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# Peer Review

Near Surface Disposal - Cost for Reactor Decommissioning Wastes.  
An Economic Review for CoRWM. Project TS061.

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# Summary

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Jackson Consulting was commissioned by the UK Government's Committee on Radioactive Waste Management (CoRWM) to peer review CoRWM Document No. 679 "*Near Surface Disposal - Cost for Reactor Decommissioning Wastes*" issue 1, dated September 2004. The purpose of the document was to inform CoRWM of the estimated cost of providing a near-surface repository at the site of each civil nuclear power station in the UK, suitable for disposing of short-lived low level radioactive waste (LLW) and short-lived intermediate level radioactive waste (ILW) arising from the decommissioning of the nuclear reactors on each site.

The CoRWM report concludes that a near-surface repository for short lived ILW at each nuclear reactor site in the UK would cost approximately £30 - £33 million each (based on SKB unit costs) or £43 - £47 million each (based on Nirex unit costs) for repository construction, operation, maintenance and closure. A single centralised near-surface repository for all short-lived ILW reactor wastes would cost approximately £125 million (based on Nirex unit costs). The report suggests that these costs would escalate substantially if the repository capacity was extended to include short lived LLW from reactor decommissioning. If LLW was included the cost at each reactor site would increase to approximately £105 million (based on SKB unit costs) or £175 million (based on Nirex unit costs).

In our view the quality of the cost analysis carried out is reasonable given the period of time allowed to undertake the study and it achieves the main objective of delivering a short focussed report on the likely principal costs. It is difficult to be certain whether or not these cost estimates are reliable. On balance, our view is that the costs presented are a reasonable first approximation for use by CoRWM to compare the relative costs of near-surface disposal with other waste management options, but the report should not be regarded as a comprehensive costing exercise nor an economic feasibility study. In essence the report provides a good foundation for a more detailed economic inquiry that may need to be undertaken by CoRWM in the future. We have recommended a number of actions to clarify areas of uncertainty and refine the cost analysis, focussing particularly on repository siting factors, NDA strategy and scenarios for reactor decommissioning and confirmation of the expected inventory of reactor decommissioning wastes by Nirex.

# Table of Contents

|  |           |
|--|-----------|
| <b>Background</b>                                      | <b>4</b>  |
| <b>Approach to the Peer Review</b>                     | <b>4</b>  |
| <b>Findings</b>  | <b>5</b>  |
| Quality  | 5         |
| Transparency and readability                           | 5         |
| Balance  | 6         |
| Auditability   | 6         |
| Reliability of conclusions                             | 6         |
| Fitness for purpose                                    | 7         |
| <b>Observations and Recommendations</b>                | <b>7</b>  |
| Siting factors influencing disposal costs              | 7         |
| NDA strategy and scenarios for reactor decommissioning | 8         |
| Confirmation of reactor waste inventory by Nirex       | 9         |
| Full cost analysis and feasibility study               | 9         |
| <b>Bibliography</b>                                    | <b>10</b> |

## BACKGROUND

Jackson Consulting was commissioned by the UK Government's Committee on Radioactive Waste Management (CoRWM) to peer review CoRWM Document No. 679 "*Near Surface Disposal - Cost for Reactor Decommissioning Wastes*" issue 1, dated September 2004. The purpose of the document was to inform CoRWM of the estimated cost of providing a near-surface repository at the site of each civil nuclear power station in the UK, suitable for disposing of short-lived low level radioactive waste (LLW) and short-lived intermediate level radioactive waste (ILW) arising from the decommissioning of the nuclear reactors on each site. The document would also compare the total cost of separate repositories with the estimated cost of a single centralised national repository for near-surface disposal.

The CoRWM report set out approximate cost estimates based upon two independent sets of disposal cost data developed by UK Nirex Limited (Nirex), the United Kingdom national radioactive waste management organisation and Svensk Kärnbränslehantering AB (SKB), the Swedish national nuclear fuel and waste management company.

## APPROACH TO THE PEER REVIEW

Our approach to the peer review involved a technical review of the report compared with its scope and objectives set by CoRWM, a short discussion with the authors of the report to understand any particular areas of difficulty or uncertainty encountered and a discussion of the applicability of the underpinning UK waste management cost data with Nirex. We also compared the projected cost estimates contained within the CoRWM report with the findings of an earlier major international study published by the OECD Nuclear Energy Agency (OECD/NEA) in 1999<sup>1</sup> and with a recent technical report on near-surface repository development published by the International Atomic Energy Agency (IAEA) in 2003<sup>2</sup>. Finally we compared the cost data with an analysis of near-surface low level radioactive waste disposal costs in the United States, which has one of the largest LLW disposal programs in the world<sup>3</sup>.

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<sup>1</sup> *Low Level Radioactive Waste Repositories: An Analysis of Costs*. OECD/NEA. February 1999.

<sup>2</sup> *Considerations in the Development of Near Surface Repositories for Radioactive Waste*. IAEA Technical Report Series No. 417. August 2003.

<sup>3</sup> *Low-Level Radioactive Waste: Disposal Availability Adequate in the Short Term, but Oversight Needed to Identify any Future Shortfalls*. United States General Accounting Office. GAO-04-604. June 2004.

## FINDINGS

### Quality

The authors explained that CoRWM Document 679 was one of a series of short technical reports, intended to provide briefing material to members of CoRWM on a range of issues including the approximate costs of near-surface disposal. The intention was that the technical report would be prepared with 5-7 days of expert input, be around 10 pages in length and would quickly identify key issues and major cost drivers. The report was not intended to be a comprehensive costing exercise nor an economic feasibility study for the development of a near-surface repository but it would identify the principal cost elements in the UK.

CoRWM Document 679 comprises of a 15 page report with an Appendix containing 2 pages of data estimating the total likely number of packages of ILW waste from reactor decommissioning using data extracted from the UK ILW national waste inventory. A further 2 pages of data project the approximate cost of a near-surface repository to dispose of the ILW waste packages, based on unit disposal costs for waste packages developed by Nirex and SKB.

In our view the quality of the cost analysis carried out is reasonable given the period of time allowed to undertake the study and it achieves the main objective of delivering a short focussed report on the likely principal costs. However the analysis does of course rely on the accuracy of the waste package data derived from Nirex inventory information. We understand that Nirex was not consulted on the suitability of this data or asked to comment on any underlying information gaps or data uncertainties or data sensitivities that might be present in the national inventory, that could affect the range of cost projections estimated for a near-surface repository. Ideally the data projections and assumptions made should have been confirmed with Nirex but we appreciate that the report was prepared within a very tight timescale.

### Transparency and readability

The information sources used to develop the near-surface repository cost estimates are clearly referenced and traceable to the source documents published by Nirex and SKB. The report also references a useful IAEA Bulletin published in 1997 summarising disposal practices in near-surface repositories throughout the world<sup>4</sup>. However the report does assume some prior technical knowledge by the reader and as a consequence it is sometimes difficult to understand by the non-expert. For example the inventory of reactor decommissioning waste is explained as the difference between the Nirex Variant Case and the Nirex Reference

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<sup>4</sup> *Radioactive Waste Disposal: Global Experiences and Challenges*. IAEA Bulletin 39/1. 1997.

Case, without explaining what these terms mean and why they are significant. Similarly the report states that only reactor decommissioning wastes arising after 2090 have been considered in the study (ignoring disposal of wastes arising earlier than this) without explaining the relevance of the Safestore decommissioning strategy currently applied in the UK for Dismantlement and Decommissioning (D&D) of civil reactors.

## **Balance**

The report provides a good description of the main types of near-surface disposal facilities in operation globally and gives some practical examples from specific repository sites. However the estimated repository costs are based mainly on Nirex and SKB data without drawing on wider economic experience, for example the OECD/NEA international study of near-surface disposal costs and the United States General Accounting Office LLW cost review.

## **Auditability**

The assumptions and uncertainties used in the cost analysis are clearly stated by the authors and the source data is well referenced. The results of a computer spreadsheet analysis estimating the total number of ILW waste packages from reactor decommissioning has been clearly presented although it is not possible to audit the data without access to the original spreadsheet and inventory information. Ideally the source data should be independently audited and verified by Nirex as the owner of the national radioactive waste inventory.

## **Reliability of conclusions**

The CoRWM report concludes that a near-surface repository for short lived ILW at each nuclear reactor site in the UK would cost approximately £30 - £33 million each (based on SKB unit costs) or £43 - £47 million each (based on Nirex unit costs) for repository construction, operation, maintenance and closure. A single centralised near-surface repository for all short-lived ILW reactor wastes would cost approximately £125 million (based on Nirex unit costs). The report suggests that these costs would escalate substantially if the repository capacity was extended to include short lived LLW from reactor decommissioning. If LLW was included the cost at each reactor site would increase to approximately £105 million (based on SKB unit costs) or £175 million (based on Nirex unit costs).

It is difficult to be certain whether these cost estimates are reliable. The apparent difference between Nirex and SKB costs - around 70% - has not been explained although both the 1999 OECD/NEA study and the 2003 IAEA guidance point out that costs can vary considerably

from one country to another and that different repository design concepts can have different cost structures (the relative proportion of costs spent on licensing, construction, operation, closure and monitoring) even if the the total life-cycle costs are reasonably similar<sup>5</sup>. Also the UK civil nuclear industry is substantially larger than in Sweden so some scalability effects might account for the increase in UK disposal costs compared with Sweden.

### **Fitness for purpose**

On balance, our view is that the cost estimates presented are a reasonable first approximation for use by CoRWM to compare the relative costs of near-surface disposal with other waste management options, but the report should not be regarded as a comprehensive costing exercise nor an economic feasibility study. In essence the report provides a good foundation for a detailed economic inquiry that may need to be undertaken by CoRWM in the future.

## **OBSERVATIONS AND RECOMMENDATIONS**

One area where the report could be strengthened and made more useful for CoRWM is to present a wider strategic analysis of the economics of near-surface disposal in relation to the broader socio-economic and policy drivers behind disposal costs. We have provided some observations on these issues below and offered suggestions to help refine the cost analysis.

### **Siting factors influencing disposal costs**

IAEA comment in their 2003 technical report that costs per unit waste volume or mass depends strongly on the the size of the facility due to the relatively high weight of costs which are independent of the amount of waste to be disposed of, such as those related to siting, design, construction, licensing and public involvement. Furthermore in his book on toxic and nuclear waste siting, US environmental lawyer Michael Gerrard points out that when the waste management industry wants to add new disposal capacity it is often much easier to expand existing sites than to develop new ones and communities are much more likely to accept expansions of existing facilities even though they are often not sited in environmentally optimal locations<sup>6</sup>. (Gerrard contends that past decisions on where to site disposal facilities were made in the same way as decisions on where to site any heavy industry - by organisations seek-

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<sup>5</sup> See for example Table 3.2 “*Summary of Cost Data for LLW Repositories*” in the 1999 OECD/NEA study, pages 52-53.

<sup>6</sup> *Whose Backyard, Whose Risk: Fear and Fairness in Toxic and Nuclear Waste Siting*. Michael Gerrard. MIT Press. 1995.

ing the best combination of factors such as proximity to markets, materials, labour and infrastructure and low land and development costs). The implication is that the total cost of developing a near-surface repository may strongly depend on whether the repository is to be constructed at a new greenfield location or whether the repository is to be sited at an existing nuclear installation or radioactive waste repository. The simple cost estimates presented in the CoRWM report do not take these complex socio-economic siting factors into account, but they could have a relatively large impact on the actual cost of developing a repository and so could be significant economic issues when CoRWM compares different waste management options. If CoRWM decides to refine the cost analysis in the future we recommend that the effect of siting factors on near-surface disposal economics is taken into account.

### **NDA strategy and scenarios for reactor decommissioning**

CoRWM had requested that the report verified the scope of near-surface disposal facilities required under decommissioning strategies adopted by the civil UK nuclear power plant operators British Energy plc (BE) and Magnox Electric plc (BNFL Magnox). Confirmation of the operators' decommissioning strategies has not been provided in the report, although it should be noted that ultimate responsibility for decommissioning BE and BNFL power stations will shortly transfer to the Nuclear Decommissioning Authority (NDA), subject to state aid clearance by the European Commission<sup>7</sup>. It is not certain that Safestore will continue to be the preferred UK strategy since experience in the United States is moving toward accelerated early dismantlement and decommissioning for some types of reactors. It is possible that in the future US clean-up companies awarded Management and Operation (M&O) contracts by the NDA for dismantlement and decommissioning of civil UK reactors might propose early decommissioning as a more cost-effective alternative to Safestore. In this case the volumes of ILW generated by early decommissioning may be substantially larger than Safestore, because Safestore typically takes advantage of 50-85 years of radioactive decay to reduce the amount of ILW requiring disposal<sup>8</sup>. The effect of early reactor dismantlement on near-surface repository costs might be to substantially increase the overall cost-base because of higher waste volumes requiring disposal, although this scalability problem is not completely certain

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<sup>7</sup> *Energy Act 2004: Explanatory Notes*. September 2004.

<sup>8</sup> See for example Figure 6-4 "*Projected Packaged ILW Volumes Plotted Against Decommissioning Deferral Periods*" in Chapter 6 "*Reactor Decommissioning - The Safestore Concept*", published in "*Nuclear Decommissioning, Waste Management and Environmental Site Remediation*". Colin Bayliss and Kevin Langley. Elsevier. October 2003.

to occur since much of the total life-cycle cost is associated with facilities and infrastructure fixed costs that are largely independent of the size of the repository. We recommend that CoRWM obtains the advice of the NDA on its current life cycle baseline (LCBL) cost estimates for reactor decommissioning and whether the NDA intends to consider any accelerated decommissioning scenarios as an alternative to Safestore.

### **Confirmation of reactor waste inventory by Nirex**

The cost analysis relies on the accuracy of waste package data derived by the authors from inventory information owned by Nirex. We recommend that CoRWM obtains the advice of Nirex on the suitability of this data and whether any underlying information gaps or data uncertainties or data sensitivities are known to be present in the national inventory, that could affect the range of cost projections estimated for a near-surface repository.

### **Full cost analysis and feasibility study**

The cost analysis presented is a reasonable first approximation for use by CoRWM to compare the relative costs of near-surface disposal with other waste management options. However we suggest that CoRWM may need to consider undertaking a more detailed feasibility study (including economic factors) to support any recommendation to Ministers in 2006, for example building on the results of the earlier OECD/NEA and IAEA international studies.

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