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CARBOWASTE

Treatment and Disposal of Irradiated Graphite and Other Carbonaceous Waste

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Minutes (M2.2.1)

- WP 2 Workshop -

14th - 16th July 2009
Gateshead, United Kingdom

Author(s):
L. Maciver

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Document title
WP 2 Workshop Minutes (14th - 16th July 2009)
Executive summary

This meeting is part of the process to meet the requirements of deliverable D2.2.1.The purpose of the workshop was to review existing Magnox, RBMK and UNGG issues and then to develop a generic process for retrieval and segregation, to relate to the MCDA analysis in the context of WP1 task 1.6 and to support development of best practice and to facilitate specification of diagnostic and modelling requirements, task 2.3.

A workshop environment allowed the beneficiaries to mutually interact, to involve other participants from other work packages and to encourage student input. The starting point of the workshop was the Data Pack issued to all beneficiaries prior to the workshop, which was firstly outlined in the workshop.

Presentations were given on the plans for decommissioning of Magnox, UNGG and RBMK and these were used as the basis for developing a generic process for i-graphite retrieval and segregation. The workshop reviewed the elements of the generic process, defined the characteristics of each step of it and used an MCDA approach to define and consider several strategic options.

Many issues were identified and recorded to complement those in the Data Pack that relate to retrieval and segregation of graphite for various reactor access configurations, forms of graphite and gangue material and for handling. The output is recorded in the minutes and the supporting attachments.

An i-graphite retrieval and segregation register based on information held by Doosan Babcock and for use by work package 2 beneficiaries is described. This covers tooling options for carriers, arms and manipulators, end-effector tools and ancillary support systems.

A list of requirements for diagnostic & modelling activities is attached.

An action list has been included that will facilitate finalisation of the final report: deliverable D-2.1.1.

Revisions

Rev.	Date	Short description	Author	Internal Review	Task Leader	WP Leader
00	dd/mm/yyyy	Issue	Name, Organisation	Name, Organisation *Signature*	Name, Organisation *Signature*	Name, Organisation *Signature*
01	28/07/2009	First issue	L. Maciver, Doosan Babcock			

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1 Introduction /Open Workshop

1.1 Welcome/Workshop Plan

Welcome and Introduction by Michael Grave, Doosan Babcock and David Ross, NNL.

1.1.1 The Purpose of the Workshop

The purpose of the workshop was to:

1. Review data available on retrieval and segregation of graphite from graphite moderated reactors
2. Starting from Magnox, RBMK and UNGG designs develop generic process for retrieval and segregation
3. Review the application of technologies and processes necessary to arrive at best practice using MCDA
4. Define additional work for input to the final report for legacy waste for task 2.2 to be undertaken by WP2 beneficiaries.
5. Understand modelling requirements for task 2.3

Assumptions, exclusions and bounding conditions are presented in Attachment 01[i]. Michael Grave noted that in arriving at this Task 2.2 workshop, much preliminary work has been done in WP1 (route map, properties and country reports) and Task 2.1 (preparation of the Data Pack[ii]). Participants had commented on the Data Pack and this workshop would develop its contents.

1.1.2 Person Months Allocated to Workshop

ORGANISATION	WORKSHOPS	PERSON MONTHS
Doosan Babcock	WP1/2 WP2	8 Lead tasks 2.1 and 2.2
NNL	WP1/2 WP2	17 Lead task 2.3
AMEC	WP1/2 WP2	2
EdF	WP1/2 WP2	2
ENRESA	WP1/2	3
FI	WP1/2 WP2	2
LEI	WP1/2 WP2	3
INR	WP1/2	1

Table 1: Person Months attached to each member organisation

1.1.3 Meeting Organisation and Facilitation

The workshop content was scheduled as presented in the Agenda[iii]. David Ross, as joint facilitator with Paul Fisher explained the work shop rules. These are presented in Attachment 02[iv].

1.2 Attendees

Anthony Banford	NNL (also representing WP1)	
David Ross	NNL	(Tuesday and Wednesday only)
Dominic Chadwick	University of Manchester (Student)	
Francis Berenger	EdF	
Grigorijus Duskesas	FI	
Jim Harken	NNL	
Jon Goodwin	Hyder (representing Bradtec WP5)	
Jon M Montgomerie	AMEC	(Tuesday and Wednesday only)
Lionel Maciver	Doosan Babcock	
Michael Grave	Doosan Babcock	
Paul Fisher	Doosan Babcock	
Povilas Poskas	LEI	
Werner von Lensa	FZJ (also representing WP4)	

2 Reactor Presentations

Four presentations were given from which a generic process could be developed. It was noted that previous presentations on GLEEP and Windscale AGR graphite removal had been given at an earlier workshop on 18th February 2009 at Manchester[v].

Note: the Magnox presentation below includes a comparison of various core sizes for a range of reactors.

2.1 Magnox

Presentation by Michael Grave, Doosan Babcock. The presentation is Attachment 03[vi]. Overview of the Magnox design including the core layout, brick design, restraint system and keying. Afterwards, the discussion raised the possibility of reverse engineering the construction method to dismantle the core. The point was raised as to whether the graphite components should be removed as found, or should size reduction take place within the reactor prior to removal. The latter option presents the opportunity to utilise existing small penetrations into the reactor core. Access to the core through existing large gas ducting in earlier Magnox designs was also discussed.

It was noted that Hinkley Point A and Oldbury, whilst being typical of the range of the range of designs, did not fully represent all possible variations. For example, Wylfa has anti-lift restraints that prevent the top layer of graphite from moving vertically during fuel extraction procedures - see Attachment 04[vii]. Other variations such as the steel specification for the reactor pressure vessel evolved with time. A unique variation on the Magnox design is the bottom fuelled reactors at Hunterston A.

2.2 UNGG

Presentation by Francis Berenger, EdF. The presentation is Attachment 05[viii] Overview of the design of the prototype Bugey 1 nuclear power plant including the core layout, brick design and restraint system and brick locating system (dovetail design). The presentation also included the proposed underwater core dismantling order and the proposed graphite waste route. Afterwards, the issue of light diffraction through the water was discussed. Francis informed the group that dismantling activities would be viewed vertically so diffraction of light does not become an issue. The issue of water clarity was then discussed with Francis notifying that the water clarity would be maintained through filtration. Francis also informed the group that weight loss is a major issue with this particular reactor, with up to 40% weight loss measured in certain areas of the reactor.

Merging of blocks was emphasised as a concern and as such studies have been performed into release of the core restraints and in identifying specific 'key' blocks that once released (through brute force) will free the majority of its neighbours and hence the whole graphite layer.

Similarities between the proposed Bugey dismantling technique and decommissioning activities at Fort St. Vrain nuclear power plant in the U.S were discussed. **An action was raised at this point for Francis to provide more information on the keying system and brick dimensions used at Fort St. Vrain (Action 1)**.

The added value of the use of water to control dust, the handling of graphite totally underwater up to the point of placing in a lifting container, the changing water level to close to the graphite and the ability to seal all reactor penetrations was noted.

2.3 RBMK

Presentation by Povilas Poskas, LEI. The presentation is Attachment 06[ix]. Overview of the design of the reactors at Ignalina nuclear power plant including the core layout, top level metal structure and reactor hall layout. Differences between the RBMK and other graphite moderated designs were highlighted, particularly the key distinction that the

RBMKs do not have a pressure vessel as the coolant pressure is contained within tubes in the core channels.

Feature	Ignalina RBMKs	Typical Gas Cooled Reactor
Long channel components	Fuel and cooling water channels, control rods etc, below standpipes	Details vary, but basically channels for fuel, cooling gas and control rods below standpipes
Large area at charge face	Access to channels is through removable shield blocks at vault floor	Access to channels is through removable shield blocks at charge face
Above core structures	Top cover, steam/water Pipework bundles	Details vary, but basically, guide tubes, neutron shield, and pipe bundles
Graphite stack	Graphite moderator and reflector comprising several thousand blocks	Graphite moderator and reflector comprising several thousand blocks
Core support structure	Core support structure for graphite stack and other components	Core support structure for graphite stack and other components
Cylindrical structures	Diaphragm, water cylinder and sand cylinder around graphite	Core restraint structure around graphite. Not a continuous structure, but still requiring 360 degree access
Pressure Vessel	Doesn't exists, pressure is contained in the channels, the major key design difference, may or may not affect dismantling, according to option chosen etc.	Spherical and cylindrical pressure vessels, either steel or prestressed concrete
Concrete structures	Reactor is surrounded by the concrete vault	Reactor is surrounded by the concrete bioshield, either separately in the case of steel vessels, or integrally for prestressed concrete vessels
Penetrations	Large openings through the concrete vault for steam and water pipes, standpipes for fuel, control, and instrumentation	Penetrations through the bioshield for gas cooling, inlet and outlet, standpipes for fuel, control instrumentation

Table 2: Key Differences Between RBMK and other Gas Cooled Reactors

A description was provided of the unique removal of a column of graphite bricks at a matching plant in Leningrad through an existing mounting hatch on the top level metal structure. The possibility of using this approach for decommissioning of the Ignalina reactors was discussed after the presentation.

Following the workshop, Povilas provided a detailed description of the use of these hatches during operations at Leningrad NPP and the possible options for decommissioning the Ignalina reactors. This is available in Attachment 07[x].

2.4 German Reactors

Presentation by Werner von Lensa, FZJ. Overview of decommissioning activities and experience in Germany. 28 research reactors have already been decommissioned and there are currently a mixture of 17 research and commercial reactors undergoing decommissioning, 2 of which involve the retrieval of graphite from their cores. The AVR reactor has a small pressure vessel and so the decision was made to fill its interior with grout and remove as a single unit. The THTR used two different grades of carbon material in its construction, the main core is a pure carbon while the reflector is a less pure carbon-stone. This carbon-stone layer has 100x more activity associated with it compared to the purer graphite. Both reactors utilised Helium coolant so comparisons with other reactors may be appropriate. Dust was considered to be a major issue, especially with respect to the carbon-stone.

3 Define Generic Processes

The purpose of this session was to identify the issues associated with the retrieval of graphite from a generic reactor. Attachment 08[xi] was used to facilitate the discussion. The result was the development of a new flow diagram (Figure 2) to compliment the existing Data Pack version (Figure 1). The process to generate this new diagram was centred on the following key questions:

- Are there a set of generic issues to consider to remove graphite blocks?
- Can we decide on them?

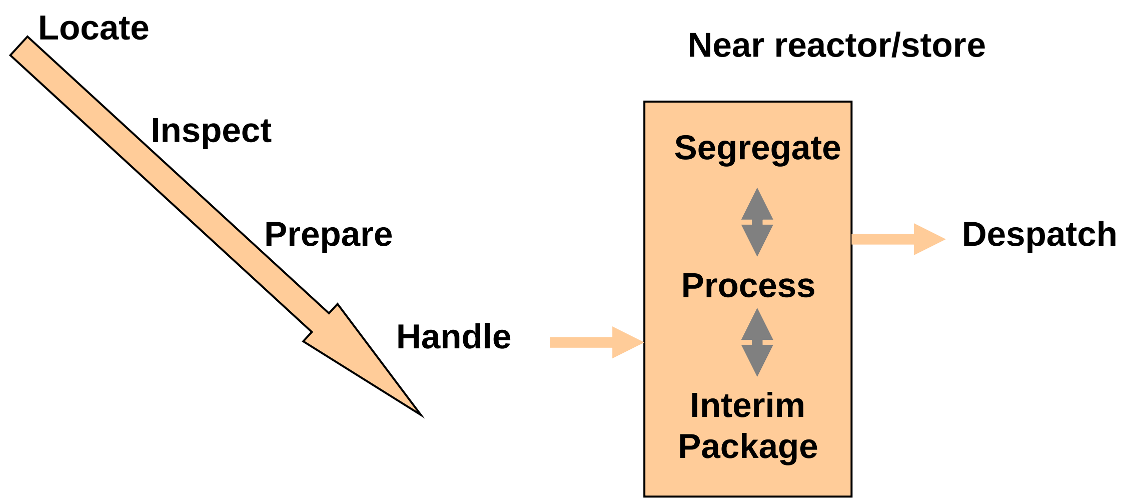

Figure 1: Existing Data Pack Flow Diagram

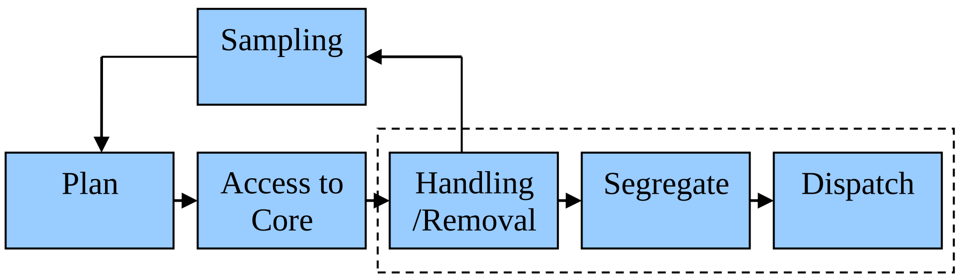

Figure 2: New Complimentary Flow Diagram

Agreeing Figure 2 was challenging because the original Data Pack flow diagram considered largely the movement of a specific piece of graphite. It was commented by Michael Grave that the flow diagram can be applied in different degrees of detail at:

1. the planning stage
2. the safety case stage
3. the implementation stage

Whilst this was inferred in the Data Pack, it was agreed that the introduction of a planning step to include all the front end issues and a sampling feedback assisted the visualisation of the comprehensive retrieval and segregation process.

It was noted by Doosan Babcock that whilst planting is generally seen as a front end process, it does continue in ever increasing detail throughout and to the end of the implementation stage. Sampling also can proceed throughout the life cycle.

A number of the individual elements of this new model were defined during the workshop. The top issues in these are identified below:

Plan

1. Regulatory Issues
2. Original Design
3. Operational History
4. Previous Experience
5. Timescale/Endpoint
6. Waste Route
7. Uncertainties (Risk Management)
8. Cost
9. Use of existing infrastructure/staff/knowledge

Access to Core

1. Access for retrieval equipment*
2. Route out/Export/Changes*
3. Reach all parts*
4. Environmental control
    a. Dose/shielding
    b. Air/water/gas
    c. Dust management
5. Existing/new routes

**Note: Interaction with other dismantling activities should not be overlooked.*

Handling/Removal, Segregate, Dispatch

1. Sampling/validation
    a. Radiation
        i. Graphite
        ii. Activated components
    b. Physical/Mechanical
2. Working environment
        i. Air
        ii. Gas
        iii. H_2O
3. Physical dimensions/geometry
4. Condition for lifting
5. Solutions (range of tools)
6. Protection → Proximity**
7. Risk/Hazard/Analysis
8. Traceability of components
9. Design

   a. Release of component (keys, restraints, anti-lift)
   b. *Graphite supporting system - structural*

10. Size reduce in situ
11. Secondary Wastes
12. Number of operations
13. Transfer to export point
14. Headroom
15. Waste route
16. Technology status
17. Assume BPM
18. Different techniques for keys, solid blocks, components, etc

***Note: This is related to the balance between the need to protect workers from radiation and other hazards on the one hand, and the desirability to encourage good line of sight for the retrieval and segregation task.*

An action was raised during discussions that input from WP3/4 should be provided when considering a generic process (Action 2).

4 Check Data Pack Issues

The purpose of this session was to review the Data Pack as it stands and to determine whether, on the basis of what had been previously discussed, any additional issues should be included. Attachment 09[xii] was used to facilitate the discussion. Key issues in the Data Pack were preliminary waste route, access route, list of components to be removed, and ancillary activities/processes.

4.1 Preliminary Waste Route

On review of the issues already defined in the Data Pack, it was decided that the following issues were also important:

- Form of the waste is important when considering the next treatment stage. For example, for gasification the graphite will have to be in a crushed form.
- The assessed initial state of the graphite pre-retrieval.
- Any conditions imposed on the graphite immediately post-retrieval.
- The requirements for primary routes in terms of waste forms also applies to secondary wastes.
- Packing factor considerations:
  - dictated by activity level
  - % hole space in brick/tile
- The need for size reduction and facilities to do it
- Allow for varied approach e.g. a range of tools required
  - Could be integrated with treatment
  - *Keep it simple*

4.2 Access Routes

On review of the issues already defined, it was decided that the main possible access routes had been covered, but that the unique RBMK mounting hatches route should be included. **The addition of RBMK mounting hatches to the Data Pack was raised as an action (Action 3).**

4.3 Agree Components

On review of the issues already defined in the Data Pack, it was decided that the following issues compliment those already identified:

- Some reactors have additional components/fixings in the graphite. For example nails/plates were used for mounting the graphite in the German THTR.
- Asbestos
- Insulation
- Debris
  - From initial penetration works
  - From reactor operations
- Thermocouples
- Dropped items/tools
- The project only covers reactors which have not been damaged during operation but what defines a damaged reactor? Does minor fuel contamination due to a single burst fuel cartridge constitute a damaged reactor?
- Minor fuel components
- Cables, cable trays

The condition of graphite components is also considered in the Data Pack. On review of the issues already defined, it was decided that most of the issues had been covered but the following should also be considered:

- Merging of blocks (a condition considered to be prevalent in Bugey)
- Details of the geometry of keys/blocks

4.4 Other Processes

On review of the issues already defined, it was decided that the following issues require addressing in the Data Pack:

- Dust inside some reactors may be extremely fine - adequate filters may be hard to source.
- Training of operators for remote handling equipment is a critical issue
- Important to be aware of any catalytic reactions that could take place with the reactor due to dismantling operations.

An action was raised that WP5 should provide feedback on processes for consideration in the WP2 Data Pack (Action 4).

5 Technology Review

5.1 Tooling

Presentation by Lionel Maciver, Doosan Babcock. The presentation is Attachment 10[xiii]. Overview of the 'Retrieval and Segregation of i-Graphite Register' built in recent weeks. The register is a summary of the information available concerning the graphite retrieval within the vast library of decommissioning papers which have been collected over the past 25 years by Doosan Babcock in Gateshead.

The register can be easily interrogated to find information as it includes 25 different filters to 'drill down' to the information that is required. Keywords can be used to facilitate search for information. Electronic copies of most papers have been attached to the register via hyperlinks to allow quick access to the full information, although this has not been possible for all papers. A demonstration of the register was then given to find information on decommissioning activities at Latina NPP.

A review of the current remote handling techniques was provided, the conclusions of which were that current technology is capable of the challenge of dismantling reactor cores, although some concepts are yet to be proven. A categorisation system was presented where remote handling equipment is broken down into four main components:

- The carrier
    - Suspended platform (Crane deployed)
    - Vertical mast (WAGR RDM)
    - Mobile carrier (ROV)
- The arm or tool manipulator
- The tools and associated processes
- The control system

Finally, the importance of flexibility in the choice of technique/equipment was also emphasised in order to deal with any circumstances encountered, and it was suggested that a combination of different techniques was the best way to achieve this.

During discussion, it was suggested that the classification system also include control system details as a sub-set which includes:

- The control system
    - Vision Systems/CCTV (noting line of sight is always best)
    - Man-machine interface
    - Power Distribution

The importance of operator training was emphasised again, including the possibility of screening during training on full scale rigs to find those with the highest level of spatial awareness.

It was also suggested that the choice of tooling for retrieval could depend on the required waste form for the next stage.

Two more actions were raised during discussions:

- **Consult the graphite manufacturers as to how they cut and handle graphite (Action 5)**
- **Any specifics on the tooling/methodology of the RBMK column removal technique are to be provided (Action 6)**

5.2 Modelling Introduction

Anthony Banford, NNL reviewed the status of the current modelling work, which is due to be completed in month 27. A PhD Student studying nuclear modelling at Birmingham University is being supported as part of this. The challenge is in identifying the specific model inputs. This was discussed and the following inputs were identified:

1. Nuclear Physics
   - Thermo-hydraulics
     - includes irradiation history
     - includes spatial
     - radiolytic effects
2. Chemical/molecular modelling
3. Structural
   - stresses
   - seismic
   - locking
   - thermal effects
4. Flow sheet modelling
   - mass balance
   - flow sheet
5. Production engineering (logistics)
6. Visualisation
   - 3D models
   - maps of properties
   - core mapping
   - physical mock-up
7. Environmental
   - Dust and dispersion

- Nuclide release (links to WP6)

The discussion also identified that there is a need to identify the specific models relevant to WP2 and whether there is a need to go into more detail on these selected models. These need to be identified either during or after the workshop by WP2 partners.

This is also the first time that operational modelling and decommissioning modelling will be compared. It was recognised that there is a need to understand the level of cross-over between the two. It was noted that a number of operational models were referenced on the Graphite Training Course at University of Manchester, 11-13th March 2009 sponsored by CARBOWASTE.

Attachment 11[xiv] was created during the discussions and is a summary of the modelling inputs described above.

6 Processes for Retrieval & Segregation

The purpose of this session was to review the present options for graphite retrieval and segregation and attempt to identify the main issues and areas of concern for each. An approach to option review that was compatible with MCDA was led by David Ross, who has been leading the MCDA work in WP1. This exercise was also designed to facilitate completion of Task 1.6 of WP1. Attachment 12[xv] was used to facilitate the session.

6.1 Review and Add to Options

The main options focussed on during the session are summarised below:

Option	Retrieval Medium	Delay	In-Situ Treatment	Disposal Conditioning	Disposal	Operator at Workface
1	Air	75 Years	No treatment	Condition (grout)	Deep disposal	Low doserate
2	Water	<25 Years	In-situ chemical treatment	Condition (grout)	'Shallow' disposal	Low doserate
3	Air	<25 Years	None	Grout	Intermediate Depth Disposal	High doserate
4	Air/Inert	50 Years	Size reduction	Gasification	Capture	Low/medium doserate

Table 3: Main Options

Time only permitted the first two options to be scrutinized during this session but the group were encouraged to repeat the process privately with the other variations after the workshop and feed back any relevant issues to Doosan Babcock outside the meeting so that consideration could be given to incorporation in the final report.

6.2 Comments from Participants

The group was split into pairs and a series of keywords were distributed. Attachment 13[xvi] is a copy of the keywords. The groups were instructed to consider each keyword in the context of the two main options and note any specific issues. The results of this process were recorded in following tables:

Note: *Text in italics* has been added post workshop to assist interpretation of the table.

Option 1 **'UK Option'**

Keyword	**Issues**	**Control Measures**
Environmental and Public Safety - Radiological - Man	Lower dose situation Lower impact to the environment, people	*Appropriate to 75 year status*
Environmental and Public Safety - Radiological - Environment	Low significant effluent No potential of leak 75 years reduces impact Dust/aerosol more of an issue than dose	Negative pressure ventilation system Filtration i.e. in the containment building, Building maintenance/ refurbishment required
Environmental and Public Safety - Resource Usage	No water use No interim storage required Infrastructure may have to be rebuilt Future cost unknown	None significant
Environmental and Public Safety - Non-Radiological		*Normal civil engineering procedures*
Environmental and Public Safety - Nuisance (to people and environment)	Rebuilding infrastructure Transport	Normal civil engineering procedures
Environmental and Public Safety - Solid Wastes	Filters No resins as for water	
Environmental and Public Safety - Catastrophic Accidents	Loss of containment less of an issue than with water Lifting Structure degradation Weather Other unknowns (e.g. demographic)	Monitoring of gases Fire extinguishers Building maintenance/ refurbishment/ Surveillance
Worker Safety - Radiological	Lower dose rate but possible airborne contamination More semi 'hands on' operations possible	Normal civil engineering procedures Temporary shielding
Worker Safety - Non-radiological		Normal civil engineering procedures: 'best practice'
Security		Maintain proper physical protection
Technology - Maturity	Proven at WAGR	
Technology - Operational	Loss of services Decrease of knowledge	Good design

Table 4: Comments on Option 1 'UK Option'

Option 2 **'French Option'**

Keyword	**Issues**	**Control Measures**
Environmental and Public Safety - Radiological - Man	Dust and gas issues are a lower risk No accidental discharge?	
Environmental and Public Safety - Radiological - Environment	Resin disposal (same disposal route) Reactor sealing required Still need to ventilate system Water loss issue • Contamination • Loss of shielding	Secondary containment required Evaporation dealt with Water treatment required Discharge authorisations Environmental control e.g. temperature
Environmental and Public Safety - Resource Usage	No major structural works No interim store required	
Environmental and Public Safety - Non-Radiological	Chemical additives to water e.g. pH	Control of water additives: acid (controls algae growth)
Environmental and Public Safety - Nuisance (to people and environment)	Not as much as option 1 Disturbance after only 25 years instead of 75 years	
Environmental and Public Safety - Solid Wastes	Resins	Good design + operational control
Environmental and Public Safety - Catastrophic Accidents	Catastrophic water loss, Dropping from top of reactor (very high)	Secondary containment Seismic substantiation Substantiated lifting procedures
Worker Safety - Radiological	Water shielding External dose from steelwork Internal dose during tool removal	Washdown/contamination procedures Secondary shielding and removal of steelwork as work progresses
Worker Safety - Non-radiological	Drowning	Normal pond procedures + design
Security	Higher radioactive inventory	*Graphite is maintained in an enclosed system from underwater to encapsulation*
Technology - Maturity	Previously proven (Fort St. Vrain and other pond work)	
Technology - Operational	Tools suitable for underwater use Visibility? Only suitable for certain reactor designs	Adequate design of tools Needs careful control of particulate control

Table 5: Comments on Option 2 'French Option'

7 Workshop Review

7.1 Review Modelling Needs

The purpose of the session was to ensure that all modelling requirements have been identified and prioritised so that Anthony Banford can progress with implementing them. Attachment 14[xvii] slide 1 was used to facilitate the discussion and slide 2 listed options and noted probable priority areas. During the course of discussions it was identified that there is a need for access to reactor core data for modelling. It is also desired to use this sharing of information as an opportunity to take forward the state of the art in modelling. The possibility of cross-channel cooperation on this was raised as well as the collaboration with Lithuanian personnel.

A number of actions were therefore raised:

- **Data on reactor cores are to be provided to Anthony Banford for modelling purposes (Magnox, AGR, UNGG) (Action 7)**
- **A dialogue is to be established between Anthony Banford and Grigorijus Duskesas regarding RBMK modelling (Action 8)**
- **Any particular area of modelling that can be incorporated should be passed on to Anthony Banford as soon as possible (Action 9)**
- **NNL are to provide information on both physical and computer modelling (Action 10)**

With regard to the French approach, a structural model has not been produced as the preferred philosophy is to inspect the 'real' state of the graphite core and base the dismantling strategy on that.

The University of Manchester has produced a broad model, which is similar to the commercial models. It is essentially a large optimisation program. **An action was**

raised that Dominic Chadwick would consult Bernard Kelly, University of Manchester, regarding input to the modelling required for WP2 (Action 11).

At the conclusion of the session, the general consensus was that the group were indeed working on the same issues with regards to modelling and confidence has been increased as a result.

7.2 Review Contents of Report

The purpose of this session was to review the proposed contents of the WP2 report and identify any missing issues, if any. Attachment 15[xviii] was used to facilitate the session and was generally supported. Comments centred around what type of document it should be. FI suggested an IAEA Tecdoc for example (See Section 7.3 for action). Discussions revealed three main issues that should be included in the report. Firstly, the report should include a section on the 'state of the art' in remote handling techniques, specifically for the handling of i-graphite. Examples of such technology should be included to support this

The report should include the clearing of graphite from storage vaults. This is an issue at a number of power plants including Hunterston A Magnox in Scotland and the RBMK design where graphite sleeves were used for fuelling the reactor. Once they were removed from the reactor, these sleeves were stored in the vaults along with other radioactive components. Comment was made that, although they are considered a lower priority than the reactors themselves, they will be the first to be decommissioned and as such lessons learned during these activities may be applicable. Reference was made to the clearing of the vaults already done at Vandellos NPP in Spain (a UNGG design) and perhaps the report on this could be attached as an appendix and used as a base line.

An action was raised at this point that permission should be sought for the inclusion in WP2 Report as an appendix of an ENRESA report regarding the clearing of active material from vaults at Vandellos NPP (Action 13).

Finally, it was identified that a variety of different definitions had been used during the workshop. The report should strive to use a harmonised set of definitions that all participants can understand. It was recommended that IAEA terminology should be used if possible

The discussion following the review raised a number of actions:

- **Confirm that all presenters consent to the content of their presentations be used in the workshop and final reports (Action 12)**
- **Groups not represented at the workshop should confirm how they intend to input to the WP2 report (Action 14)**
- **The workshop proceedings should be made available to attendees who are members of other Work Packages (Action 18)**

7.3 Participant Comments

Participants produced additional comments on Post-it notes during the workshop. These are recorded in Attachment 16[xix], which is an Information Park for points raised during the workshop. The following comments were raise in the general discussion and included further discussion of many of the issues on the Post-it notes. So there is some duplication of reporting.

Werner von Lensa:

- Make sure we cover Japan/Italy Magnox stations
- Impressed with RBMK graphite removal
- RBMK dust issues
- UNGG - operational status, utilities

- External R&D - nibble & vacuum - look beyond Carbowaste
- All reactors - construction information important to source
- Look at parameters important to retrieval
- Infrastructure use - exploit
- Visit alternative approaches - ask the people involved in the construction
- Thousands of standpipes available - exploit them. Do not consider them a burden.
- Consider different geometries
- Packing fraction (*within RPV)*

Jim Harken:

- Carbowaste - real challenge given the numerous designs
  - Action on the Romanians to provide research reactor geometry
- Consider multiple approaches to reactor access
  - Possibly two different routes simultaneously
- We are not removing part of the reactor in isolation - consider other decommissioning activities
- Concerns with underwater visibility (*noted problems with visibility in ponds, changing with ambient conditions*)
- Physical mock-ups very important
- Issues with safestore, lots of work to re-establish infrastructure
- WAGR considered relatively easy, there will be further issues to overcome when decommissioning the commercial size reactors
- Any computer model is only as good as the information fed to it
  - Validation is therefore necessary
- Versatility and adaptability of approaches is essential
- Comment on detail of workshop - switching between high and low level continually. Difficult to follow.

Dominic Chadwick:

- Scoring system to be used on MCDA. Doubts on whether it can be done.
- Modelling - set up a single model as the worst case scenario. This should then include all other scenarios.
- Volume optimisation of wastes. Packing factors

Anthony Banford:

- UK is the worst case scenario (re Dominic's comment)
- Potential for Francis and Anthony to collaborate to validate models

Francis Berenger:

- Top view of techniques
- Manage knowledge , reduce uncertainties
- MCDA plan will help extract the general components
- Feels that the general components have to be considered now
- This workshop is the beginning of this process

Povilas Poskas:

- Found it useful to prepare the presentation
- Easy to understand the different approaches used in the different countries
- It is not easy to read the report
    - Important to define wording
- Should be based on what is actually done
- Background information essential
- Request to have contact details in an electronic format

Grigorijus Duskesas:

- Dust problem is not solved - needs more attention
    - How much is actually produced?
    - Find solutions and recommendations to problem
    - Big challenge, possibly easily dismissed

- Impressed with presentation by Francis on changing graphite stack structure (release of blocks)
  - Preparatory work necessary though
  - Issue of topple/crack - solution is variety of tools/processes available
- **Could an IAEA TechDoc be commissioned based on WP2 work? This issue was raised as an action (Action 15).**

Jon Goodwin:

No comments that had not already been made.

8 Visit to Reactor Training Rigs

The group enjoyed a tour of the reactor training rig facility where Doosan Babcock engineers train for outages at nuclear power plants by practicing in simulated vessel conditions. Whilst this was specific to access into operational reactors, it demonstrated a number of key issues for physical models that will be relevant to retrieval and segregation:

- Representability of model
- Routing of materials/personnel
- Multiple models to cover safety and tooling development
- Recovery form accident situations
- Class room training, visual/contact, umbilical control
- Personnel dressing and medical management
- Control of lost items
- Balancing man-access, jigging and set up times to account for doses likely to be encountered in the RPV or adjacent areas.

9 Summarise Workshop Actions

Actions have been highlighted in bold text during this report but a summary of all actions raised during and after the workshop is provided below:

ID No.	Action	Responsibility	Completion Date By
1	Data to be supplied on Fort St. Vrain keying system and dimensions.	Francis Berenger	14/09/09
2	Input to WP2 from WP3/4.	Werner von Lensa	14/09/09
3	Add RBMK mounting hatches to list of possible reactor access routes.	Michael Grave	14/09/09
4	Feedback on processes from WP5.	Jon Goodwin, Hyder	14/09/09
5	Set up contact with graphite manufacturers regarding graphite handling and cutting.	Jon Goodwin, Hyder	14/09/09
6	Information on RBMK graphite column removal technique to be supplied.	Povilas Poskas	14/09/09
7	Data to be supplied on reactor cores for modelling purposes including Magnox, AGR, UNGG. To be lead by Anthony Banford.	Anthony Banford Francis Berenger Jon Montgomerie	TBA by AB
8	Establish dialogue regarding RBMK nuclear physics modelling.	Grigorijus Duskesas Anthony Banford	TBA by AB
9	Any particular area of modelling that can be incorporated should be passed on to Anthony Banford as soon as possible.	General action on all	03/08/09
10	Data to be supplied on computer/physical modelling.	Anthony Banford Jim Harken	03/08/09
11	To request input from Bernard Kelly on modelling if possible.	Dominic Chadwick, Uni. of Manchester	21/08/09
12	Confirm that information in presentations during workshop is allowed to be used for WP2 report. (Note EdF and LEI confirmed their acceptance at the meeting)	All presenters	03/08/09
13	Confirm that ENRESA report on Vandellos Vault retrieval can be appended to final report	Michael Grave	14/09/09
14	Verify how they will input to WP2, technical and budget	Groups not represented at workshop INR ENRESA	21/08/09

ID No.	Action	Responsibility	Completion Date By
15	Start dialogue with IAEA regarding possibility of funding a Technical Document.	Michael Grave	07/09/09
16	Review workshop comments for notes and report	Michael Grave	30/07/09
17	Define report content and input responsibility for partners.	Michael Grave	03/08/09
18	Move references from Data Pack WP1 into WP2 so that Francis Berenger can access them.	Michael Grave	03/08/09
19	Produce report on workshop.	Michael Grave, Doosan Babcock	07/08/09
20	Capture all issues raised at workshop on Post Its, other comments and comments after issue of the notes of the meeting Note; Action on All is post issue of notes of meeting	Michael Grave and All	On-going

Table 6: Action List

10 Contact Details

Contact details of those that attended the workshop are presented below:

Name	Institution	Phone	E-mail
Anthony Banford	NNL	+44 192 583 2415	anthony.w.banford@nnl.co.uk
David Ross	NNL	+44 194 677 9217	david.n.ross@nnl.co.uk
Dominic Chadwick	Uni of Manchester	+44 781 721 4286	dominic.chadwick@postgrad.manchester.ac.uk
Francis Berenger	EDF	+33 472 824 037	francis.berenger@edf.fr
Grigorijus Duskesas	FI (JoP)	+37 061 445 955	duskesas@fi.lt
Jim Harken	NNL	+44 773 433 5712	jim.p.harken@nnl.co.uk
Jon Goodwin	Hyder	+44 139 551 4640	jon.goodwin@hyderconsulting.com
Jon M Montgomerie	AMEC	+44 192 567 5491	jon.montgomerie@amec.com
Michael Grave	Doosan Babcock	+44 191 478 8265	mgrave@doosanbabcock.com
Paul Fisher	Doosan Babcock	+44 191 478 8290	pfisher@doosanbabcock.com
Povilas Poskas	LEI	+37 037 401 891	poskas@mail.lei.lt
Werner von Lensa	FZJ	+49 246 161 6629	w.von.lensa@fz-juelich.de

Table 7: Contact Details

11 References

Note: Unless indicated references are in the SINTER Folder for the WP2 Workshop Meeting. Non WP2 beneficiaries should apply to Doosan Babcock for issue of copies of the references.

i Attachment 01 - CARBOWASTE WP 2 - Workshop Introduction

ii SINTER: Grave. CARBOWASTE Work Package 2.1 Data Pack. CARBOWASTE-0904-T-2.1.1

iii Workshop Agenda

iv Attachment 02 - CARBOWASTE WP 2 - Workshop Rules

v SINTER: Not available. WP1 Meeting Minutes, Manchester 16-18 February 2009. *note: Contact A Banford, NNL for this information.*

vi Attachment 03 - CARBOWASTE WP 2 - Magnox Presentation

vii Attachment 04 - CARBOWASTE WP 2 - Wylfa Anti-lift Device Email

viii Attachment 05 - CARBOWASTE WP 2 - UNGG Presentation

ix Attachment 06 - CARBOWASTE WP 2 - RBMK Presentation

x Attachment 07 - CARBOWASTE WP 2 - RBMK Graphite Retrieval

xi Attachment 08 - CARBOWASTE WP 2 - Define Generic Process

xii Attachment 09 - CARBOWASTE WP 2 - Check Data Pack Issues

xiii Attachment 10 - CARBOWASTE WP 2 - i-Graphite R&S Register

xiv Attachment 11 - CARBOWASTE WP 2 - Summary of Modelling Requirements

xv Attachment 12 - CARBOWASTE WP 2 - Processes for R&S

xvi Attachment 13 - CARBOWASTE WP 2 - Processes for R&S Keywords

xvii Attachment 14 - CARBOWASTE WP 2 - Modelling Specification

xviii Attachment 15 - CARBOWASTE WP 2 - Review Report Contents

xix Attachment 16 - CARBOWASTE WP 2 - Information Park