feasibility Study – March 2011

• Suitable route available that minimises road transport
  • Road to Sharpness Docks
  • Barge to Avonmouth as Sharpness access is limited
  • Sea going vessel to Sweden

• Route survey undertaken as part of the transport study identified challenges on route
  • Telephone cables
  • Utilities
  • Street furniture
  • Bridges/culverts
  • Tree trimming
  • Road closures
Stakeholders & Regulators

Early Engagement

- Office for Nuclear Regulation
- Environment Agency
- Site Stakeholders Group
- Swedish Regulator SSM
- Finnish Regulator STUK
- Maritime & Coastguard Agency
- Gloucestershire County Council
- Highways Agency
- Port Authorities & Trustees
Conclusions

• Transport as whole units was feasible
• SCO-1 Criteria met
• Initial Regulatory interaction was positive
• Methods were proven
• Preparatory Works should be carried out to reduce project risk
  – Health Physics Surveys and Characterisation
  – Non Destructive Examination
  – Engineering Design Assessment
  – Bridge & Culvert Assessment
  – Transport and Load Planning
  – Trans Frontier Shipping Approval
  – Confirmation of Transport Category

Preparatory work was key to unlocking the project and exploiting in-year funding
Tendering Programme

• Competitive Tendering Exercise August 2011
  – New Constraint – Ground Loadings due to underground structures

• Project Funding possible late 2011 – “Flywheel”

• Key Driver – Specified number of boilers off site by 31\textsuperscript{st} March 2012
  This was Lot 1 : Minimum 1 x boiler : Studsvik Proposed 5 x boilers

• Remaining boilers to be dealt with under separate contract (Lot 2)

• All preparatory work identified in study was still required

• Lot 2 was re- bid in August 2012 for removal of remaining boilers by 31\textsuperscript{st} March 2013
## Contract Programme

<table>
<thead>
<tr>
<th>Event</th>
<th>Lot 1</th>
<th>Lot 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract award:</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Nov 2011</td>
<td>5&lt;sup&gt;th&lt;/sup&gt; Nov 2012</td>
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<tr>
<td>Highways Agency approval:</td>
<td>12&lt;sup&gt;th&lt;/sup&gt; Jan 2012</td>
<td>16&lt;sup&gt;th&lt;/sup&gt; Nov 2012</td>
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<tr>
<td>TFS Approval:</td>
<td>19&lt;sup&gt;th&lt;/sup&gt; Jan 2012</td>
<td>In place</td>
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<tr>
<td>Lift 1&lt;sup&gt;st&lt;/sup&gt; boiler:</td>
<td>25&lt;sup&gt;th&lt;/sup&gt; Feb 2012</td>
<td>12&lt;sup&gt;th&lt;/sup&gt; Jan 2013</td>
</tr>
<tr>
<td>Transport 1&lt;sup&gt;st&lt;/sup&gt; boiler:</td>
<td>16&lt;sup&gt;th&lt;/sup&gt; Mar 2012</td>
<td>22&lt;sup&gt;nd&lt;/sup&gt; Feb 2013</td>
</tr>
<tr>
<td>Transport last boiler:</td>
<td>22&lt;sup&gt;nd&lt;/sup&gt; Mar 2012</td>
<td>15&lt;sup&gt;th&lt;/sup&gt; Mar 2013</td>
</tr>
<tr>
<td>Last boiler in Sweden:</td>
<td>6&lt;sup&gt;th&lt;/sup&gt; Apr 2012</td>
<td>31&lt;sup&gt;st&lt;/sup&gt; Mar 2013</td>
</tr>
</tbody>
</table>
Design Considerations
Structural Integrity

Review of Component parts
- Boiler Shell
- Saddles
- Internal Structures
- Tubes

Assessment methods
- Design information
- Inspection & survey
- Operation & maintenance records
Penetrations – Method of Sealing
Design - Enabling Works

• Engineering
  – Weld Assessment
  – Finite Element Analysis
  – Loading Models

• Non Destructive Examination
  – Boiler Vessel
  – Seal Welds
  – Flanged Connections
  – Saddles
Project Delivery
Delivery - Enabling Works

- Project and Site Mobilisation

- Documentation
  - Project and Specific

- Regulatory Authorisations

- Substantiation
  - Design Integrity (engineering review, NDE)
  - Radiological Condition (surveys)
  - Radiological Characterisation (WAC Studsvik & LLWR)
  - Transport Category
  - Regulators (ONR RMTT, EA, HA, GCC, Port Authorities)
  - Boiler preparation
  - Ground Loading

*Integral tasks that must be completed before lifting / transport could commence*
Site Preparation

- Removal of ancillary steelwork
- Thermocouples / penetrations
- NDE & Visual Inspection
  - Boilers
  - Transport Saddles
- Welding
- Health Physics Surveys
  - Early completion
  - Regulatory checks
- Civil Preparations
Lifting and Site Transport
Lifting to skid tracks
Skidding & Transfer to Site Storage
Off site transport
Tranship to road trailer via SPT
Shipping operations
Video – First Project (Lot 1)
Treatment
Volume reduction & recycling - SWE

Large Components (BWR, Magnox)

- Arrival inspection
- Segmentation
- Blasting
- Melting
- Crushing (slag)

Secondary Waste

Free Release > 95%

Ingots
Processing

• Recovery of loose material
• Size reduction
• Decontamination of internal surfaces
• Smelting
• Casting of ingots for free release
  – Melting of metal ensures robust characterisation analysis
  – Representative sample “pucks”
  – Metal is released as per Studsvik license
Secondary Waste Management

- Volume reduced waste consists of:
  - Grit blasting dust from decontamination
  - Dust from ventilation systems
  - Slag from cutting and metal melting
  - Ash and dust from incineration

- All secondary waste packages are gamma analysed for radiological content

- Existing residual dust (including graphite) analysed for Carbon – 14.

- A comprehensive Final Report is generated during processing with radiological analysis data

- Use of standard packages for return of secondary waste
Project Outcomes – Secondary Waste

- **Volume:** < 12 m$^3$
  - 95%+
- **Weight:** < 20 tonnes
  - >90%+

- **Volume:** ~ 650 m$^3$
- **Weight:** ~ 310 tonnes
Lessons from Treatment
Transport Category – SCO1

Lot 1 Original Assumptions – Conservative

- Based upon micro-shield modelling activity was assumed to be x2 Magnox fingerprint i.e. 71GBq.
- Only surface area of the boiler shell was considered for contamination distribution i.e. 3,520,000cm².

From Treatment Results

- Activity based upon measurements of all ingot batches and every secondary waste drum = 14 to 22GBq.
- Internal structures excluding tube fins account for more than 130,000,000cm²
- External dose rates correlated well to measurements during treatment

Considered for Lot 2 & supported by Regulators
Lessons from Treatment

- Very small amount (5kg) of residual material so far from 12 boilers.
- Internal components and materials have not deteriorated.
- Flanged assemblies contain Metaflex gaskets (Asbestos)
Lessons from the Project

Early evaluation of project
- Identification of uncertainties and risks
- Early enabling / preparatory works

Early engagement of stakeholders (international)
- Regulators
- Interested Groups
- Site personnel
- Client(s)
- Contractors

Collaboration between all parties
- Joint Risk Register
- Single schedule
- Weekly progress review
- Daily interaction
Conclusions

Lot 1
- First five Boilers completed
- 3 x HHISO LLW & 3 x HHISO LALLW

Lot 2
- All boilers delivered to Sweden by 31\textsuperscript{st} March 2013
- Seven boilers now completed
- Treatment & return of secondary waste will complete by December 2014

Magnox Gas Circuit Large Components
- Can be safely transported
- Can be effectively recycled
- Small amount of secondary waste