BPEO and ALARP: Lessons learned from decommissioning in the UK.

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Abstract. Best Practicable Environmental Option (BPEO) studies in support of decommissioning projects in the UK are discussed in a generic fashion. BPEO is a framework concept that establishes, for a set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long as well as the short term. BPEO is strategic, evaluating alternatives in terms of their implications for environmental quality, giving consideration to the practicability and overall strategic objective to reflect the wider context in which the decision is being made. It considers environmental effects in both the short and long term and the relative importance of different indicators of environmental performance. These are not limited to the direct emission of pollutants. BPEO is reinforced by the introduction of ‘Best Practicable Means’ (BPM) to ensure optimization in any decision making process. BPM can be viewed as a level of management and engineering control that minimizes, as far as practicable, the radiological impact of an option taking account of wider factors such as cost effectiveness, technological status, operational safety and social and environmental factors. Where BPM is demonstrated to have been applied, dose and risks may be regarded as ‘As Low As Reasonably Practicable’ (ALARP). This approach to decision making serves to ensure that discharges and associated dose and risk are driven down. However, decommissioning and decontamination of land can generate substantial volumes of low level liquid waste and presents the potential choice of elevated discharges or conversion to a passively stable solid form.

1. Introduction

This paper discusses the approach to undertaking Best Practicable Environmental Option (BPEO) studies to support radioactive waste management in the UK. This involves some limited discussion of provisional findings from a number of BPEOs undertaken for a major nuclear facility in the UK that is currently undergoing decommissioning. At present these studies are ongoing and, as such, it is not the intention to discuss the specific details of the individual BPEO studies undertaken by Enviros and this paper represents solely the opinions of Enviros staff members.

Given that BPEO is largely a UK concept it is worth considering briefly its development, objectives and interaction with other regulatory drivers within the UK. The BPEO concept was first introduced, in the UK, by the Royal Commission of Environmental Pollution (RCEP), which had identified the need for a more unified approach to regulatory control over pollutant discharges than that which prevailed at the time. RCEP [1] proposed, in their Fifth Report, that rather than having separate and effectively independent controls over the dispositions of waste to air, water and land, the aim should be to identify the optimum overall environmental solution for any given waste stream by directing polluting releases to the medium where the least damage would be done.

In its 12th Report the RCEP [2] described the key elements of a BPEO appraisal study, identifying its role in developing a systematic audit trail that would contribute to openness and transparency in decision making. Seven key stages were identified:

- Define the objective
- Generate options
- Evaluate the options
- Summarise and present the evaluation

¹ ALARP is the UK equivalent of ALARA (As Low As Reasonably Achievable). The distinction is not one of implementation, rather that the term ALARP has case precedence in UK law
- Select the BPEO
- Review the BPEO
- Implement and monitor

The identification of the key stages extended the applicability of the concept beyond pollution control to encompass all ‘projects affecting the environment’ and provided a strategic shift in emphasis toward broader consideration of environmental factors, including the justification of the choice of process that gave rise to the pollution in the first instance.

RCEP [2] also provided the most widely used definition of BPEO in the UK, as follows:

“...the outcome of a systematic and consultative decision making procedure which emphasises the protection and conservation of the environment across air, land and water. The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as the short term.”

It is important to understand that the BPEO process has been introduced and promoted within the UK as a framework concept, linked to an underlying systematic process, rather than a precise decision making tool. Further application and development of the concept by the RCEP [3, 4 and 5] has, by focussing on examples of its use in supporting regulatory judgements, policy making and planning decisions, further defined the implications of the original definition and the following key points are highlighted.

- The process is holistic and is intended to identify a preferred overall strategy from the perspective of the environment as a whole, as opposed to detailed optimization of the selected scheme.
- Alternatives should be evaluated in terms of their projected implications for environmental quality, giving consideration to questions of practicability (including financial costs and/or benefits, as well as wider social and economic benefits) and overall strategic objectives, in order to reflect the wider context in which the decisions are being taken.
- The appraisal process should involve consideration of environmental effects in both the short and long term and the relative importance of different indicators of environmental performance.
- Effects on the environment are not necessarily limited to the direct emissions of pollutants and life cycle consideration may also play a part in the decision process.

With respect to the decommissioning of nuclear facilities, BPEO can be viewed as one of the ‘principles’ or specific objectives that should be pursued implying that it should constitute part of an overall strategic approach to radioactive waste management. This is reinforced by the identification of a separate requirement, alongside the use of detailed assessments to evaluate the radiological impact of discharges, to ensure optimization by means of Best Practicable Means (BPM) to ensure that discharges are as low as reasonably achievable, social and economic factors taken into account. Whilst there is currently no formal definition of BPM in UK Guidance, the Environment Agency for England and Wales [6] has given the following definition in relation to the requirements for the authorisation of the disposal of solid radioactive waste:

“Within a particular waste management option, the BPM is that level of management and engineering control that minimizes, as far as practicable, the radiological impacts of the option whilst taking account of a wider range of factors, including cost effectiveness, technological status, operational safety and social and environmental factors. In determining whether a particular aspect of the proposal represents the BPM, the Agencies will not require the applicant to incur expenditure, whether in money, time or trouble, which is disproportionate to the benefits likely to be derived. Where it is demonstrated that BPM has been applied, doses or risks may be regarded as ALARA (As Low As Reasonably Achievable)”. 
A requirement to consider both BPEO and BPM in the authorisation of radioactive waste management would suggest that BPEO is concerned with identifying and justifying a preferred or ‘best practicable’ overall management approach, whereas BPM relates to optimization of that option from the perspective of radiological protection. Furthermore, the implication is that where BPEO has been identified and BPM implemented, resulting doses and risks may be considered as ALARP.


Enviros has been involved in undertaking a number of BPEO exercises to support a major UK nuclear operator in the management of a number of radiological waste streams during an ongoing programme of site decommissioning. Generically speaking, these have included:

- BPEO assessment for strategic, site wide radioactive waste management issues which includes the management of solid, liquid and gaseous waste streams but does not include the management of nuclear fuels on site.
- BPEO assessment for the management of high activity liquids wastes (HALs).
- BPEO for the management of medium activity liquid wastes (MALs).
- BPEO for the management of solid low level wastes (LLW).
- BPEO for the remediation of the radiologically contaminated land.

In each instance the approach taken to applying BPEO to the management of the waste streams involved 6 distinct stages:

1. Defining the scope and objectives of the BPEO.
2. Generating a list of potential options.
3. Developing and applying screening criteria.
4. Defining and calibrating the attributes.
5. Scoring of each option against those attributes.
6. On this basis, the BPEO is identified or additional options are identified for further validation.

The process of optioneering is perhaps best demonstrated by consideration of a potential waste stream that may arise during operational waste management or during decommissioning. In this instance, the management of liquid waste stocks is considered.

2.1. The use of BPEO in the management of liquid waste stocks

In considering, for example, the BPEO for generic active liquid waste stocks a number of options are identified and assigned into option groups. The option groups serve to define various endpoints for the liquid waste and examples could include:

1. Continued storage of the liquid waste in a non-passively stable form.
2. Generation of passively stable solid product through, for example, vitrification or cementation for indefinite storage or disposal.
3. Generation of product requiring additional processing or packaging, such evaporation and volume reduction, prior to indefinite storage or disposal.
4. Immediate, unrecoverable disposal such as discharge to the marine environment or borehole injection to groundwater.

Screening criteria are then identified and defined. These are developed from national, in this instance UK, law as well as international conventions to which the UK is a signatory and applicable dose constraints as established by the national regulators. They are likely to include but not necessarily be confined to:

1. The London Convention.
2. The OSPAR Convention.
3. The Groundwater Regulations.
4. Restrictions on the import and export of radioactive wastes.

On the basis of the screening criteria, a number of options can be immediately rejected from further consideration. For example, immediate unrecoverable discharge to the marine environment would be construed as infringing the intent of the OSPAR convention and borehole injection would be in contravention of the UK Groundwater Regulations. Similarly, the export of the active liquid waste for treatment in another country, should one be prepared to accept such a waste stream, would be prohibited.

The performance of the remaining options, identified as potentially viable, can then be compared against a number of attributes covering areas related to the potential human health and safety, environmental impacts, projected technical performance, socio-economic impacts on the local community and financial costs. Within these attributes are a number of sub-attributes for consideration. Examples of sub-attributes would include stability of waste product, time scale of implementation and costs entailed in reducing discharges associated with an option.

Each option can be scored against each attribute on a scale from 0 to 5 where 0 is considered an unacceptable outcome and 5 acceptable. The scoring process can be carried out by a project team in a round table forum. Options scoring 0 for any of the attributes are rejected from further consideration on the basis of unacceptable performance.

The option of continued storage in a non-passively stable form would be likely to receive a low score against technical sub-attributes such as ‘stability of waste product’ whilst vitrification would score low against projected timeliness of implementation and the associated costs. Evaporation and volume reduction of the waste will have a low score against associated costs of reducing the resulting aerial discharges.

Cementation of existing active waste stock as solid intermediate level waste, a currently viable technology, could be identified as the best option on the grounds of timeliness of its implementation and the acceptable associated cost. The use of BPEO to identify this option would leave a systematic, consultative and auditable trail of decision making at the strategic level.

In implementing the option identified as the BPEO, the underpinning process of BPM is used to ensure that associated discharges are ALARP. The implication could be construed as implicit that any chosen option would result in reduction in discharges, following the intent of the OSPAR Convention. However the process can support a waste management strategy the results in an increase of discharges to the environment.

The decommissioning of plant associated with a nuclear facility and the decontamination of land on the site can generate substantial volumes of low level liquid waste (LLLW). This presents the choice of containment or dilution and issues of proportionality become apparent when considering whether the low level liquid waste should be converted to a passively stable and solid form and stored or whether it should be discharged. In effect the identified BPEO for dealing with the arising LLLW can involve an increase, in the short term, in the levels of discharge from a site to the environment. This possibility is reflected in the UK Strategy for Radioactive Discharges [7].

DEFRA [7] discusses the UK strategy for radioactive discharges and states “…this strategy recognises that, within the policy of progressive reduction, some flexibility will need to be maintained to safeguard other key government objectives, in particular the safe and timely decommissioning of redundant facilities, the clean up of the historic legacy of radioactive wastes…”

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This suggests that, over the short term at least, the BPEO for the handling of low level liquid waste on a decommissioning site may involve an increase in the levels of liquid waste discharged from the site. Clearly, in order for this option to be the BPEO there would be a requirement to demonstrate that over the longer term, discharges would be reduced relative to other options involving containment. It might also be anticipated that particular scrutiny would be paid to the application of BPM in the waste treatment techniques applied.

3. Discussion

The BPEO process presents a unified approach to regulatory control with the aim of identifying an optimum overall environmental solution. The process presents a systematic audit trail and contributes to openness and transparency in decision making. BPEO as a process is essentially strategic in nature as opposed to a precise decision making tool and, as such, is used to identify a preferred strategy.

The BPEO process is effectively underpinned by the use of BPM which can be viewed as a level of management and engineering control that minimizes, as far as practicable, the impacts of a chosen option. Effectively BPM ensures that each contributory stream to the overall environmental impact is optimised and that the decision making process as whole ensures that doses and risks associated with an option are ALARP.

The overall intent of selecting a BPEO should be to reduce impacts to the environment. In many instances the BPEO process for the treatment of certain waste stocks will identify an option which results in an immediate reduction of discharges to the environment. This reflects the link from BPEO to ALARP. Frequently the reductions in discharges, and hence dose or risk, reflects the implementation of international guidance and requirements such as the OSPAR Convention. In other circumstances the BPEO process can identify an option where there is an associated short term increase in the levels of discharge to the environment, a trend which could be viewed as against the intent of the OSPAR Convention.

4. References