Best Available Techniques (BAT) for the Management of the Generation and Disposal of Radioactive Wastes

Good Practice Guide

This Good Practice Guide on Identifying and Implementing Best Available Techniques (BAT) was prepared on behalf of the Nuclear Industry Safety Directors Forum. It contains all the content of the previous NICoP of the same title and retains that documents Issue status and date but is no longer a Code of Practice. A full update of the document is planned to be completed during 2017.

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Questions or comments about this Good Practice Guide (GPG) should be sent to the Environment Agencies Requirements Working Group (EARWG): c/o Nick Hesketh, EARWGSecretary@cavendishnuclear.com

Executive Summary

Introduction

Permits to dispose of radioactive wastes require the operator to keep all exposures to the public As Low As Reasonably Achievable (ALARA), having regard to relevant factors such as protection of the environment and other social or economic impacts – the 'optimisation requirement'. In England and Wales the application of Best Available Techniques (BAT) is the means to demonstrate compliance with the optimisation requirement. This has replaced the previous requirement to employ Best Practicable Means (BPM).

This Code of Practice presents the principles, processes and practices that should be used when identifying and implementing BAT for the management of radioactive waste.

The use of BPM continues to be required by the Scottish Environment Protection Agency (SEPA) and the Northern Ireland Environment Agency. The Environment Agency and SEPA consider that the requirements to use BPM are equivalent to the requirements to use BAT and that the obligations on waste producers are the same. Consequently, much of the guidance will be applicable within Scotland and Northern Ireland (see Section 1).

What is BAT

Section 2 outlines the history and application of BAT. In broad terms, "best available techniques" means the latest stage of development of processes, facilities or methods of operation which is practicable and suitable to limit waste arisings and disposals (Section 2.2). BAT applies throughout the lifetime of a process, from design to implementation, operation, maintenance and decommissioning.

Identification and implementation of BAT implies a balanced judgement of the benefit derived from a measure and the cost or effort of its introduction. The level of effort expended to resolve an issue, and to record the selection process, should be proportional to the scale of the challenge, the range of options available and the extent to which established good practice can be used to assist in the decision making process. Nonetheless, guidance and precedent make clear that practicable measures to further reduce health, safety and environmental impacts can be ruled out as not reasonable only if the money, time, trouble or other costs involved would be "grossly disproportionate" to the benefit (Section 2.2; expanded in Section 4). The following principles should also be taken into account (Section 4):

- sustainable development;
- waste hierarchy and waste form;
- the precautionary principle;
- the proximity principle.

Subject to meeting regulatory obligations, the identification and application of BAT takes into account all relevant circumstances.

Identifying and Implementing BAT

<u>Management Arrangements</u>

It is a requirement within the terms of permits issued under the Environmental Permitting Regulations 2010 (EPR2010) and the Radioactive Substances Act 1993 (RSA93) that an Operator shall have a management system, organisational structure and resources sufficient to comply with limitations and conditions stipulated within the permit (Section 5.1). The principle of applying 'best practice' should be explicit in all site strategies, whether construction and operation or decommissioning programmes and activities.

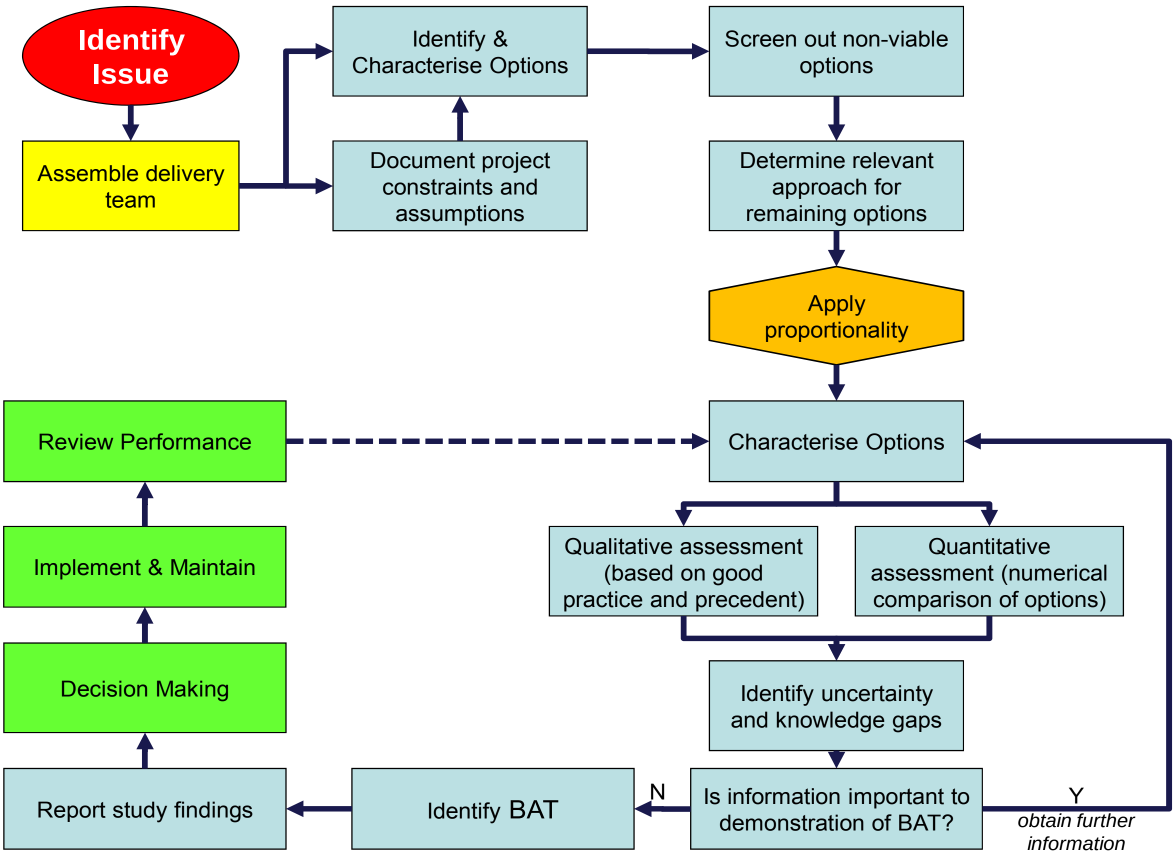
How to Identify BAT

It is emphasised (Section 5) that there is no single 'right way' to identify BAT; although all studies will be based on information, verified where practicable, and documented for transparency. BAT may be established by reference to previous studies, or as an independent comparison of detriments and benefits. The general rule is that the level of effort expended to identify and implement BAT should be proportionate to the scale of the issue to be resolved (Section 5.2).

In many cases, studies will be constrained by one or more factors, depending upon the assessment context. A number of assumptions may also be required, particularly where long timescales are considered (Section 5.5).

Whichever approach is adopted the process, and any underpinning constraints or assumptions, must be documented and justified (Section 5.7).

Simplified approach to determining, implementing and maintaining BAT



Key to a robust BAT assessment is to demonstrate a thorough consideration of available options (Section 5.4). Once all options have been identified, a high-level screening should be applied to identify non-viable options and thus, by elimination, identify a short-list of options that can credibly satisfy the objective (Section 5.6). Stakeholder input, broadening the basis of experience available, may be helpful where larger projects are involved (Section 5.3).

Qualitative Assessments

Where previous appraisals have been undertaken, or good practice established, it may be possible to demonstrate BAT without the need for more detailed consideration of options (Section 5.8). This requires that the precedent is fully applicable to the facility in question. In such instances, it may be sufficient for a short report to be produced comparing the advantages and disadvantages of any alternative technologies or management practices with those currently in use, together with a description of any improvements that will be implemented following the study.

Such an approach must be reasoned, logical and transparent. It must contain sufficient information to allow an informed review to be undertaken.

Quantitative Assessments

The purpose of a quantitative or semi-quantitative appraisal is to inform and assist in identifying the best practicable option (Section 5.9). Assessments:

- must be carried out in a systematic, consistent manner, including analysis of options and assessment criteria, and identification of the best option;
- require data on radiological impacts to workers and the public (under accident conditions and normal operations);
- need to consider non-radiological impacts and all relevant legal and policy, societal and economic factors;
- need to document all relevant risks and uncertainties.

For each short-listed option, underpinning technical and economic data should be collated to support the selection of a preferred option (or options).

<u>Implementation and Maintenance of BAT</u>

Once BAT has been established it needs to be reviewed at appropriate intervals (Section 7). The requirement to implement and maintain BAT embraces:

- proportionality of effort;
- the provision, maintenance, and operation of relevant plant, machinery or equipment;
- the supervision of any relevant operation;
- taking samples and conducting measurements, tests, surveys, analyses and calculations, to demonstrate compliance with limits and conditions.

Failure to operate equipment as intended, to inspect or maintain equipment such that it remains in good working order, to train and supervise staff, or to monitor the effectiveness of systems may be interpreted as a failure to apply BAT (Section 7.1).

Decision Taking

The identification of BAT is an important element within the decision making process, but does not necessarily represent the final decision (Section 6). For instance, a study may be inconclusive, in that more than one approach may be regarded as essentially equivalent. In such a case, an element of judgement is required. Likewise, a decision may be influenced by other factors, either known at the time of the initial assessment or emerging subsequently. For instance, there may be reasons for implementing a disproportionate response. Where this is the case, the specific drivers need to be identified to avoid setting this as a new benchmark. This reinforces the need to document information, including constraints and assumptions, throughout the assessment process (Sections 5.11 and 7.8). Subject to meeting regulatory obligations at all times, there may also be a balance to be reached across site-wide initiatives, recognising that the balance of priorities may lie with achieving the biggest benefit or detriment reduction within a finite pool of resources.

Within this Code of Practice it is stressed that adopting an evidence-based approach is fundamental to identifying BAT; rather than implying that a numerical comparison of options is a necessary or sufficient basis to determine the way forward. An 'aide memoire' is presented (Section 8), to assist in determining that an appropriate and proportionate approach to identifying and implementing BAT has been adopted.

The legal framework and context around the use of BAT is outlined in Appendix 1, and an illustrative approach to conducting a BAT study (based on a Multi-Attribute Assessment) is presented in Appendix 2. Complementary approaches adopted within Central Government and the Nuclear Decommissioning Authority are illustrated in Appendix 3.

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1 Introduction

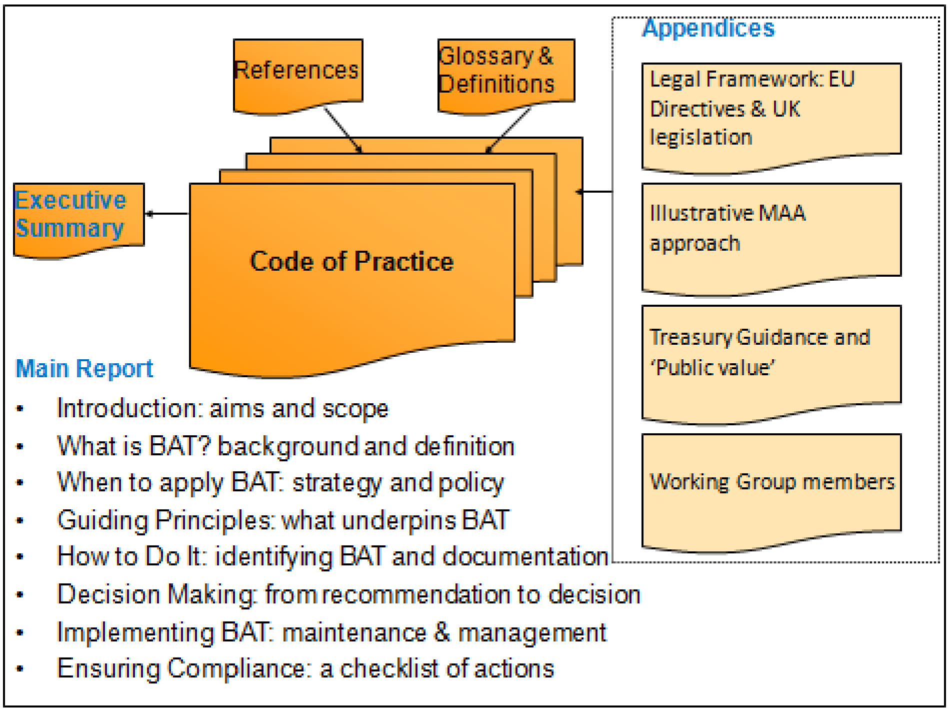
The Environment Agency is responsible under the Environmental Permitting (England & Wales) Regulations 2010 (EPR) for regulating all disposals of radioactive waste on and from nuclear licensed sites in England and Wales[1], where "disposals" include discharges into the atmosphere, discharges into the sea, rivers, drains or groundwater, disposals to land, and disposals by transfer to another site. In Scotland and Northern Ireland the management and disposal of radioactive waste is regulated under the Radioactive Substances Act 1993 (RSA 93).

With respect to radioactive waste disposal, the key regulatory requirement is to demonstrate optimisation, maintaining doses to people As Low As Reasonably Achievable (ALARA). The optimisation requirement covers all aspects of activities leading to the generation and disposal of radioactive waste. Optimisation is achieved through the use of specific permit conditions requiring the application of Best Available Techniques (BAT), where BAT means both the technology used and the way in which the installation is designed, built, maintained, operated and dismantled. Therefore, in principle, the regulation of radioactive waste disposal embraces all aspects of nuclear site processes - not just waste management - which have a bearing on radioactive waste production and which relate to the foreseeable disposal of those wastes at some stage. It follows that BAT should be identified early in any process and implemented throughout its lifetime.

In Scotland, optimisation is achieved through the use of authorisation conditions requiring the application of Best Practicable Means (BPM). The Environment Agency and SEPA consider that the requirements to use BPM are equivalent to the requirements to use BAT and that the obligations on waste producers are the same.

This document is presented in three component parts (Figure 1): an Executive Summary, the Main Report and separate Appendices providing illustrative approaches and other information too detailed to go into the main report.

Figure 1. Document structure



1.1 Aim of this Code of Practice

This Code of Practice aims to present the principles, processes and practices that should be used when identifying and implementing BAT for the management of radioactive waste in compliance with regulatory conditions.

1.2 Scope and Application of this Code of Practice

This Code of Practice is intended to provide guidance for practitioners for the demonstration and implementation of BAT and to assist those responsible for formulating organisational policy and developing working level procedures applicable to operators of nuclear licensed sites. The Code of Practice draws on examples of good practice within the nuclear industry, offering points of comparison and presenting brief case studies. At the same time, it is not intended to restrict the choice of methods for demonstrating BAT, or to constrain organisational policy.

The provision of a Code of Practice for the assessment of BAT will have a direct application in England and Wales. As BAT and BPM both demonstrate compliance with optimisation, much of the guidance will also be applicable within Scotland and Northern Ireland.

2 Introduction to BAT

2.1 Brief History

2.1.1 Use of Best Practicable Means

Use of Best Practicable Means to control discharges and impacts is a concept with a long pedigree in the UK. It was first used in UK legislation in the Alkali Act (Amendment) 1874, which required that "*the owner of every alkali work shall use the best practicable means of preventing the discharge into the atmosphere of all other noxious gases arising from such work, or of rendering such gases harmless when discharged.*" The related concept of Best Practicable Environmental Option (BPEO) was introduced by the Royal Commission on Environmental Pollution in 1976[2] as, "*the outcome of a systematic and consultative decision-making procedure which emphasises the protection and conservation of the environment across land, air and water*"[3]. Over a number of years, BPEO and BPM have been applied as a sequential process, the former identifying 'what to do' and the latter 'how to do it', although the concept of BPM was always intended to cover both aspects.

2.1.2 Introduction of Best Available Techniques

The Treaty of the European Atomic Energy Community (EURATOM) gave the European Community the task of establishing uniform safety standards to protect the health of workers and the general public in all Member States from exposure to radiation. In 1996 the European Council issued a Directive[4] laying down basic safety standards for the protection of the health of workers and the general public from exposure to ionising radiation. This Directive, which took account of the recommendations of the International Commission on Radiological Protection (ICRP)[5], has been enshrined in UK legislation. The most recent recommendations of the ICRP[6] for practices involving radioactive substances retain the principles of:

- justification of a practice;
- optimisation of protection;
- application of individual dose and risk limits.

Text Box 1. Justification, Optimisation and Limitation

Justification aims to ensure that no practice is adopted which involves exposure to ionising radiation unless it produces a nett benefit to the exposed individuals, or to society as a whole. Justification is not an obligation on the operator.

Optimisation is the process whereby an operator selects the technical or management option that best meets the full range of relevant health, safety, environmental and security objectives, taking into account factors such as social and economic considerations. With respect to optimisation, ICRP[5,6] state that, "*in relation to any particular source within a practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received should be kept As Low As Reasonably Achievable, economic and social factors being taken into account*" (the ALARA principle). In addition, all exposures should be constrained to minimise inequalities arising from risks to any individual or part of society.

Limitation provides a mechanism of dose limits which ensure that no individual shall be exposed to ionising radiation leading to an unacceptable risk under normal circumstances.

The requirement to keep all exposure to radiation ALARA was given effect within authorisations issued under RSA93 by the inclusion of conditions requiring the authorisation holder to use the BPM to minimise the production of waste that will require disposal as radioactive waste and to minimise the impact of such disposals, for example by considering the physical and chemical form of the waste and the disposal route (see Section 4.2).

The 2009 UK strategy on radioactive discharges signified the adoption in England and Wales of 'Best Available Techniques' (BAT), in place of the previous requirement to employ BPM, to minimise radioactive waste arisings and disposals[7]. BERR[8] also stated that BAT would be used in considering plans for new build nuclear power stations. In parallel, the Environment Agency released proposals for the implementation of environmental principles to radioactive substances regulation, including the application of BAT[9].

2.1.3 The Adoption of BAT in Place of BPM in England and Wales

Regulatory guidance is that BAT and BPM represent essentially the same assessment processes[9], both having the aim of "*balancing costs against environmental benefits by means of a logical and transparent approach to identifying and selecting processes, operations and management systems to reduce discharges*"[10] and the effect of discharges.

2.2 Definition of BAT

There is a long-standing commitment under the OSPAR Convention[11] to apply BAT at nuclear facilities, "*to minimize and, as appropriate, eliminate any pollution caused by radioactive discharges from all nuclear industries … into the marine environment.*"[12] DECC[7] has adopted the OSPAR definition of BAT for the regulation of radioactive substances.

Text Box 2. Definition of BAT

Best Available Techniques (BAT) means the latest stage of development of processes, facilities or methods of operation which indicate the practical suitability of a particular measure for limiting waste arisings and disposal[11]. In determining what constitutes BAT consideration shall be given to:

1. comparable processes, facilities or methods which have been tried out successfully;
2. technological advances and changes in scientific knowledge and understanding;
3. the economic feasibility of such techniques;
4. time limits for installation in both new and existing plants;
5. the nature and volume of the disposals concerned.

It follows that BAT will change with time in the light of technological advances, economic and social factors, and changes in scientific understanding.

The requirement to use BAT has been part of the regulatory framework for non-radioactive Pollution Prevention and Control (PPC) for many years[13,14,15] (see Appendix 1). Statutory Guidance[18] indicates that ministers consider the PPC and OSPAR definitions of BAT to be similar. Nonetheless, the Environment Agency[1] has made clear that the adoption of BAT in RSR does not mean that:

- in general, the requirements of the PPC Directive have been applied to RSR;
- specifically, the approach to BAT is the same in both regimes.

There are differences between the legal and policy requirements of PPC and RSR. Adoption of BAT is not intended to change practices within RSR. Consequently, differences will remain between RSR and PPC in demonstrating application of BAT.

2.2.1 Meaning of Available

"Available" requires consideration of[9]:

- whether the techniques under consideration have been developed on a scale which allows implementation in the relevant industrial sector;
- whether the conditions mean that techniques are economically and technically viable, taking into consideration both the benefits and detriments.

Defra Guidance on BAT[16] makes clear that a technique does not have to be in general use; it only needs to have been developed to such a level that it can be introduced *confidently*. There does not need to be a competitive market, nor does it matter whether a technique is used or produced within the UK or the EU, as long as it is reasonably accessible and meets UK legislation requirements. Conversely, the fact that a technique is available does not mean that it represents BAT.

The second test is common to duties under Health and Safety legislation, as well as radiation protection[16] and requires the operator to establish an appropriate balance of cost and benefit.

2.2.2 Meaning of Best

"Best" means the most effective in achieving a high level of protection of the public from exposure to ionising radiation[9] assessed against the full range of detriments and benefits of further reductions.

2.2.3 Techniques

"Techniques" includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.[9]

As set out within discharge permits, the application of BAT includes management regimes to ensure competence, maintenance, inspection, supervision and monitoring across all stages in the lifecycle of a facility.

2.2.4 Proportionality of Approach

In relation to reducing radioactive discharges, some flexibility is needed to safeguard other Government objectives.

Looking at the selection of the most appropriate abatement technology to reduce disposals shows how the environmental, social and economic aspects of sustainable development need to be balanced. For example, there would be no overall benefit to the environment if, as a result of a new abatement process, a plant emitted large quantities of carbon dioxide or toxic (but non-radioactive) substances into the environment, resulting in environmental harm equal to or greater than that avoided by abating the radioactive discharges.

Likewise, while affordability is not a justification for applying lower levels of environmental protection, if the burden of installing abatement equipment was so great that other activities were to become uneconomic, the social and economic impact could be judged to outweigh the environmental benefit of the proposed abatement technology. In this context, the Courts[*] have set a precedent for judging whether duty-holders have done enough to reduce risks. In effect, practicable measures to reduce risk can be ruled out as not

[*] Notably Edwards v. National Coal Board (1949: 1 All ER 743)

'reasonable' only if the money, time, trouble or other costs involved in taking them would be "grossly disproportionate" to the risk.

At this time, there is no authoritative guidance as to when cost is grossly disproportionate. Hence, the judgment must be made on a case by case basis. Both Environment Agency and HSE guidance on the topic of gross disproportion make clear that cost cannot form the sole argument of a BAT, nor can it be used to undermine existing standards and good practice. It is also important to note that, should a technique be adopted by an operator even though it is clearly disproportionate, it would not determine BAT for other operators (see Section 4).

2.3 Application of BAT in England and Wales

The Government[17] has stated that it will maintain, and continue to develop, a policy and regulatory framework which ensures that radioactive wastes are not created unnecessarily. Where such wastes are created, they are to be managed, treated and disposed of safely, at appropriate times and in appropriate ways.

In 2009, DECC and the Welsh Assembly Government issued Statutory Guidance to the Environment Agency for England and Wales[18], laying down a requirement that regulators set limits on radioactive discharges based on BAT. This includes the guidance that, "*where the prospective dose to the most exposed group of members of the public is below 10 μSv/y from overall discharges … the Environment Agency should not seek to reduce further the discharge limits in place, provided that the holder of the authorisation applies and continues to apply BAT".*[*]

Text Box 3. Threshold to Optimisation

The term 'threshold to optimisation' may be misunderstood. The key provision is that there is no threshold in terms of dose to the public at which the techniques in place can be presumed to be BAT simply because of their resulting impact[1]. The 10 μSv per year figure is not a dose target, or a dose limit, or a threshold, or a radiation standard. It merely represents an appropriate level of dose, below which discharge limits need not be reduced further if the operator is continuing to apply BAT. The onus remains with the operator under all circumstances to demonstrate that BAT has been applied. If any benefit or reduction in detriment, however small, can be achieved using little or no additional resources then it should be secured.

Guidance from the Environment Agency[9] states that BAT is the point when the detriments from implementing further techniques become grossly disproportionate to the benefits gained. Even then, if the reduction of disposals resulting from the use of BAT does not lead to environmentally acceptable results, additional measures have to be applied.

2.4 Application of BPM in Scotland

The use of BPM continues to be required by SEPA in authorisations issued under RSA 93. BPM was defined in Command 2919[17] in relation to the release of radioactivity into the environment. However, SEPA uses BPM in the wider context of keeping ionising radiation exposures to the public ALARA. Therefore BPM is not restricted to minimising the release of radioactivity to the environment. With this in mind SEPA has redefined BPM so that it can be applied in a fashion which is consistent with BAT.

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[*] In England and Wales, this value supersedes the 'threshold to optimisation' of 20 μSv/y set out in Cmnd 2919, although this will continue to be used in Scotland. In all other respects, the requirements as laid out for application of BAT are essentially identical to those currently identified for the demonstration of BPM.

In order to satisfy the requirement to keep public exposures ALARA, SEPA requires radioactive substances users to use BPM to minimise:

1. the activity and volume of radioactive waste generated;
2. the total activity of radioactive waste that is discharged to the environment;
3. the radiological effects of such discharges on the environment and members of the public.

Although it is individual exposures that should be minimised, the optimisation process should take account of such factors as the availability and cost of relevant measures, operator safety, the benefits of reduced disposals and other social and economic factors, as appropriate. As with BAT applied in England and Wales, it is important to recognise that selecting BPM to achieve the given objectives is not a one-off process. The users of radioactive substances should keep their operations under review to ensure that they are continuing to use BPM.

2.5 Protecting People and the Environment

There is a distinction between the requirement to *optimise* impacts to people (that is, keeping exposures ALARA, having regard to social, economic and other factors) and the requirement to *protect* the environment [e.g. 5]. Impacts on non-human biota are typically assessed at the population level, based on reference organism types, although for protected species or habitats, more detailed impact assessments may be required.

Text Box 4. Basis for Protecting People and the Environment

The Environment Agency[1] offers the following guidance on the regulation of radioactive substance activities on nuclear licensed sites under the EPR.

"*Dose limits for people are set at a level intended to prevent those radiation effects in humans which are known to occur above a certain level or threshold of dose (deterministic effects) and to ensure that the incidence of those radiation effects for which it is assumed that there is no threshold and that the risk of causing the effect increases with the level of the radiation dose (stochastic effects) is not at an unacceptable level. Application of the optimisation principle and the use of constraints, which are set below dose limits, further reduces this risk to as low as reasonably achievable*."

With respect to protection of non-human species, a full framework for radiological protection is still under development. In the meantime, an interim assessment approach has been developed[19,20]. This uses models of the behaviour and transfer of radionuclides within ecosystems to predict environmental concentrations, from which the radiation doses to reference organisms can be estimated. These doses can then be compared to 'guideline values' to assess the level of risk.

In a discussion document, the IAEA[21] recognised that definitions of, and attitudes to protecting, the environment are culturally based. Thus, the introduction of radioactivity or any other material, or change in property of the physical environment may be deemed intrusive; even if there is no perceptible resultant change in any part of the living environment. Similarly, the UK Discharge Strategy[7] states that introduction of radioactivity to the environment is 'undesirable'.

Advice from the ICRP[6] applies optimisation both to the protection of people and of the broader environment. Whilst the recommendations of the ICRP in this respect may influence assessments undertaken by site operators, it is not a regulatory requirement.

2.6 Role of Collective Dose in Optimisation

Permit conditions principally require that individual exposures should be optimised. However, the Basic Safety Standards Directive[4] places a duty on Member States to minimise the exposure risks faced by the general public, both individually and collectively.

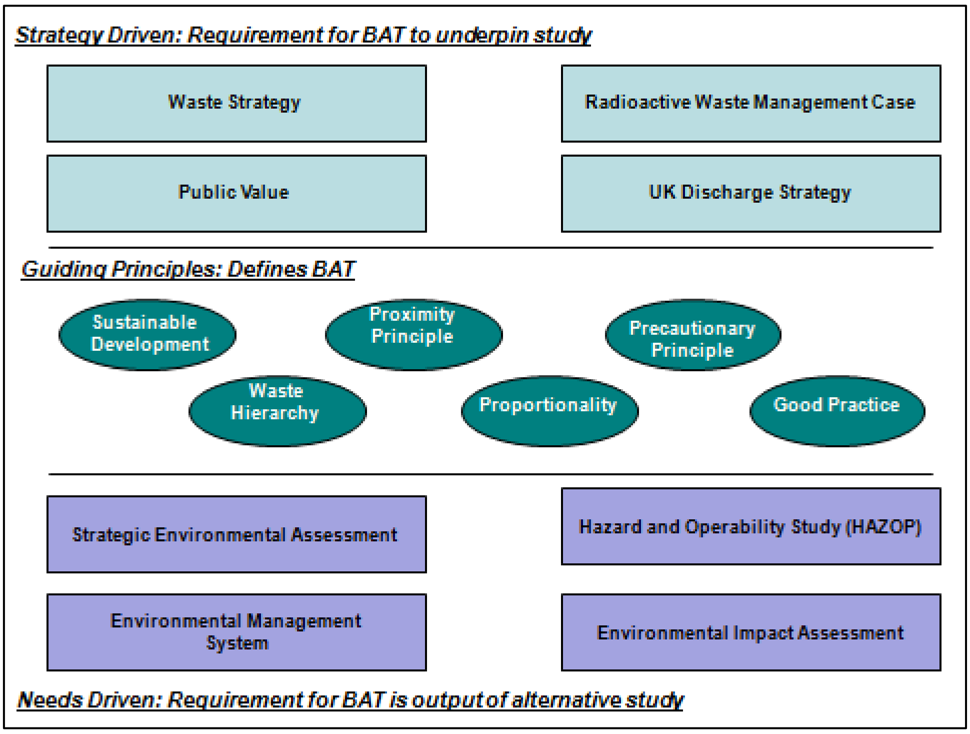
Consideration of exposure to the population as a whole is typically expressed through the concept of collective dose.

Use of collective dose is not without its pitfalls, as it may aggregate very small doses expressed over long periods of time in such a way as to exaggerate perceptions of detriment[6]. As collective dose is highly dependent on the selection of an exposed population and the timeframe over which exposures are received, the concept is best suited to comparing options as part of an optimisation exercise. Guidance on the determination and application of collective dose has been offered by the Health Protection Agency[41]. In summary, the HPA favours the truncation of collective doses to a period of 500 years, with identification of specific populations and geographic regions (e.g. UK, Europe, World).

3 Drivers for BAT Beyond Permit Conditions

Site Permit Conditions specifically require the application of BAT as a means to demonstrate optimisation* (Section 2 and Text Box 8, Section 5). In addition, there are other drivers which use similar processes (see Figure 2 below and Appendix 1 for a summary of legislative drivers).

Figure 2. Interactions with BAT: strategy, principles and needs



Strategies and policies requiring a BAT (or equivalent) assessment include the following.

- **UK Discharge Strategy**. The UK strategy for radioactive discharges[7] sets out how the UK intends to implement the OSPAR Radioactive Substances Strategy. The Strategy, which calls for continuous reductions in the discharges and emissions of radioactive materials to the environment, requires operators to demonstrate the application of BAT or BPM to manage any discharges during operations.

- **Waste Strategy**. Government policy requires a Waste Strategy for the management and disposal of radioactive wastes, including consideration of the non-radioactive properties of the wastes. The NDA, for example, has established a specification supporting the development of such documents[22]. It is considered good practice to cover non-radioactive wastes in a similar way.

- **Business Case and Options Appraisal**. The production of business cases to support projects is a fundamental requirement placed on the NDA by government. The NDA has produced guidance[23] supporting the production of business cases. Business cases must be underpinned by options appraisal (Appendix 3).

- **Radioactive Waste Management Case.** A RWMC is a mechanism to demonstrate the long-term safety and environmental performance of the management of specific wastes from their generation to their conditioning into the form in which they will be suitable for storage and (in England and Wales) eventual disposal. The RWMC should detail the

* In Scotland, equivalent requirements within Site Authorisations under RSA require the application of BPM as a means to demonstrate optimisation.

available options and processes considered and any reasons and assumptions used to reject options. Preferred options should be identified on the basis of safety and environmental performance. Proposed packaging and conditioning strategies should be fully underpinned by BAT assessment to minimise long-term environmental impact and ensure associated doses are ALARA[24].

There are also a number of policies and strategies relating to environmental management which do not explicitly require that BAT studies are undertaken, but where the need for BAT assessments may be identified.

- **Environmental Management Systems.** The majority of nuclear sites operate an EMS. Such systems provide a framework for managing environmental responsibilities, maintenance arrangements, etc.

- **Environmental Impact Assessments.** Throughout the UK there is a statutory requirement for the preparation of an EIA for a range of planning applications, in order to ensure that the likely effects (both positive and negative) of a proposed development on the environment are fully understood and taken into account. A key initial stage in an EIA is an options appraisal, encompassing site selection and project design. A planning applicant is required to identify the alternatives considered and reasoning for the choices made. Measures to prevent, reduce or offset any significant adverse effects must be described.

- **Strategic Environmental Assessment.** Public sector plans and programmes that are likely to have significant effects on the environment must have an SEA when they are being prepared[25]. The SEA process requires that all reasonable alternatives to the plan are identified and that all likely effects on the environment are assessed. Where significant adverse effects are identified, information must be given as to how these will be prevented, reduced or offset. The SEA process[26] requires objective definition, context setting, options identification and evaluation.

- **HAZOP**. A Hazard and Operability (HAZOP) study is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation. Typically, a HAZOP is a qualitative technique carried out by a multi-disciplinary team during a set of meetings. Individual components within a HAZOP study may be underpinned by identification of BAT or, *vice versa*, a BAT study may require a HAZOP analysis.

4 Guiding Principles

All activities must comply with the legal framework of justification, optimisation and limitation (Section 2 and Appendix 1). In order to identify BAT, there are a number of principles which may influence studies. On a case by case basis, the relative importance of the factors may vary. The following list is neither prescriptive nor exhaustive, but provides indications of factors which may be taken into account:

- sustainable development;
- waste hierarchy and waste form;
- the precautionary principle;
- the proximity principle.

At all times, the key aspect of a BAT assessment is the use of evidence to present a balanced judgement, taking into account all relevant factors. In addition, studies should be proportional to the issue under consideration and should demonstrate knowledge of Relevant Good Practice. These principles are also considered here.

It is recommended that any project for waste minimisation should have knowledge of other relevant studies being completed on-site. This will avoid duplication of effort and may add value through a coordinated waste management programme.

4.1 Sustainable development

The UK Strategy on Radioactive Discharges[7] requires, amongst other considerations, reference to sustainable development, meeting "*the needs of the present without compromising the ability of future generations to meet their own needs*". The demonstration of sustainability requires an analysis of the environmental, social and economic impacts when making decisions about the way to implement policy objectives.

The environmental strand of sustainability involves minimising so far as practicable the UK's impact on the environment.

With respect to societal considerations, the UK Strategy is to reduce discharges to the environment, reduce concentrations in the marine environment and achieve progressive reduction in human exposure where practicable (subject to this not leading to unacceptable increases in risk from accident scenarios).

The remaining strand of sustainability encompasses economic growth, to maintain quality of life, while decoupling such growth from environmental degradation. The costs of discharge reduction must include wider economic, societal and environmental detriment, as well as monetary expenditure.

4.2 Waste Hierarchy and Waste Form

It is a requirement within permits issued under EPR that the Operator shall minimise the activity of radioactive waste that will require disposal and, where disposal is required, shall do so in a form and manner so as to minimise the radiological effects on the environment and members of the public. Under the Nuclear Installations Act[27] standard licence condition 32[28] also requires adequate arrangements to minimise the rate of production and total quantity of radioactive waste and to record such waste.

Adoption of the waste hierarchy is embedded in UK policy for the management of solid, liquid or gaseous radioactive wastes[e.g. 29,30,31,32,33]. The waste hierarchy means:

- not creating waste where practicable;
- reducing waste arisings by activity, mass or volume to a minimum through the design and operation of processes and equipment, including effective waste characterisation, sorting and segregation, volume reduction and removal of surface contamination;
- minimising quantities of waste requiring disposal through decay storage, re-use, recycling or incineration (including recovery of energy from waste schemes).

Disposal of waste is always the least preferred option[34]. Where disposals are necessary, BAT should be applied to minimise impacts (Figure 3). Options for the management of radioactive waste include discharge of gaseous or liquid radioactivity into the environment ('dilute and disperse') or trapping in a solid, concentrated form for storage and eventual disposal ('concentrate and contain'). The Government's view is that 'concentrate and contain' is generally appropriate for managing radioactive wastes, although if it can be demonstrated that a 'dilute and disperse' option is BAT, such an option could be preferred.

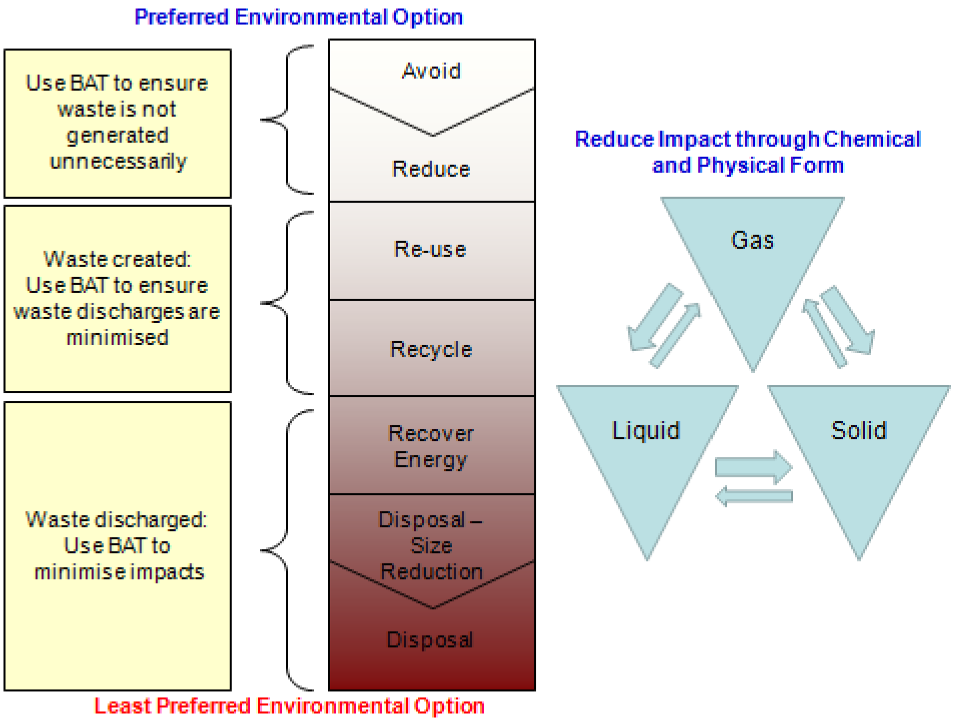


Figure 3. BAT and Waste Management Principles

Whilst there is a general preference for solidification of wastes, optimisation of waste form and potential impact may include chemical rather than physical changes of state (e.g. pH of aqueous wastes). In addition, permit conditions may raise specific considerations such as the exclusion of entrained solids, gases and non-aqueous liquids from radioactive aqueous waste or the removal of suspended solids from waste oils. In all cases, optimisation of radiation doses is the overriding requirement rather than application of the waste hierarchy.

4.3 Precautionary Principle

The basis of the precautionary principle is that, "*where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*."[35]

The Commission of the European Communities issued a Communication on the Precautionary Principle[36], indicating that the principle should be considered within a structured approach to the analysis of risk which comprises three elements: risk assessment, risk management and risk communication. Where action is deemed necessary, measures based on the precautionary principle should be, *inter alia*:

- proportional to the chosen level of protection;
- non-discriminatory in their application;
- consistent with similar measures already taken;
- based on an examination of the potential benefits and costs of action or lack of action;
- subject to review, in the light of new scientific data;
- capable of assigning responsibility for producing the scientific evidence necessary for a more comprehensive risk assessment.

The Precautionary Principle allows policy makers to make discretionary decisions in situations where there is the possibility of harm, even when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public from exposure to harm whenever there is a plausible risk.

4.4 Proximity Principle

The proximity principle requires that waste is managed or disposed of as close as possible to the point of generation, reducing pollution from transportation. This principle is closely related to 'self-sufficiency' taken from the Framework Directive on Waste. This requires Member States to take appropriate measures to provide an integrated network of disposal installations adequate to enable the European Union to become self-sufficient in waste treatment and disposal.

At the same time, it is recognised that for certain types of wastes, including some LLW, the development of local, regional or national facilities (see, for instance, the low level waste management policy[30]) may require the transport of materials. Where it is not feasible to treat at, or in close proximity, to source, preferred transportation options (e.g. water or rail) may serve to minimise environmental impacts. In some instances longer distance travel by rail or sea link may be preferable to road transport over shorter distances. In other instances, transport to a remote location for treatment (e.g. to facilitate recycling) may be preferable to disposal in close proximity to source.

It is clear that the proximity principle requires a broad overview of options and cannot be applied as a simple hierarchy based on distance.

4.5 Proportionality

The concept of proportionality is that the level of effort or cost expended to resolve an issue, and subsequently to record the selection process, should be linked to the scale of the challenge (e.g. public exposure to radiation), the range of options available to resolve the issue and the extent to which precedent and established good practice can be used to assist in the decision making process. Consequently the demonstration of optimisation can vary from a detailed study involving options assessment, selection and minimisation for a complex operation with no established good practice, to a short description of operation in accordance with recognised standards and guidance for a less complex operation or one with well established good practice.

The Environment Agencies offer the guidance that anything further that can be done to reduce doses to people should be implemented unless the associated detriments are grossly disproportionate to the benefits gained.

Text Box 5. What is 'gross disproportion'

In judging whether duty-holders have done enough to reduce detriments, practicable measures to achieve further reductions can be ruled out as not 'reasonable' if the money, time, trouble or other costs involved in taking them would be grossly disproportionate to the benefit.

There is no authoritative guidance as to what determines whether cost is grossly disproportionate to benefit. It is likely that where the impact before measures are introduced is high, a higher ratio of costs to benefits will be judged 'reasonable' and the Treasury[37] has accepted the general argument that there is an inherent fairness to assigning higher levels of disproportionality for higher impacts.

As a rule of thumb, when considering cost benefit arguments in support of ALARP arguments, the HSE[38] takes as a starting point its submission to the 1987 Sizewell B Inquiry that a factor of up to 3 (i.e. costs three times larger than benefits) would apply for risks to workers. For low risks to members of the public a factor of 2 may apply and for high risks a factor of 10 may apply. Nonetheless, at present, each judgment must be made on a case by case basis.

According to HSE[38] guidance for health and safety ALARP determinations, judgements on gross disproportion should take into account:

- the number of people (workers and public) that may be exposed to radiological risk;
- the magnitude, and frequency, of the consequences;
- nuclear security and safeguards requirements;
- non-radiological hazards, resources used (e.g. energy) and other economic, societal or environmental factors.

The process of identifying BAT involves compromises between different factors in order to achieve the best overall outcome. BAT is not just about minimising the environmental impact of the disposal of radioactive waste, but minimisation consistent with meeting other obligations. Consequently, determining when an action is grossly disproportionate to the benefits is not straightforward. Nonetheless, guidance can be given. By way of illustration, suppose there are six options, each of which offers increasing levels of benefit, but where the 'cost' (in terms of time, effort or money) also increases. The overall measures of benefit and detriment can be assessed against one another, as indicated in Figure 4.

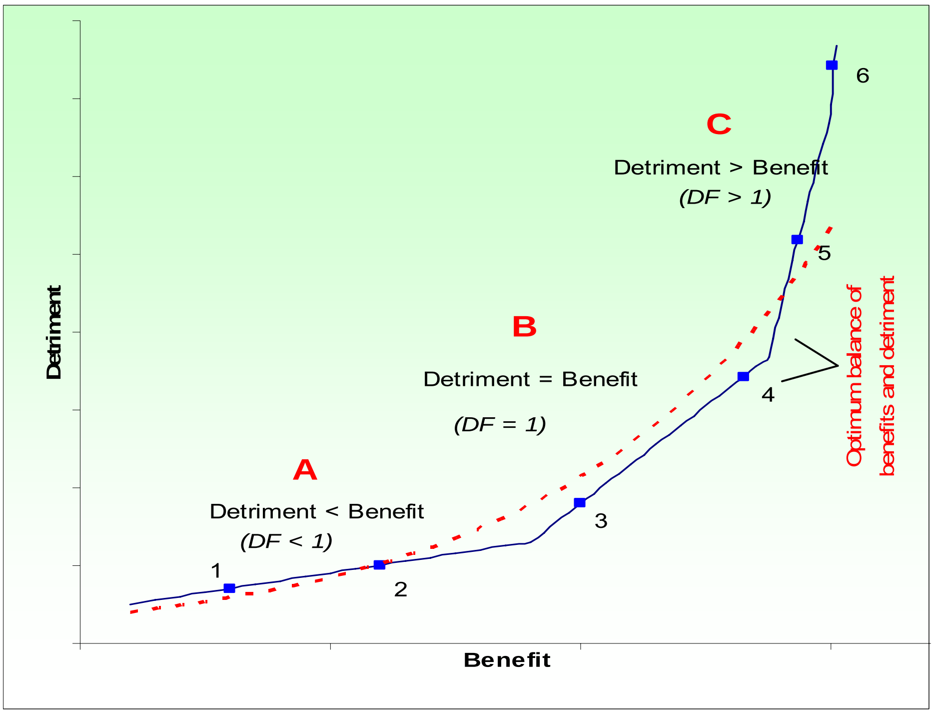


Figure 4. Illustrative approach to identifying disproportionality

In this illustration it can be seen that for options 1 and 2 the benefits actually increase more than the associated level of effort or detriment (i.e. the Disproportionality Factor, DF, is less than 1). For options 3 and 4 the level of benefit derived and the corresponding level of effort required increase at the same rate (i.e. the DF equals 1). For options 5 and 6, however, the additional levels of benefit derived become small by comparison to the overall level of effort to achieve them (i.e. the DF is more than 1). For this illustration, option 4 is near to the optimum balance of benefits and detriments whilst options 5 and 6 represent increasing levels of disproportionality, the adoption or exclusion of which then requires justification.

In general, wherever a simple, low cost, action can be undertaken to reduce an impact, it will almost always be justified. As an analogy, removing packaging before taking items into a controlled area may represent a relatively small saving in total waste volumes. Nonetheless, the level of effort required at an individual and corporate level is sufficiently small that it will almost always represent good practice. At the same time, a distinction is required in expressing benefits (or detriments) in relative or absolute terms. Thus, reducing a dose from 0.1 μSv to 0.001 μSv represents a relative reduction of two orders of magnitude, but is very small in absolute terms.

It is also necessary to recognise that 'cost' may not be a simple measure of financial spend, or of effort. For instance, installing a treatment plant to reduce waste generation or impact may itself present an environmental or social burden in terms of land occupied (and loss of ecological habitat), raw materials and energy use, greenhouse gas emissions or other non-radiological discharges. Secondary costs may involve additional regulatory requirements and permits or H&S considerations.

Text Box 6. A Case Study on Proportionality

In 2002, the Environment Agency granted Devonport Royal Dockyard Limited (DML) an authorisation to dispose of radioactive waste from their operations at Devonport Royal Dockyard. The Authorisation contained a requirement that DML "*carry out a feasibility study for the installation of a pipeline to transfer the discharge point to the Hamoaze from the effluent treatment plant [ETP] to an area beyond the breakwater in Plymouth Sound*."

DML conducted an:

- Engineering Feasibility Study for the design, construction, operation, maintenance and decommissioning of a pipeline 8-10 km long;
- assessment of radiological discharges and impacts;
- analysis of alternative options for disposal of liquid wastes from the ETP.

The studies concluded, i) that a scheme to construct and operate a pipeline was feasible, at an estimated cost of £12M and with associated construction impacts in a Special Area of Conservation, ii) that the radiological doses averted would be very small (a fraction of the 10 μSv a^{-1} identified in the Basic Safety Standards), and iii) of 11 options identified and evaluated, the prevailing discharge method was identified as the BPEO.

On these grounds, the option to construct a pipeline to transfer the discharge point was not adopted.

4.5.1 Comparing dissimilar properties

In many cases, balancing benefits and detriments will require the comparison of dissimilar properties. Whilst translation of detriments or benefits into monetary units is often uncertain, and should be justified, this may be possible in some cases where sufficient information is available. The method used for converting intangible costs into fiscal units must be transparent and it is recommended that independent verification is sought. Particular difficulties often arise with:

- providing an objective measure for benefits or detriments associated with environmental damage;
- identifying indirect benefits, such as avoidance of deploying emergency services, avoidance of countermeasures (e.g. evacuation or post accident decontamination), and reduced operational or maintenance costs;
- quantifying societal expectations;
- applying cost measures where potential impacts span long time periods.

Cost cannot be used in isolation when developing a BAT case. An assessment of cost, and a direct comparison of costs and benefits where it can be carried out, will generally be only one of the factors in determining an optimised outcome[38]. Nonetheless a cost-benefit analysis can provide a benchmark to help identify proportionate and disproportionate levels of effort or cost (Section 5.7 and see Appendices 2 & 3).

Text Box 7. Comparing Costs of Dissimilar Properties

Human activities, including energy conversion, transport, industry, or agriculture may result in detrimental impacts on human health and the broader environment. Both the causative factors, and the scale of the impact, can vary widely. Borrowing a concept adopted from welfare economics, environmental policy calls these damage costs externalities or external costs. Analysis of such impacts, and their conversion to units of cost, is complex and often controversial. It is also subject to changing societal expectations.

Over the past 20 years, the 'ExternE' (External costs of Energy) European Research Network[39], funded by the European union, has become a well-recognised source for externalities estimation. Information is also available from the Sixth Framework Programme 'MethodEx' (methods and data in environmental and health externalities)[40].

In a UK context, additional guidance may also be offered by the Health Protection Agency[41], HM Treasury (see Appendix 3) and Defra[42].

4.5.2 Proportionality as Applied to Documentation

The concept of proportionality also extends to the BAT process and accompanying documentation. The primary output of a BAT assessment should be fit for purpose documents that provide a basis for regulatory scrutiny and for subsequent work instructions (see also Section 5.1.4 and Section 7 with respect to communication and implementation). In principle, documents should guide the reader through the assessment process, without introducing material not used as part of the assessment basis.

Where the process of determining BAT has required a large and complex study, drawing on a range of information sources and including assessment panels drawn from technical experts as well as internal and external stakeholders, more complex documentation may be required. In such cases, the initial preparation of information should be undertaken and presented in a format suitable for external distribution. As a guide, the use of electronic documentation allows for in-depth cross referencing (e.g. to primary and summarised information sources, minutes of meetings, register of risks and uncertainties) without the significant effort to re-write documents for inclusion within a hard copy final report. This allows for the production of a much shorter summary for circulation.

4.6 Application of Relevant Good Practice

4.6.1 Identifying Relevant Good Practice

The Environment Agency's guidance on Principles of Optimisation[9] states that, in demonstrating BAT, the operator should have regard to the use of standards, guidance and relevant good practice. This applies to all aspects of operation, including matters such as sampling and monitoring, management systems, maintenance, record keeping etc. Sources of such guidance and good practice include:

- Government Policy (e.g. UK Discharge Strategy);
- Environment Agency Guidance (including joint guidance with the HSE/SEPA);
- Codes of Practice;
- Standards (whether international or national or trade);
- Company standards/procedures; and,
- Working practices, processes and techniques.

Operators may seek to argue that the adoption and implementation of regulatory guidance and relevant good practice represents BAT without the need for more detailed consideration of options appraisal and optimisation. This approach is acceptable providing that the operator demonstrates that the guidance and good practice is relevant, up to date and fully applicable to the facility and circumstances in question. This forms part of a proportionate approach to applying and demonstrating BAT. Similar guidance is offered by HSE[43].

4.6.2 Applying Relevant Good Practice to New and Existing Plant

For existing plant, relevant good practice is established by using the techniques and standards that would be applied to a new design as a benchmark and subjecting any shortfalls in the existing plant to the test of reasonable practicability - that is: unless the sacrifice entailed in moving towards the benchmark is grossly disproportionate to the environmental benefit, the practice should be adopted.[44]

In general, retro-fitting a process will require a higher justification than installation as part of a new development. Similarly, the inclusion of monitoring equipment as 'good practice' on new plant may be justified whereas retrofitting such equipment on older plant (even though it gives rise to a higher impact) may not. In effect, it is not the definition of 'good practice' which changes, but the cost of achieving the relevant good practice which rises when modifying existing plant.

5 How to Identify BAT

5.1 Management Arrangements

It is a general requirement that an Operator shall have a management system, organisational structure and resources sufficient to comply with limitations and conditions stipulated within the terms of a permit. Specific requirements may include:

- written operating instructions;
- written arrangements specifying how the operator will comply, including control of modifications to the design and operation of systems or equipment;
- written maintenance schedule and instructions;
- use of RPAs, Qualified Experts or other competent persons to provide advice and supervision of operation and maintenance of equipment;
- provision for audit and review.

The principles of applying 'best practice' should underpin all site strategies and project leadership. In particular, there should be clear senior management commitment to ensure that sufficient resources are available to train personnel, to maintain site knowledge of developing options and to review existing practices as appropriate.

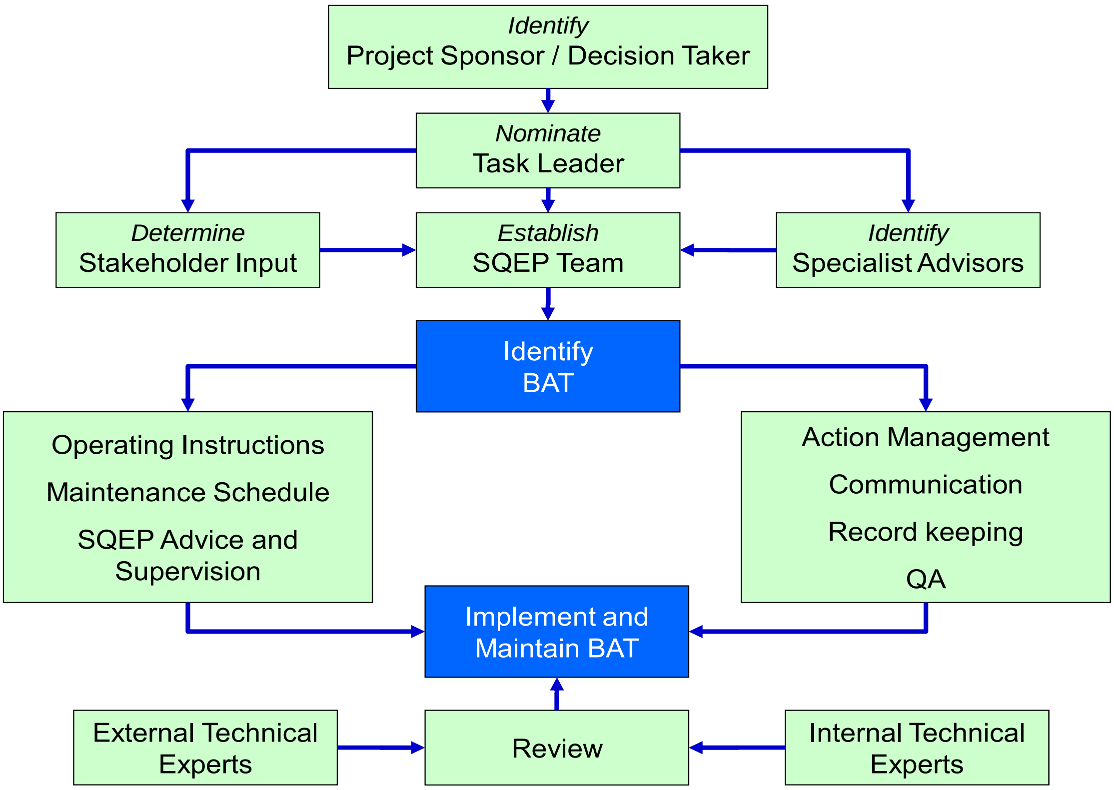


Figure 5. Management structure and responsibilities for delivering BAT

BAT studies, and implementation of BAT in a particular area, plant or facility, require a clearly identified 'owner'; someone who knows that they are responsible for implementing BAT and reviewing the relevant processes to ensure that they are, and remain, relevant.

A key leadership responsibility is to ensure that programme or project activities and milestones are understood and developed, and the appointment of a programme or project manager should be considered. Such arrangements may already be established within site project management systems.

Management of safety, engineering, operation and waste creation and disposal should be explicit in all construction and operational activities as well as decommissioning programmes.[43] Environmental protection initiatives should have a defined management structure, with responsibilities clearly understood, proportionate to the study. From the outset, there must be a clear recognition of who owns the process and who owns the decision.

With respect to contractors carrying out projects or work packages, the responsibility for assessing BAT should be stated clearly within contracts so that the interaction between client and supply chain is understood prior to contract issue. Ring fenced work may have specific arrangements that need to be stated, although operators remain responsible for ensuring that BAT is applied, even when work is contracted out. Some contracting organisations may not be familiar with the requirement to undertake BAT studies and may require guidance.

5.1.1 Management System

It is important to recognise that most projects (whether design, construction, commissioning, modification, operation, excavation or decommissioning) will produce waste of some form and consideration of BAT should be incorporated as a standard requirement for all work that will, or has the potential to, generate radioactive waste. Given that optimisation is intended to be integral to site operation, and not an added extra, it is evident that, as far as is practicable, BAT studies should be carried out in the early stages of any project design. This applies to small scale projects as much as to large scale undertakings, whilst recognising that the effort devoted to the BAT study should be proportionate to the impact potential of the project. For example, when digging up a drain, consideration should be given to minimising waste generation and discharges to the environment. For larger projects such as new build of processes or plant decommissioning, consideration should be given to setting 'trigger' points for identifying BAT at various stages during the work programme. Likewise, Hold Points should be identified during large scale project delivery, to formally assess and confirm that BAT is being employed.

BAT must be considered for all projects, including any initiating work, where radioactive waste management arrangements are required.

5.1.2 Team Composition

Team members (both permanent and temporary) should be identified clearly and their roles and responsibilities understood. Team size should be proportionate to the demands of the study, whilst containing all the relevant skills (e.g. inclusion of suitable RPAs, Qualified Experts or other competent persons) necessary to achieve project aims.

Team composition, including the use of temporary members, will depend on the nature and extent of the project and stage of the process. There are occasions where an issue is highly specialist in nature, and it is appropriate for a single author to produce an options appraisal document with independent review and approval.

Within a team, clear accountability needs to be established for ensuring that studies are taken through to completion, with clear recommendations and a route through to the ultimate decision takers (Section 6).

5.1.3 Action Management

Programme or management arrangements should establish criteria for identifying opportunities and making the most appropriate decisions. Existing site tools and techniques (see section 5.7) may be utilised but a full understanding of waste stream and waste stream characteristics is essential.

The presence of competent persons is essential and consideration should be given to the assignment of specific responsibilities. For instance, managing the actions arising from waste minimisation studies is likely to be the responsibility of the project manager or a person assigned by the project manager.

All actions, recommendations or other outputs from the BAT study need to be recorded, with clear accountabilities and timescales for implementation. These must be agreed with the relevant person, department or organisation. All actions must be communicated throughout relevant work processes and programmes.

5.1.4 Provision of Written Instructions

Arrangements for implementing BAT, including operation and maintenance of equipment should be implemented through written instructions. Such arrangements should include:

- operating instructions;
- Environmental Operating Rules and instructions;
- maintenance schedules and instructions;
- control of modifications to the design or operation of systems/equipment.

It is essential that instructions are communicated to all relevant personnel and are accompanied by training through competent persons. In addition, all written instructions must be subject to clear version control and periodic review and update as required.

5.2 Demonstration of Best Available Techniques

The demonstration of optimisation, giving rise to disposals and impacts being ALARA, is a requirement in relation to setting discharge limits for radioactive substances. The Environment Agency in England and Wales and SEPA in Scotland will require reassurance that permit holders under EPR2010 or RSA 93 are taking account of:

- all relevant guidance and good practice;
- the technical characteristics of the facility;
- local environmental conditions.

Day to day management of operations decisions need to be consistent with the principles established for BAT but do not require re-evaluation of the process for all operational decisions.

Text Box 8. RSR Permit Conditions Requiring the Use of BAT to Demonstrate Optimisation

The Environment Agency has offered guidance on the regulation of radioactive substances under EPR[1] and on compliance with permit conditions[45]. The optimisation requirement (ALARA) is achieved through the use of the following permit conditions, based on Government requirements[7].

2.3.1 The operator shall use the best available techniques to minimise the activity of radioactive waste produced on the premises that will require disposal of on or from the premises.

2.3.2 The operator shall use the best available techniques in respect of the disposal of radioactive waste pursuant to this permit to:
- (a) *minimise the activity of gaseous and aqueous radioactive waste disposed of by discharge to the environment;*
- (b) *minimise the volume of radioactive waste disposed of by transfer to other premises;*
- (c) *dispose of radioactive waste at times, in a form, and in a manner so as to minimise the radiological effects on the environment and members of the public.*

These conditions deliver the provisions in the Regulations about optimisation and the corresponding provisions of the Basic Safety Standards Directive. In addition, site-specific conditions may be set, such as:

2.3.3 The operator shall use the best available techniques to
- (a) *exclude all entrained solids, gases and non-aqueous liquids from radioactive aqueous waste prior to discharge to the environment;*
- (b) *remove suspended solids from radioactive waste oil prior to incineration*.

Permit conditions also extend to the continued demonstration of BAT and may include requirements to undertake sampling, analyses or calculations to determine the efficiency of plants and processes and may require modifications to plants or processes in order to maintain the BAT case.

Similar conditions apply in SEPA authorisations issued under RSA (1993).

The identification and application of BAT, as a means of demonstrating optimisation, may be expressed on a qualitative basis (for instance by reference to previous studies), or a more quantitative basis (i.e. expressing risks and benefits in comparative terms). Both approaches are evidence based and are similar in process; although there are many tools which may be applied, with no single 'right' way to do it which covers all situations.

Given that there are no absolute rules to identify BAT, the key requirements are to:

- document and justify the process adopted;
- demonstrate that the outcome is robust; and,
- ensure that the level of effort expended is proportionate to the scale of the issue to be resolved.

Text Box 9. Optimisation and BAT

Optimisation implies that all reasonably accessible options have been considered. The BAT process should therefore include:

- identification and justification of any boundary conditions that constrain the choice of option;
- application of screening criteria to discount those options that are not reasonably accessible.

Selection of the most appropriate option may be demonstrated through either an argument by logic (for instance, by reference to existing studies) or by undertaking a quantitative assessment (based on a numerical approach). In either case, the identification of BAT is evidence based.

Irrespective of the method employed, or the outcome of the study, no assessment can be used to argue against statutory duties, to justify risks that are intolerable, or to justify what is evidently poor engineering.

Identifying the right approach to take is part of the proportionate response to establishing BAT. The following flow diagram will help to establish which approach is likely to be most appropriate, although the choice will also reflect both policy and practical considerations (such as the timescale and availability of information).

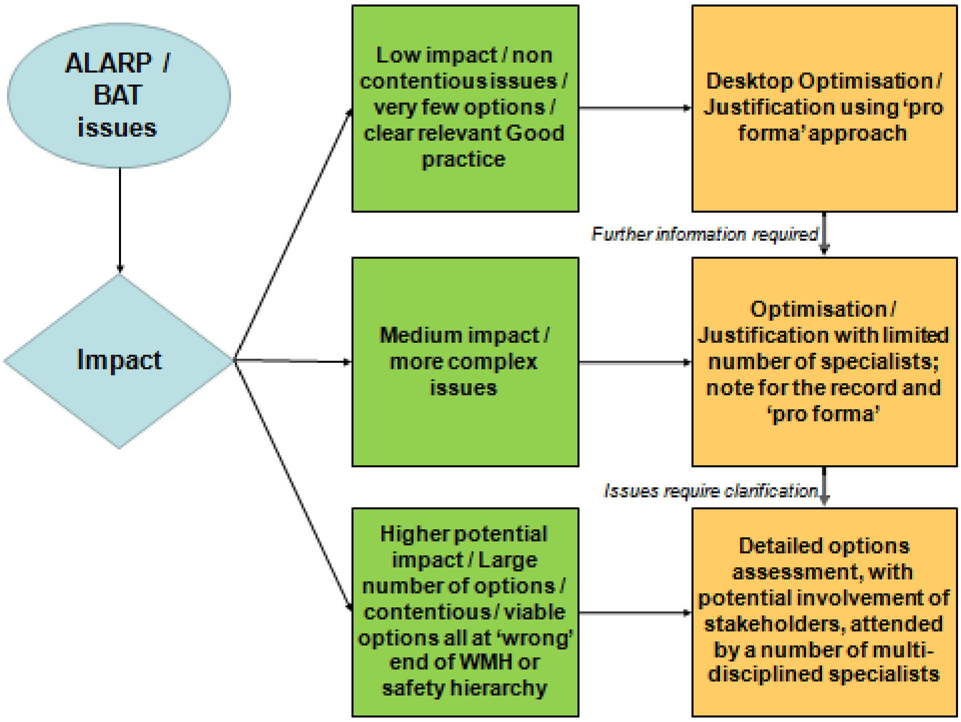


Figure 6. Guide to selecting the appropriate process to identify BAT

Note that there will generally be options at various points of the overall optimisation process and hence there is a need to consider options appraisal throughout. There may also be situations where a nuclear BAT assessment is not deemed necessary (for example, where no radiologically contaminated wastes are produced).

5.3 Preparation

As noted in Section 5.1 an appropriate delivery team needs to be established proportionate to the task and a simple route map for identifying and implementing BAT is presented in Figure 7. The initial scoping activities will help to ensure that a study is both appropriate and proportionate to the issues. Considerations should include:

- problem requirements;
- an initial scoping review and meeting with key stakeholders (e.g. project manager and sponsor);
- provision of an initial list of options to assess scale and viability;
- identification of constraints and the level of study likely to be required.

Producing a documented scope, and seeking review from the Project Sponsor, will ensure that the BAT assessor is fully aligned with the issue to be resolved.

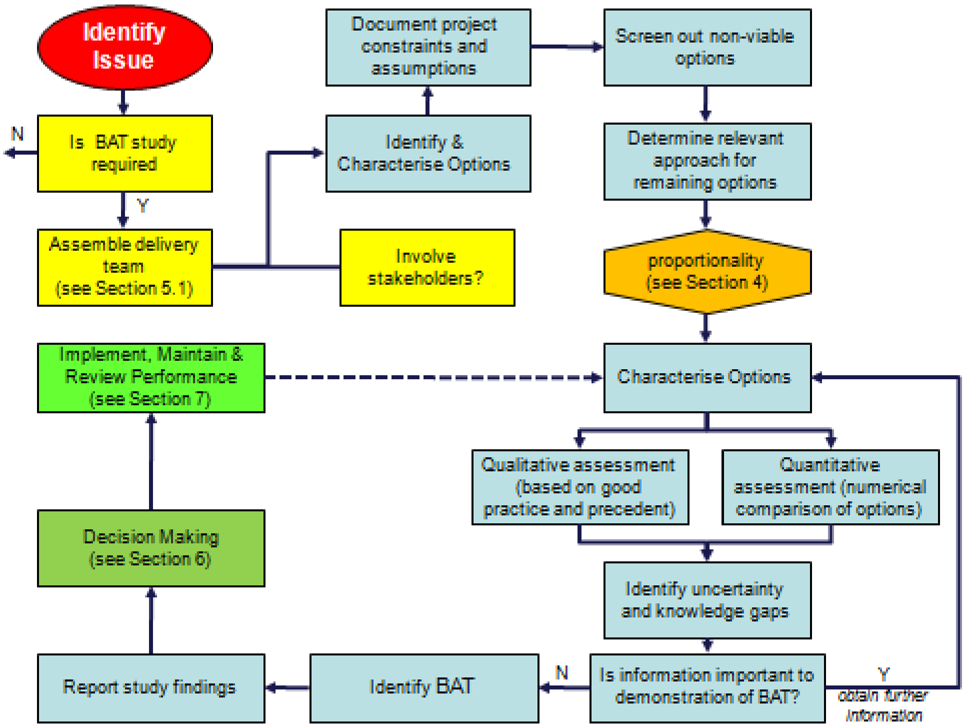


Figure 7. Example flow chart for identifying and delivering BAT

5.3.1 Identifying the scope and process

All BAT studies are evidence based (that is, based on factual information, verified where practicable, and documented for transparency). Key to any study is an understanding of the issues to be addressed, preparation of relevant information and identification of the process to be followed. The preparation of information should be proportional to the issue to be addressed but must be sufficient to undertake an evaluation.

Where multiple facilities have similar issues to be addressed, it is reasonable to undertake a generic BAT study. This generic study can be used as a baseline for site-specific studies.

Text Box 10. When is a new BAT study required

In many instances, the first stage in demonstrating BAT is to identify if there are any existing studies that are relevant to either the project or the wastes that the project will generate. If so, it may be possible to use them to identify and apply BAT.

Studies may include Site Integrated Waste Strategies (IWS), which identify and justify the strategy for the management of all waste types on site. This may be underpinned by specific BAT assessments which support the strategy. If a relevant study has been identified (from the IWS or other sources) the Project Manager, with the Project Sponsor, should confirm that the study is valid for use in this specific case. All studies can only be based on the technologies and information available at the time. Hence, studies need to be reviewed to take account of significant developments to ensure that the assessed outcome remains valid.

For many small or relative minor projects, it is likely that existing guidance (for instance where strategies are maintained up to date through periodic review) will remain valid. In making such judgements care should be taken to ensure that a holistic view is taken: many small projects can add up to a larger impact.

The preparation stage should set the foundation of a BAT assessment, and should include consideration of data requirements and sources of information, constraints and criteria for screening and peer review requirements. It is clear that some information can be considered as fundamental to studies. For instance, any study relating to waste management must be underpinned by adequate characterisation of the waste materials.

It is possible that reference to a national strategy, relevant good practice or a previous options comparison study can be used to underpin a decision on the BAT, rather than carry out a detailed optioneering study. However, the responsible person must demonstrate that the underpinning justification in question is relevant and appropriate for their particular circumstances and they must be able to demonstrate that the management options identified are implemented following optimisation.

Decisions on whether to undertake a peer review should take into account the level of public interest and the political sensitivity. Any reviewer should be independent of the project team and suitably qualified for the role. The timescales over which a solution is required should be addressed, where this is a key driver in an assessment.

It is important to ensure that criteria against which options will be screened are pre-determined to ensure that bias is not introduced following options identification.

A work programme should be developed which details clearly the scope and context of the study and identifies the resources and stakeholder engagement strategy required. Once the work programme has been developed, it is advisable to gain the agreement of the budget holder or sponsor.

5.3.2 Involving stakeholders

Stakeholder input can be helpful to good decision making and time for stakeholder engagement should be factored into the schedule, where appropriate. Stakeholders may include internal users, operators of adjacent facilities and programme facilitators. External stakeholders may include regulators, contractors, designers and other suppliers as well as local groups. The definition of stakeholders is broad and it is apparent that their inclusion in a study can add value through inputting to screening criteria and drawing the attention of decision makers to wider considerations.

It is common practice to engage stakeholders on certain site based initiatives[*]. Nonetheless, the requirement for, and development of, a strategy for engagement should be considered carefully. Where stakeholder engagement is proposed, a balance of expertise should be involved in evaluating options and performing BAT assessment. Where extended participation is to be included in the process (for instance, where an assessment panel is to be established), invitations to participate should be issued as early as practicable. This is especially important if options assessments panels are to be constituted with broader stakeholder participation.

The use of an independent facilitator may be advisable for more complex or contentious topics. Facilitators should be independent of the project team and with no direct vested interest in the outcome and should be briefed on the assessment well in advance of any options appraisal workshops.

5.3.3 Documenting the study

Mechanisms should be put in place to ensure that all issues, problems, difficulties and knowledge gaps are clearly documented. Responsibilities for action plans should be

* For statements on Stakeholder Engagement, the Sellafield Sites web pages indicate current good practice. See http://www.sellafieldsites.com/corporate-responsibility/stakeholder-engagement and associated links.

assigned and a process agreed to ensure that the project delivery team are aware of information arising.

5.4 Identify Options

Regulators will require that a sufficiently wide and imaginative range of process and management options are considered to ensure the best option from a range of alternatives is implemented. Options should be available, reliable and reasonably robust within the required timeframe for a solution.

The option offering the greatest protection of the public should be implemented, provided it is reasonably practicable taking social, economic, environmental and other relevant factors into account. It is not sufficient to consider the cheapest option first and consider the more expensive options only for the marginal improvement they would give.

An option can be regarded as reasonably practicable if it is currently available or is capable of being developed on a scale which allows implementation, under economically and technically viable conditions, taking into account the costs and benefits. An option must be reasonably accessible, but not necessarily currently used within the UK.

A number of approaches can be used to identify options, including the following.

- Comparison with other site methods or recent relevant optioneering assessments. What has been done at similar facilities elsewhere may help identify relevant approaches, although it should be borne in mind that 'best practice' is likely to change over time as technology and knowledge develop.
- Workshop elicitation exercises using relevant experts, regulators and the wider stakeholder community as appropriate. It may be useful to divide into groups during workshops to identify as many options as possible, with plenary sessions to collate options and identify fresh ideas arising.
- Web searches and contact with current service suppliers to identify new techniques.

There should be options for varying degrees of precautionary action and, depending on the assessment context, it may be appropriate to consider different timelines. For example, techniques may be identified that provide short term mitigation; enabling alternative technologies, giving longer term resolution, to be implemented.

Options may include:

- limiting overall quantities of wastes arising;
- limiting disposal; and,
- minimising radiological effects on the environment and members of the public.

Techniques may include alternative management procedures as well as technical aspects.

For complex BAT assessments (e.g. for new plant or process), it may be appropriate to discuss with the regulator the range of options being considered and to discuss appropriate screening criteria.

All options should be assessed on a comparable basis. This will include a clear description of the process and the end point (e.g. interim position or complete discharge of liability). Supporting evidence should be gathered and the quality of the available information considered. For example, whether information may be identified as:

- supposition, i.e. the views of individuals;
- knowledge, i.e. based on individuals' qualifications and experience;
- fact, i.e. validated from reputable and auditable sources.

Where recent relevant studies are identified, it is not sufficient to conclude that the preferred option within the study is BAT. There will be a requirement to demonstrate similarity of circumstances, and that all reasonably accessible options have been considered, whether or not they were included in the previous study.

5.5 Constraints and Assumptions

In many cases, studies will be constrained by one or more factors. Constraints will vary depending upon the assessment context and the identified options and these should be clearly documented, including any dependencies. Such constraints must be justifiable and may include, but will not necessarily be limited to:

- availability of required technology;
- availability of disposal routes;
- space or location;
- compatibility with existing facilities;
- reliance on external facilities or operation.

In addition to any constraints which influence study considerations, a number of assumptions may be required in order to progress a BAT assessment, particularly where long-time scales are considered. For example, wastes generated as a result of a process may require disposal to a geological disposal facility for radioactive waste. The assumption that this facility is made available, in line with current policy in England and Wales, may therefore be appropriate. Additional assumptions may include, but will not necessarily be limited to:

- availability of landfill disposal sites;
- permits for disposal / process etc will be granted;
- regulatory regimes remain constant;
- alternative (related) site works completed to plan;
- the issue being assessed remains constant (e.g. rate of waste volume generated); and,
- key resources and skills will be available as required.

Identifying, documenting and justifying constraints and assumptions is an important component of the evidence-based approach to determining BAT. It may be particularly important for small scale projects or where rapid decisions are required since these may be more likely to follow a qualitative, logical argument rather than a quantitative analysis of options. For longer term projects constraints and assumptions may be modified as knowledge develops, and should be regarded as guiding studies rather than hard and fast rules for evaluating options.

5.6 Screening

Once a list of all options has been identified, and relevant constraints and assumptions which affect the scope of the study have been documented, an initial high-level screening should be applied to identify non-viable options and thus reduce the list to a short-list of options that can credibly satisfy the objective. Options may be screened out if they do not comply with legal requirements, or are clearly not feasible (for instance where the technique is conceptual only or has been attempted elsewhere and demonstrated very poor performance).

Relevant screening criteria may include consideration of the following key questions.

- Is the option legal (accepting that challenges to permit conditions may be permissible)?
- Is the option available within the required timescale?
- Does the option meet the objective (bearing in mind that options may be combined to meet the required objective)?
- Is an option clearly sub-optimal (alternative options are available which achieve the same endpoint and which have readily identifiable benefits)?

Cost should not routinely be used as a screening criterion for identifying short-list options, although it may have a role where it clearly precludes an option from being practicable. Even so, this criterion should only be used where sufficient short-list options remain.

All information relating to options should be presented in a transparent way. Where any options are discarded, the reasons for such decisions must be documented and defensible.

5.7 Options Appraisal

An option should only be selected as practicable if it has been selected through a proportionate options appraisal process. There are number of methods that may be used for options appraisal and these vary in complexity, and consequent time and effort required to implement. The purpose, in each case, is to present an evidence based comparison between a range of options to determine a relative ranking in terms of the function required, in order to inform decision making, although it does not always follow that the top ranked option will represent BAT.

Options can be appraised in both a qualitative or quantitative manner and in most instances the approaches are used in series with qualitative assessment and reasoned argument being used in the first instance to reduce the options that require more detailed assessment. If further discrimination between options is then required more complex quantitative techniques can be employed.

In all cases when carrying out option assessments it is important that:

- a systematic and transparent approach is used with clear definitions of the criteria that are being considered as part of the assessment;
- options are described at similar levels of detail and account taken of the levels of maturity of different options;
- adequate time is allocated in the project programme to enable the generation of options descriptions of adequate quality;
- the assessments are evidence based and the evidence is available to support the conclusions reached;
- options should be assessed based on consideration of their full life cycle including R&D, design, construction, operation and decommissioning;
- options deliver comparable outcomes;
- risks and uncertainties with respect to individual options are taken into account.

5.7.1 Qualitative Assessments

Where previous appraisals have been undertaken, or good practice established, it may be possible to demonstrate BAT without the need for more detailed consideration of options, providing that the guidance and good practice is applicable to the facility in question.

In such instances, it may be sufficient for a short, evidence based, report to be produced comparing the advantages and disadvantages of any alternative technologies and/or management practices compared to those currently in use, together with a defensible argument for any improvements that will, or will not, be implemented following the study.

In many cases, qualitative assessments will represent a proportionate approach, reflecting the level of information available and avoiding a false impression of accuracy within the decision making process. Nonetheless, such an approach must be reasoned, logical and transparent. It must contain sufficient information to allow a fully informed independent review to be undertaken.

5.7.2 Quantitative Assessments

There are two basic approaches to quantitative assessment which can be used individually or in combination, these are Cost Benefit Analysis (CBA) or Multi Attribute Analysis (MAA) (see Appendices 2 and 3). Both approaches are equally valid for demonstrating BAT and have their own advantages and disadvantages as follows.

Table 1 Advantages and disadvantages of CBA and MAA assessment approaches

Technique	Advantages	Disadvantages
CBA	♦ Allows direct comparisons between different studies. ♦ Fixed evaluation criteria means study work is focussed on content rather than process. ♦ Assessment methodology and means of evaluation is transparent to stakeholders. ♦ Provides means of understanding proportionality. ♦ Because evaluation scale is money, scale is not capped.	♦ Often confused with cost analysis which undermines stakeholder confidence in outcome. ♦ Need to get agreement on how benefits and detriments are valued. ♦ Perceived as requiring large amounts of detailed underpinning information and onerous to apply. ♦ Monetorisation of less tangible costs and benefits may be open to challenge. ♦ Perceived as lacking transparency due to failure to provide sufficient breakdown of numbers. ♦ Stakeholders can feel disenfranchised as they cannot substantially influence evaluation criteria.
MAA	♦ Helps build stakeholder support to outcome as they get to set the evaluation criteria ♦ Stakeholders are comfortable with the process as routinely used in nuclear industry ♦ Looks simple	♦ Lack of fixed criteria and values means cannot readily compare outcomes from different studies or determine proportionality of outcome ♦ Process can be heavily influenced by study attendees and individual bias ♦ Time consuming to agree scoring process and criteria ♦ Difficult to avoid double counting between evaluation criteria ♦ Seen as an excuse for not having underpinning data ♦ Outputs often not readily transparent to those outside of study group ♦ Need to understand how scores relate to a real world perspective.

It is worth noting that:

- Neither MAA or CBA can take account of all the factors relevant to a decision and therefore in making a decision it is also important that less tangible socio political factors are also taken account of. This is often referred to as the 'is there anything else question'.

- If an organisation fixes the evaluation and scoring system then the difference between MAA and CBA is relatively small.
- When utilising a CBA or MAA approach it is essential to carry out sensitivity analysis as this tests the robustness of individual options to change and allows the impact of different stakeholders' views on values to be assessed.

Other examples of these basic approaches are Value Engineering and Cost Effectiveness Analysis.

5.8 Dealing with Uncertainty and Evidence Gaps

Uncertainty can arise from a lack of knowledge, incomplete information, or from inherent variability within a system. Information may also be incorrectly applied. When collecting information and assessing options, consideration should be given as to whether arguments and associated evidence are suitably robust and defensible. Significant data gaps should be identified, recorded and, wherever possible, resolved through further information gathering.

An assessment should clarify how uncertainties have been addressed. Further work may be identified to address areas of incomplete information, in which case a forward action plan should be developed as part of the reporting process. Results from further work should be fed into future iterations of an assessment.

A guide to addressing uncertainty is provided below.

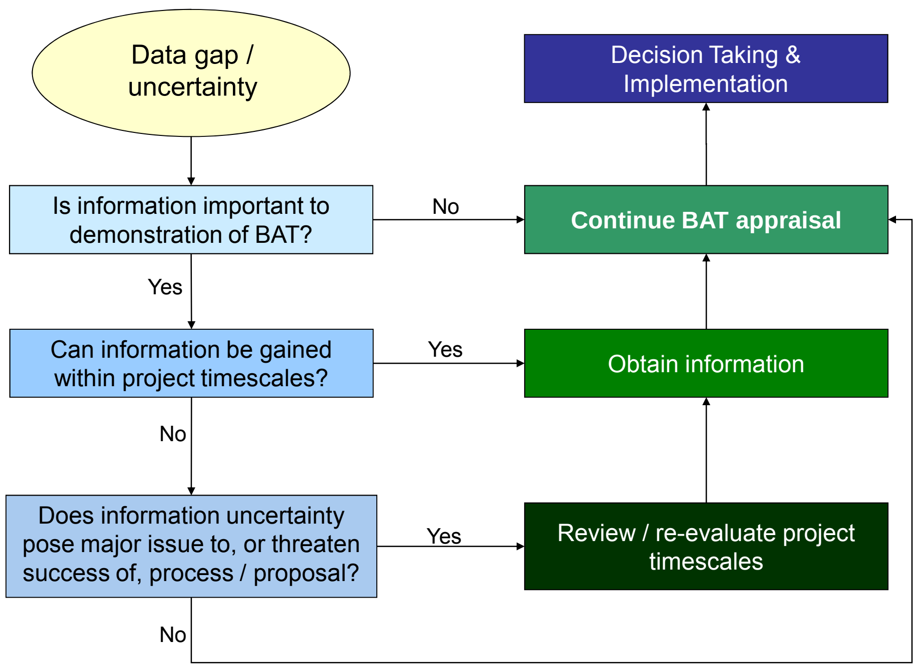


Figure 8. Guide to addressing uncertainty

With respect to numerical variability, quantitative measures can be employed, for instance to embrace the spread of data or derived impact measures around a central or 'best estimate' value with an associated range or 'statistical deviation'.

5.9 Reporting and Dissemination

It is essential that a BAT options selection process is clearly and concisely documented. All assumptions, calculations and conclusions must be open to examination. The assessment report should identify and include:

- a concise non-technical summary;
- introduction, problem definition, project constraints and assumptions;
- the overall options considered and justification for any options screened out;
- the options that are being considered for further evaluation (i.e. short-list options), including technical descriptions and/or diagrams and the value they deliver; and,
- details of all tools and techniques used to develop BAT arguments;
- justification for the selection of preferred options, including reference to supporting sensitivity analyses, risk assessments and outstanding uncertainties; and,
- a forward action plan to address uncertainties, as appropriate.

The study outcome should be disseminated to all relevant stakeholders including budget holders, to ensure that correct links are established between the BAT Team and the wider business.

Any related studies, strategies or environment cases should be updated to reflect the identified BAT.

6 Decision Making / Decision Taking

At the outset of any study, the decision making process and the decision taker, should be identified. The decision taker is responsible for the decision, not the BAT team or the report author.

A study to identify BAT represents a systematic and transparent way to demonstrate optimisation, as required within the terms of a permit to dispose of radioactive materials granted under the EPR. A study may also be initiated by a site operator who wishes to understand the balance of costs and impacts associated with decision making in the following areas:

- the development of strategies to support continued operation of a facility;
- the development of strategies associated with site or facility decommissioning;
- the development of new facilities or practices;
- major modification of existing practices.

The evidence based identification of BAT is an important input to decision making regarding the implementation of one or other proposed way forward. Nonetheless, a study leading to the identification of BAT should not be identified as the decision making process. For instance, a study may be inconclusive, in that more than one approach may be regarded as essentially equivalent. Similar cost benefit outcomes may permit a range of decisions – not necessarily the 'optimum' on paper; recognising that uncertainty is such that close outcomes should be interpreted as being the same.

In such a case, an element of judgement is required in the final decision making process. Likewise, the final decision may be influenced by other factors such as the social and political context, either at the time of the initial assessment or emerging subsequently.

Subsequent to the identification of BAT, and a decision to implement one or other specific approach, more detailed studies may be required or recommended regarding any aspect of the assessment (for instance technical performance, cost, impacts associated with implementation or other factors). A final decision should not anticipate the outcome of such studies.

There may also be a number of reasons for determining an approach that, on balance, is disproportionate to the risks and impacts posed. Where this is the case, the specific drivers need to be identified to avoid setting a disproportionate response as the new benchmark. This reinforces the emphasis which has been placed throughout this guidance on the need to document information, including constraints and assumptions, throughout the assessment process.

This Guidance has consistently stressed that the evidence based approach adopted to identify BAT provides the basis for a systematic comparison of options; rather than implying that a numerical comparison alone is a necessary or sufficient basis for determining the preferred option.

Finally, consideration should be given to the scale or networks through which decisions may be communicated externally. This is important both within and between sites and operators, particularly where decisions may result in re-appraisal of current best practice.

7 Implementing and Sustaining the BAT Case

Once a decision has been made that the selected technique(s) constitutes the application of BAT this needs to be implemented. Depending on the nature of the project this may be the start of a project leading to a more detailed design stage where further refinement and optimisation could be required. Equally, it could be at the latter stages of a project where design, specification, procurement, construction, installation and commissioning have already been completed. Alternatively, it could be once the technique has already been operated and a review is taking place to see if any further optimisation in the way the systems is operated could occur.

Importantly, the permit requires the demonstration of the application of BAT and this may manifest itself at many stages of the project. This means that the application and demonstration of BAT is a continuous and ongoing process. An illustrative example is outlined below considering the project lifecycle from concept design through to operation.

Text Box 11. Example of implementing BAT over a project lifetime

Stage	Example for a waste minimisation facility
Concept design	A shredder is selected as the best technique for minimising the volume of a specific waste stream compared to other options
Detailed design	The type of shredder is selected, for example, a low speed, high torque, vertical shaft shredder.
Specification and procurement	Trials and tests may be performed to provide further evidence of selected technique. This may provide opportunity to address uncertainties identified in earlier phase.
Construction and installation	Checks undertaken to ensure equipment meets the specification. Any variation from design needs to be recorded and go through modification control process
Commissioning	Testing to verify that the engineered systems are performing as expected. Trial working of management arrangements demonstrates management systems are optimised.
Operation	Review performance to look for any further opportunities for optimisation.

For some projects it may be relevant to consider the identification of important systems, structures and components that contribute to the application or demonstration of BAT. This may ultimately be used to determine the examination, maintenance, inspection and testing (including acceptance into service and calibration) schedule. However, it may also be used earlier in the process to inform the specification and procurement process and consideration of any factory tests.

The development of arrangements for the operation of specific techniques is an important step in the process. These may need to be tested and demonstrated in advance of operation. Of equal importance are the arrangements that should be in place to maintain the case demonstrating the application of BAT.

It is also clear that disposals will be governed by what the operator actually does, not what a design document says should happen. Experience* suggests that courts will take the view that failure to operate equipment as intended, or failure to inspect or maintain equipment such that it remains in good working order, provides evidence of a failure to apply BAT to these activities.

* R v Magnox Electric 2002 and R v Magnox Electric 2009

In this section, guidance is given on the considerations to be included in the implementation, operation and management of systems in order to provide a demonstration that they continue to represent BAT.

7.1 Management Arrangements

Management of radioactive wastes is integral within site and regulatory priorities.

The Environment Agency have issued guidance on their expectations for management arrangements at nuclear sites[46]. They outline a number of interrelated principles, including: leadership, organisation, implementation and learning. These set the outcomes to be achieved for effective leadership and management for environmental safety rather than describing the systems, processes and procedures to be followed. In their subsequent Principles of Optimisation guidance document[9], the Environment Agency offered the following detailed indication of their expectations.

> "*The operator must put in place and implement the management systems in order to operate the facility in accordance with the conditions of his permit including the use of BAT. The operator must ensure that the processes, techniques, procedures etc that constitute BAT are consistently and properly implemented at all times.*
>
> *We will normally regard any failure by an operator to properly implement the management system, techniques, procedures etc constituting BAT as a breach of the relevant permit condition(s). An operator cannot defend any such error, omission or violation on their part on the basis that these did not affect discharges or the resulting radiological impact. For example, an increase in releases as a result of an operator failing to follow operating procedures should be regarded as a failure to use BAT. It would not be correct to accept an argument that because the releases and resulting dose had been small (or even zero) that it would not have been worth spending more on, say, training to ensure proper implementation of BAT.*
>
> *Operators should also use BAT (and have ready appropriate instructions etc as part of their management systems) to ensure that wastes arising from accidents or maloperations are minimised and disposed of to meet the requirement for optimisation.*"

This guidance makes clear that the application of BAT (or BPM) extends beyond selection of the process to include all aspects of its use and operation. These principles are similar to those issued by the Health & Safety Executive in their Safety Assessment Principles (SAPs)[33].

7.2 Implementation

The use and implementation of BAT applies at all stages in the lifetime of a facility, from design, through construction and operation to decommissioning and site restoration, and to the many different activities which comprise its management, operation and maintenance. The use of BAT therefore incorporates the many different techniques and measures that collectively ensure that a facility, as a whole, is operated using BAT.

Failure to implement BAT/BPM is frequently a part of court proceedings against operators where the Environmental Agencies have chosen to prosecute.

In all cases it is the responsibility of operators to demonstrate that they are using BAT to achieve an optimised outcome. This includes setting up the necessary management arrangements and selecting the staff to be involved. It also includes demonstration that both planned and unplanned occurrences have been taken into account and that the application of BAT relates to the control of an activity as a whole rather than applying in isolation to a single decision.*

BAT will also change over time. It is therefore necessary to ensure that a review of current approaches is undertaken on a timely basis (see Section 5.5). Importantly,

- optimisation needs to take place throughout the programme;
- optimisation will be developed and implemented by the whole project team, not just the author of the report;
- decisions in relation to environmental optimisation need to be made during those phases of the programme where they will have the biggest impact on environmental performance.

While it can be advantageous to delay decision-making until later in the programme, in order to take advantage of developments, this is not a basis for unnecessarily deferring decisions but ensuring that the right decisions are made at the right time.

7.3 Operation

Systems and equipment should be operated in such a way as to optimise efficiency. A number of examples may be given which illustrate optimisation of operation.

- Where facilities are provided for the removal of activity from pond water by ion exchange, arrangements should be made to ensure that an optimal Decontamination Factor is maintained.
- Solid waste volume minimisation processes (e.g. sorting and segregation, compaction, encapsulation, vitrification etc.) need to demonstrate that the maximum activity goes into the minimum volume.
- Disposals of gaseous or liquid wastes should demonstrate optimisation of dispersion through pipeline length, tidal window, stack height, plume entrainment etc.

Operation of plant must be undertaken by competent persons, in compliance with appropriate procedures and instructions. Provision is required both for normal operating conditions and for abnormal occurrences.

The provision of engineered systems to prevent, or reduce the risk of, inappropriate operation of the plant should be considered. For particularly sensitive systems and equipment (designated, for instance, due to potential environmental or plant throughput impacts) provision should be made for unavailability.

7.4 Training and Supervision

Plant and equipment operators need to be fully trained, both in the specific operation and maintenance of plant and in the more generic issues underpinning the need for, and application of, BAT.

Training should be documented and include a demonstration of competence. Training or training packages and operation of plant should be supervised by competent persons, including suitable RPAs and Qualified Experts where appropriate.

* In 1983, radioactive discharges from Sellafield resulted in contamination of a nearby beach. In the following investigation, BNFL argued that the decision to discharge the material, once it had been established that it could not practically be retrieved from the tank to which it was inadvertently transferred, was BPM. This argument was rejected. The Court ruled that the failures which resulted in the material being transferred in the first place, and the lack of means to safely recover it from the tank, were inconsistent with the application of BPM.

7.5 Maintenance

It is a general requirement within permits that the Operator shall maintain in good repair all systems and equipment in compliance with the implementation of BAT. This is enshrined within the permit conditions requiring the operator to:

- maintain in good repair the systems and equipment provided:
  - to meet the requirements of conditions requiring the application of BAT; and
  - to carry out any monitoring and measurements necessary to determine compliance with the conditions of this permit
- check, at an appropriate frequency, the effectiveness of systems, equipment and procedures provided to meet the requirements of conditions requiring the application of BAT;
- have and comply with appropriate criteria for the acceptance into service of systems, equipment and procedures for carrying out any monitoring and measurements necessary to determine compliance with the conditions of this permit.

This will require a written maintenance schedule for all equipment needed to maintain BAT and may include consideration of:

- plant modification procedures;
- changes to equipment and systems;
- change control procedures, including changes within the design process.

Key issues which are likely to arise may include the identification of such equipment, procedures for ensuring that it is maintained in good repair, prioritisation within maintenance schedules and the documentation of maintenance histories.

7.6 Monitoring

It is a general requirement within permits that the Operator shall use the best available techniques when taking samples and conducting measurements, tests, surveys, analyses and calculations. Furthermore there is a requirement to check, at an appropriate frequency, the effectiveness of systems, equipment and procedures in compliance with the implementation of BAT. The requirement to test and calibrate can be considered in three areas:

- testing of systems and equipment to demonstrate that operation remains within appropriate parameters;
- sampling and monitoring of wastes and materials prior to disposal;
- review of procedures.

Testing of systems and equipment might include checking water chemistry (for instance in storage ponds), efficiency of filtration equipment (gaseous or liquid) or automated detection and alarm monitors, or commissioning tests for new build.

A suitable frequency of such tests should be determined and a schedule maintained (including outcomes and remedial action where required). Calibration of test procedures themselves needs to be demonstrated and maintained up to date. Issues such as compliance with relevant standards, such as MCERTs etc need to be considered.

Monitoring may include the sampling of solid, liquid or gaseous wastes and, more generally, may relate to appropriate segregation of materials. This is likely to reference Relevant Good Practice for sampling and standards for analysis, for instance a Nuclear Industry Code of Practice has been issued for monitoring associated with the clearance and exemption of materials[47]. Guidance relevant to sampling and measurement for solid wastes has also been issued by the Nuclear Industry Working Group on Clearance and Exemption[48.] A particular issue may occur when no standards or relevant good practice can be identified, which might well be the case for some of the 'bespoke' technologies used in the nuclear industry.

It is also essential that all written procedures and instructions are subject to periodic review and update as required. The competency of the reviewer must be determined and all procedures subject to authorisation for distribution.

7.7 Decommissioning

Guidance from the Environment Agency makes clear that decommissioning of plant (and subsequent site restoration, if applicable) form part of the considerations to be included within the selection, implementation and operation of BAT. This should form part of the initial assessment process, as outlined in Section 5.

7.8 Sharing of Information

7.8.1 Regulatory Engagement

It is recommended, particularly for complex assessments, that plans are discussed from an early stage with regulators to minimise the risk of failing to gain regulatory support following the selection of BAT.

For less complex assessments, it should be remembered that all aspects of the study should be proportionate to the task being addressed. In some cases it will not be appropriate to seek formal input from the regulators during the process of identifying BAT.

7.8.2 Environment Case

A new condition has been added to the permit. This states that:

> "The operator shall maintain an environment case, consisting of documents, which demonstrates the use of best available techniques to protect people and the environment throughout the life-cycle of the activities."

Further guidance provided by the Environment Agency[46] states that:

> "Operators should maintain written demonstrations that they operate to meet relevant environmental standards and requirements, including Government policies, and have optimised the disposal of radioactive waste to reduce exposures to ALARA. This demonstration should include
>
> - how wastes will arise, be managed and disposed of during the lifecycle of the facility;
> - the quantification of those arisings;
> - their radiological impact; and
> - how the production, discharge and disposal of these wastes is being managed to reduce their radiological impact on people to ALARA and to protect the environment.
>
> Operators will, through these documents, set out their strategies for the management of radioactive waste. These strategies should be consistent with Government Policies and EA guidance.

> The "environment case" is the term we apply to the totality of documented information and records which substantiates the above high-level demonstrations and sets down how these are being implemented and delivered on a day-to day basis, including compliance with permit conditions. We do not require or expect operators to prepare and maintain separate documentation for this purpose, indeed we encourage operators to make use of documents prepared for other purposes and to take an integrated approach to safety and environmental matters. It is a matter for the operator to decide in what form it keeps this documentation. However, the operator must ensure that the documentation, however structured, makes the above demonstrations in a transparent, structured and comprehensible manner.
>
> The environment case is not a once-off series of documents prepared in support of an application for a permit or variation but a holistic, living framework which supports all environment-related decisions made by the operator."

7.8.3 External communications

Procedures introduced to optimise site management practices and to minimise their associated impacts may affect perceived good practice for other sites or operators. It is important to share information, particularly where decisions have been taken which are considered to be disproportionate and therefore should not be cited as benchmarks for future studies.

Existing networks such as EARWG[49] form potential mechanisms for sharing decision making processes and concerns.

7.8.4 Reporting Progress and Outcomes

Within the strategy and arrangements established for implementing and managing any process, reporting structures should be clearly defined. This particularly relates to inter-acting projects or processes. It is also important that all team members, the project sponsor and those responsible for action management and follow-up should receive copies of reports.

Consideration should be given to an appropriate communication strategy, and in particular, the provision of information to stakeholders. Communicating success should be seen as an excellent opportunity to engage others in site programmes.

7.8.5 Record Keeping

Record keeping is an important consideration in radioactive waste management and indeed an essential element of a number of the tools and techniques supporting such activities. Record keeping in this context is often a legal requirement. For example, permits specifically require that information that might be required for the safe management of radioactive waste, now and in the future, should be recorded and preserved.

Record keeping should be proportionate but may include:

- documenting the process in sufficient detail to support the completion of the study;
- minutes of meetings;
- reporting feasibility studies, including those supporting characterisation, transport, consignment, and exemption (in the case of recycled materials);
- providing sufficient information to support the study conclusions, remembering that proposed initiatives may have legal (including safety case) implications as well as influencing business case submissions;

- noting security aspects, where necessary.

Reporting and record keeping are vital components in any claim to identify or implement BAT. However, the process is not simply about producing documentation. Site operators need to know and understand why options have been chosen. In this context:

- the process should be evidence based;
- the conclusion should be rational, equitable and defensible; and
- the assessment must be communicated to all those affected by the outcome.

Where an application for a permit (or a variation to an existing permit) is being submitted, supporting information* is required to demonstrate optimisation.

7.9 Quality Assurance

It is good practice to establish clear, appropriate and proportionate QA arrangements, and consideration should be given to the following:

- quality objectives;
- terms of reference;
- the requirement for quality plans;
- arrangements for checking and approval documentation;
- data validation and verification;
- document control procedures;
- arrangements for internal audit.

The majority of sites already operate recognised quality management systems and the principles and arrangements established in such systems can be applied to optimisation and BAT.

7.10 Review

It should be borne in mind that what constitutes Best Practice, BAT and optimisation will change with time, both as a result of technological developments and in light of policy, regulatory and societal changes. A programme of reviewing BAT may therefore be required, depending upon the timescale over which a process or operation will remain in place. This will be determined by a number of factors, including:

- function of the programme or process;
- availability of new guidance, relevant good practice or techniques;
- the current stage of a project;
- timescale for which the programme or process applies.

For any programme or process which applies for several years, reviews should be undertaken at appropriate intervals to identify developments in guidance or techniques. The requirement to undertake a review of BAT should be identified as part of the conclusions to any study.

The availability of new techniques does not mean that they will automatically represent BAT. In particular, modification of existing processes, or retro-fitting of new processes within existing systems will require further detailed consideration. A technique or approach which represents BAT for a new application will not always represent the optimal approach when applied retrospectively.

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* In England and Wales this is identified as an ‘environment report’ in the nuclear sector and a ‘BAT assessment’ in the non-nuclear sector.

Once BAT has been identified, it will form the basis for recommendations to the relevant decision takers. If the outcome of a BAT assessment is highly significant (for instance, in terms of novel or potentially contentious outcomes, or where previously unbudgeted capital expenditure is required), it may be appropriate that the study is subject to an agreed level of independent review prior to the decision taking process. This may be undertaken using internal resources or may require external audit.

8 Checklist

It has been emphasised throughout this Code of Practice that studies to identify and implement BAT should be based on evidence and should have clear objectives which demonstrate optimisation from a range of options. It should be ensured that each stage of the study is clear, proportionate and appropriate.

The following checklist is intended to assist in determining that a study is appropriate, sufficiently defined, proportionate to the issue under consideration, presents clear outcomes and records any forward action programmes which may be required. Not all steps will apply to all studies, but all studies should be justified.

Table 2 Checklist for undertaking a BAT study

	Yes	Not Required
Preparation		
Understanding Issue		
Defined Scope		
Identified study Constraints and Assumptions		
Identified context and scope of study and role of stakeholders		
Identified method for recording the process and outcomes		
Information Gathering		
Options Identified		
Sufficient evidence base to assess viability of options		
Non-viable options excluded (with justification)		
Documented selection of options for further consideration		
Type of study		
Quantitative (numerical) based study		
Qualitative (logical argument) based study		
Scale of study is proportional to scope and context		
Documented process to be followed (with justification)		
Benchmarking		
Identified national / international Relevant Good Practice		
Defined all relevant standards and permit conditions		
Considered Guiding Principles		
Sustainable Development		
Waste Management Hierarchy		
Proximity Principle		
Precautionary principle		
Comparison to EARWG database		
Cross-reference to REPs		
Documented relevant benchmarks		
Stakeholder Engagement		
Regulators		
Internal Stakeholders		
External Stakeholders		
Invitations to participate documented and issued in good time		

	Yes	Not Required
Project Team		
Team leader identified		
Inclusion of competent persons (QE, suitable RPAs etc.)		
Accountabilities identified and communicated		
Sanity check		
Appropriate QA review of study undertaken		
Identified significant information gaps		
Identified uncertainties in requirements, options or implementation		
Determined Robustness / Sensitivity of identified BAT		
Identify & resolve any inconsistencies with related ALARP studies		
Documented assessment of study robustness		
Study Conclusions		
Announced Recommendation		
Determined proportionality (or justified if ‘grossly disproportionate’)		
Agreed period of validity		
Agreed review procedures		
Documented study		
Shared findings through appropriate fora		
Implementation		
Forward actions identified (responsibility and dates)		
Implementation plan in place		
Implementation plan agreed with regulators		
Accountability for implementation identified		
Availability of funds ensured		
Checking Performance		
Monitoring plan identified and in place		
Feedback routes established		
Contingency plans identified		

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12 PARCOM Recommendation 91/4 on radioactive discharges, http://www.ospar.org/documents/dbase/decrecs/recommendations/pr91-04e.doc

13 Directive 96/61/EC http://ec.europa.eu/environment/air/pollutants/stationary/ippc/index.htm

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10 Glossary and Definitions

For a comprehensive list of terms and definitions used in nuclear safety and radiological protection, see: International Atomic Energy Agency (IAEA) Safety Glossary, Terminology used in nuclear safety and radiation protection, 2007 edition, http://www-pub.iaea.org/MTCD/publications/PDF/Pub1290_web.pdf. Terms and acronyms used in this report are defined below.

Activity	A generic title for the practices or operations which require to be permitted (unless exempted from the need for a permit)
ALARA ALARP	As Low As Reasonably Achievable (economic and social factors being taken into account). Radiation doses comply with ALARA when they have been reduced to a level that represents a balance between dose and other factors (including economics). This is a statement of the optimisation principle. The term ALARP arises in the Health and Safety at Work etc. Act 1974, which requires "provision and maintenance of plant and systems of work that are, so far as is reasonably practicable, safe and without risks to health". The phrase So Far As is Reasonably Practicable (SFARP), and similar clauses, is interpreted as leading to a requirement that risks must be reduced to a level that is As Low As Reasonably Practicable (ALARP). For a risk to be ALARP it must be possible to demonstrate that the cost of reducing the risk further would be grossly disproportionate to the benefit gained.
Attribute	A quality, property, or performance measure of an option that enables different options to be scored or ranked in relation to one another. Depending on the attribute concerned, the scoring or ranking process may lie anywhere in the range from entirely objective to entirely subjective. Different attributes are not normally commensurable with one another in any direct way and hence a subjective weighting factor must be applied to each attribute if an overall scoring or ranking of options is to be obtained.
Authorisation	The granting of regulatory permission to undertake an activity under licence. In this document, the more generic term ‘permit’ is used, except where Authorisations granted under RSA93 are specifically referred to, or where information is cited direct from a source which uses the term Authorisation.
BAT	Best Available Techniques. See text throughout this document for a fuller meaning and application.
BPEO	Best Practicable Environmental Option. The outcome of a systematic and consultative decision-making procedure which emphasises the protection and conservation of the environment across land, air 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 in the short term.
BPM	Best Practicable Means. BPM for radioactive waste management represents the, “*level of management and engineering control that minimises, as far as practicable, the release of radioactivity to the environment whilst taking account of a wider range of factors, including cost-effectiveness, technological status, operational safety, and social and environmental factors*”. BPM requires operators to take all reasonably practicable measures in the design, operation and management of their facilities to minimise disposals of radioactive waste, so as to achieve a high standard of protection for the public and the environment. BPM applies to minimising waste creation, abating discharges, and monitoring of plant, discharges and the environment. It takes account of the availability and cost of measures, operator safety and the benefits to be gained. BPM continues to be required by the SEPA in authorisations issued under the Radioactive Substances Act. BPM and BAT are considered to be essentially equivalent.
BSSD	Basic Safety Standard Directive (96/29/EURATOM)
CBA	Cost benefit Analysis
competent persons	In this Code of Practice, taken to include (but not be limited to) SQEP, QE, suitable RPAs and other qualified or experienced personnel.
DECC	Department of Energy and Climate Change. The Government Department with policy responsibility for Radioactive Substances Regulation in England.

Defra	Department for the Environment, Food and Rural Affairs. This is the Government Department with specific responsibilities for EPR.
Discharge	The disposal of material in liquid or gaseous form by emission to the environment.
Disposal	The long term disposal of solid, liquid or gaseous materials either by emission to the environment or by emplacement in such a way that no retrieval of the material is intended. The term 'disposal' is used throughout this document in place of the more restrictive term 'discharge' except where citing information from other sources or where the more restrictive term is clearly appropriate.
Environment	There is no fixed definition of the 'environment' within national law, as it is usually taken to represent the sum of the surroundings – and therefore it is a dependent quantity, rather than a fixed, independent, article. The environment may be considered to include both the living and the physical surroundings, and their interactions. The interactions between individual members of different species in the environment are complex, and competitive. Any living organism is constantly under stress from other organisms and from physical agents. The relative numbers of individuals and species fluctuate in time. Over long periods of time, such as may be considered with respect to geological facilities for waste management and disposal, species may vary as a result of evolutionary changes, themselves a product of various stressors.
EPR 2010	Environmental Permitting Regulations (2010)
Environmental Principles	Environmental Principles aim towards desired environmental outcomes. In practice, they are a combination of International agreements, UK Government policy and the Environment Agencies' policy choices.
Environmental Sustainability	Sustainability is based on meeting the needs of the present without compromising the ability of future generations to meet their own and requires an analysis of the environmental, social and economic impacts.
EARWG	The Environment Agencies' Requirements Working Group
FSA	Food Standards Agency.
GRA	Guidance on Requirements for Authorisation. Regulatory guidance detailing the environmental objectives which an underground facility for the permanent disposal of radioactive waste must achieve. There are two versions of the GRA: one for geological disposal of higher activity radioactive waste; and one for near-surface disposal of lower activity radioactive waste.
GW	Groundwater (specifically in relation to a groundwater activity under the Regulations)
HSE	Health and Safety Executive. Regulator with responsibilities for, amongst others, IRR99 and NIA65.
HPA	Health Protection Agency
ICRP	International Commission on Radiological Protection
ILW	Intermediate Level Radioactive Waste
Integrated Waste Strategy	An integrated waste strategy is an outline plan, taking account of environmental principles, that can be applied consistently to all relevant actual and potential sources of waste, both radioactive and non-radioactive. The scope may extend to the whole site or even to multiple sites.
Justification	The benefits and detriments of any practice which could result in exposure to ionising radiation must by assessed prior to the practice being permitted. If the benefits outweigh the detriments, the practice is justified.
Limitation	Limitation provides a mechanism of dose limits which ensure that no individual shall be exposed to ionising radiation leading to an unacceptable risk under normal circumstances.
LLW	Low Level Radioactive Waste
LV-VLLW	Low Volume Very Low Level Radioactive Waste
Licensee	An operator licensed under NIA65
Multi-attribute Analysis	An analysis of different options in terms of multiple attributes they possess. In this document, a potential means of achieving a specified objective. An appraisal carried out by any person or organisation of a range of possible options for achieving a specified objective.
NIA65	The Nuclear Installations Act 1965
NII	Nuclear Installations Inspectorate

NLS	Nuclear Licensed Site. The term refers to sites that have a nuclear site licence under the Nuclear Installations Act 1965. More broadly, the Environment Agency include sites that have applied for, but not yet been granted, such a licence.
Optimisation	Optimisation is the process whereby an operator selects the technical or management option that best meets the full range of relevant health, safety, environmental and security objectives, taking into account factors such as social and economic impacts.
Option	A potential means of achieving a specified objective
Options assessment	Any formal and recorded method by which the 'best' solution is determined from a number of possible alternatives.
OSPAR	Oslo and Paris Convention for the protection of the marine environment in the north-east Atlantic. The UK is a signatory to this Convention, and is committed to reducing discharges of pollution, including radioactive substances, to the sea.
Permit	The granting of regulatory permission to undertake an activity under licence. In this document, the term permit is used to embrace all authorised or permitted activities except where specific reference is made to terms under RSA93 or where material is cited direct from source.
PPC	Pollution Prevention and Control.
Precautionary Principle	Where there are reasonable grounds for suspecting that an action or policy presents a risk of causing harm to the public or to the environment then, even in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is not harmful falls on those taking the action.
Proximity Principle	Enabling waste to be disposed of in one the nearest practicable installation by means of the most appropriate methods and technologies in order to ensure a high standard of protection to the environment and public health.
QA	Quality Assurance
QE	Qualified Expert
Ranking	Placing options in order from highest to lowest against a particular attribute.
Regulated facility	A collective term for the range of activities permitted under the Environmental Permitting Regulations
REPs	Radioactive Substances Regulation – Environmental Principles. Environment Agency guidance which sets out, at a high level, the principles which the Environment Agency applies to RSR.
RPA	Radiation Protection Advisor
RSA	Radioactive Substances Act
RSR	Radioactive Substances Regulation.
SAPs	Safety Assessment Principles. HSE guidance which sets out, at a high level, the principles which the HSE applies to safety cases.
Scoring	Placing a numerical value on an option in relation to a particular attribute.
Screening Criterion	A criterion representing basic expectations in relation to the practicability of proposed options; used to exclude one or more proposed options from further consideration. May be based on feasibility, legal, policy or regulatory constraints, or manifestly inferior performance against important attributes.
SFAIRP	So far As Is Reasonably Practicable
SQEP	Suitably Qualified and Experienced Person
Stakeholder	Any person or organisation that considers it has an interest in the BAT study concerned. Stakeholders may include the relevant nuclear site operator, the regulators and Government departments and persons or organisations other than these such as the local community, suppliers and other groups.
Sustainable Development	Development which meets the needs of the present without compromising the ability of future generations to meet their own needs. Specific to radioactive waste, the Government's policy is to 'ensure that radioactive waste is managed safely and that the present generation, which receives the benefit of nuclear power, meets its responsibilities to future generations'.
Uncertainty	Lack of definite information on a matter relevant to a BAT study
Waste Hierarchy	A principle of waste management which requires that (in order of preference) wastes be: Avoided; Minimised; Reused; Recycled; and, Disposed of.
Weighting Factor	A factor applied to each attribute so as to obtain an overall scoring or ranking for an option. Weighting factors are essentially subjective.

Appendix 1. Legal Framework and Context

The output of BAT assessments must be practicable and compliant with safety and environmental requirements (legal and policy). In demonstrating BAT, reference should be made to relevant standards, guidance and good practice. Defra, DECC and the Welsh Assembly Government have issued guidance to accompany the EPR[1]. This guidance includes advice on permitting requirements in relation to government policy and European directives.

This Appendix provides an outline of the key policies and legislation relating to BAT.

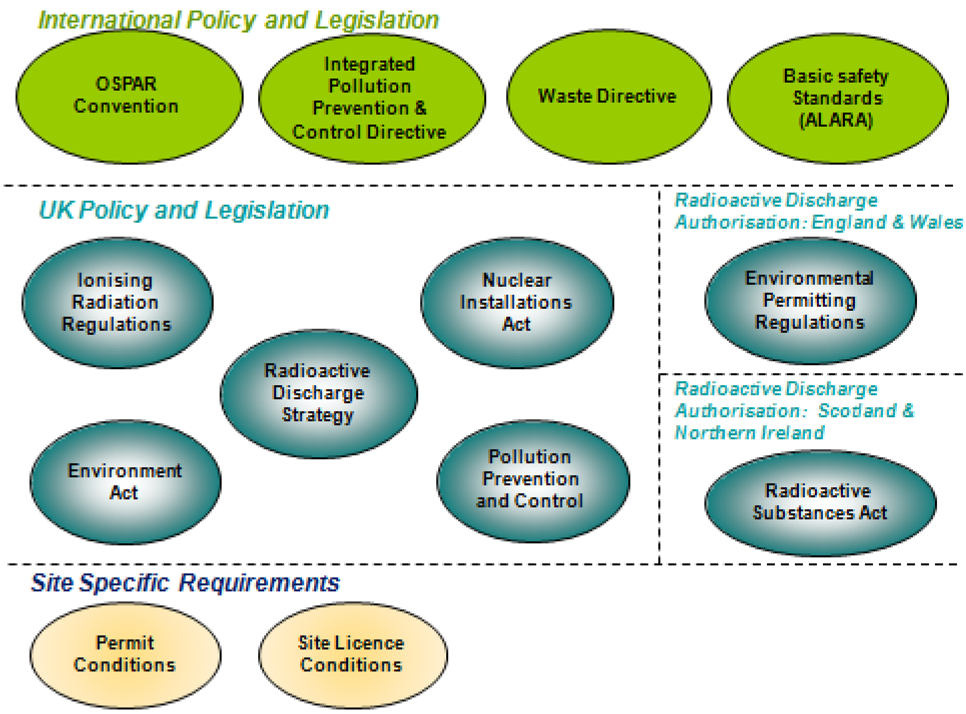

Figure A.1. Key drivers relating to BAT

A1.1 European Directives and initiatives

Much of the legislation in the UK is driven by European policy. Key European Directives and initiatives which have an influence on BAT policy in the UK include:

- **The OSPAR Convention** for the protection of the marine environment of the North-East Atlantic requires signatory countries to apply BAT and BEP (Best Environmental Practice) as a means of preventing and eliminating marine pollution. BEP is defined as "*the application of the most appropriate combination of environmental control measures and strategies*" [2]. Where disposals resulting from the use of BAT and BEP do not lead to environmentally acceptable results, additional measures must be applied.
- **The Basic Safety Standards Directive** (Council Directive 96/29/EURATOM) established basic safety standards (BSS) for the protection of the health of workers and the general public against the dangers arising from ionising radiation. The Directive, which came into force in May 2000, places a duty on Member States to keep the exposure risks faced by the general public, both individually and collectively, to a minimum (and certainly within prescribed limits). Fundamental to the BSS are the principles of justification, optimisation and limitation of exposures.

- **Integrated Pollution Prevention and Control** (Council Directive 96/61/EC) is designed to prevent or, where that is not practicable, to reduce emissions to water, air and land (including waste) from various industrial sources, in order to achieve a high level of protection for the environment taken as a whole. The key principle is the requirement for an integrated approach to the granting of permits, taking account of the whole environmental performance and the application of BAT. The Directive also introduced a requirement for the development of BAT reference documents (BREF's, see http://eippcb.jrc.es/) to ensure consistent application of BAT across EU Member States.

- **The Framework Directive on Waste** (Council Directive 75/442/EEC, as amended by 91/156/EEC) requires that Member States of the EU produce a National Waste Strategy setting out their policies on the disposal and recovery of waste. The main themes were developed from the concept of sustainable development and require that an integrated and adequate network of waste disposal installations be established, taking account of BAT, with self sufficiency in waste disposal in each member state.

A1.2 National Legislation

In England and Wales, the formal basis for the control of radioactive disposals, and other aspects of the control of radioactive materials, is the EPR 2010[3,4]. In Scotland and Northern Ireland control continues to be exercised through the Radioactive Substances Act 1993).

- **Environmental Permitting Regulations 2010.** The EPR were originally introduced in 2007, as a means of achieving a streamlined permitting and compliance regime within in England and Wales. The EPR combined aspects of the Pollution Prevention and Control (England and Wales) Regulations 2000, the system of waste management licensing in Part II of the Environmental Protection Act 1990 and the Waste Management Licensing Regulations 1994. The regulations were extended in 2010 to cover waste discharge consents, groundwater permits and radioactive substances regulations.

- **Radioactive Substances Act 1993**. In Scotland, SEPA regulates the management and disposal of radioactive waste under RSA93. The primary purpose of this legislation is to provide for the protection of public health against harm from discharges of radioactive waste. Exposures to ionising radiation of the public are kept ALARA by the use of licence conditions requiring the operator to use BPM.

- **Ionising Radiation Regulations 1999.** The IRR99 set down requirements for the safety of people who work with ionising radiations, including radioactive substances, and effectively implement the BSS Directive. The Regulations impose a duty on employers to protect their employees and other persons against radiation arising from work with radioactive substances. It requires doses to be ALARP, and specifies dose limits which must not be exceeded. The regulations are enforced by the Health and Safety Executive or, in some cases, by local authorities.

- **Pollution Prevention and Control 2000.** The PPC Regulations transposed the IPPC Directive into national legislation. The Regulations introduced a requirement for industries legislated under PPC to ensure that BAT is applied to activities and operations in order to minimise impacts on the environment as a result of discharges, emissions and waste generation. In England and Wales, the PPC Regulations were repealed and replaced in 2007 by the EPR.

- **Environment Act 1995.** The Environment Act 1995 is the mechanism by which the European Framework Directive on Waste is implemented in the UK and effectively requires BAT to be applied in relation to waste management activities. In England and Wales, aspects of the Environment Act relating to waste management activities were repealed in 2007 and replaced by the EPR.

- **Nuclear Installations Act 1965.** Under the NIA65 36 standard licence conditions (LC) are attached to all nuclear site licences. These detail how licensed sites should be managed by the operator. LC 32 requires site licensees to establish and implement adequate arrangements to minimise the rate of production and total quantity of radioactive waste and to record such waste.

A1.3 RSR Regulation Environmental Principles

The Environment Agency has issued guidance to their inspectors on Regulation Environmental Principles (REPs)[5] and the assessment of BAT[6] in the regulation of radioactive substances within England and Wales. This states that, in demonstrating the use of BAT in choosing and implementing waste management options, an operator must show:

- that they have selected the option, which best protects people and the environment as a whole in both the short and long term; and
- that they have optimised the environmental impact of the preferred option, through the choice of techniques proposed for its operation, maintenance etc.

The EA REPs guidance includes discussion of a range of principles that are relevant to the application of BAT. This includes the general advice that BAT should be identified and applied whenever new sites or facilities are planned, or when modifications to scope or function are proposed for existing sites or facilities, or when there are reasons to believe that substantially better options than are currently employed might be available.

Table A.1 Key principles for applying BAT within the EA REPs

Guidance category	REP Developed Principle (DP)	Key principles
Radiological Protection (RP)	RPDP1: Optimisation of protection	"*all exposures to ionising radiation of any member of the public and of the population as a whole shall be kept as low as reasonably achievable (ALARA), economic and social factors taken into account.*" Compliance with ALARA should be achieved by applying BAT.
Radioactive Substance Management (RSM)	RSMDP3: Use of BAT to minimise waste	"*best available techniques should be used to ensure that the production of radioactive waste is prevented and where that is not practicable minimised with regard to activity and quantity*." o Processes creating, handling, treating and storing radioactive materials should be chosen so as to prevent or minimise the production of waste over the complete lifecycle of the facility. o Optimisation should be demonstrated through options studies, particularly for new or changing facilities. o Processes producing radioactive waste should be reviewed at intervals, to identify opportunities to minimise waste production.
	RSMDP4: Processes for identifying BAT	"*the best available techniques should be identified by a process that is timely, transparent, inclusive, based on good quality data, and properly documented*." It should be carried out by competent and properly informed personnel. o Resources to identify BAT should be proportionate to the environmental benefits. o The process should be fit for purpose. Decisions should be documented, including identification of assumptions, boundaries and constraints, demonstration of sufficient information and integrity of conclusions. Uncertainties should

Guidance category	**REP Developed Principle (DP)**	**Key principles**
		be identified.
	RSMDP5: Actions having irreversible consequences	"*actions … having irreversible consequences should only be undertaken after thorough, detailed, consideration … of those actions and of the other available options. The best available technology should be used to prevent irreversible consequences from occurring inadvertently*." This may adopt the precautionary principle. In general, preference should be given to preventing and minimising discharges by concentrating and containing activity rather than dilution and dispersion, particularly for radionuclides that have long half-lives and accumulate in the environment.
	RSMDP6: Application of BAT	"*in all matters relating to radioactive substances the 'best available techniques' means the most effective and advanced stage in the development of activities and their methods of operation*." It is recognised that BAT is specific to the circumstances existing at any decision point and that an option will not be BAT if its costs would *far outweigh its environmental benefits*. However, where statutory obligations require stricter conditions and limits than those achievable by BAT, then additional measures should be applied. There is no threshold below which further consideration of BAT is not required.
	RSMDP7: BAT to minimise environmental risk and impact	"*when making decisions about the management of radioactive substances, the best available techniques should be used to ensure that the resulting environmental risk and impact are minimised.*"
	RSMDP10: Storage	"*radioactive substances should be stored using the best available techniques so that their environmental risk and environmental impact are minimised and that subsequent management, including disposal is facilitated.*"
	RSMDP13: Monitoring and assessment	"*the best available techniques, consistent with relevant guidance and standards, should be used to monitor and assess radioactive substances, disposals of radioactive wastes and the environment into which they are disposed.*"
Engineering Principles (EN)	ENDP10: Quantification of discharges	"*Facilities should be designed and equipped so that best available techniques are used to quantify the gaseous and liquid radioactive discharges produced by each major source on site*."
	ENDP13: External and internal hazards	"*External and internal hazards that could affect the delivery of an environmental protection function should be identified and the best available techniques used to avoid or reduce any impact.*"
	ENDP14: Control and instrument-ation	"*Best available techniques should be used for the control and measurement of plant parameters and releases to the environment, and for assessing the effects of such releases in the environment*."
	ENDP15: Containment systems	"*Best available techniques should be used to prevent and/or minimise releases of* [liquid or gaseous] *radioactive substances to the environment, under routine or accident conditions.*"
	ENDP16: Ventil-ation systems	"*Best available techniques should be used in the design of ventilation systems.*"
	ENDP18: Essential services	"*Best available techniques should be used to ensure that loss of essential services does not lead to radiological impacts to people or the environment.*"
Contaminated	CLDP1:	"*The best available techniques should be used to prevent and*

Guidance category	REP Developed Principle (DP)	Key principles
Land and Groundwater (CL)	Prevention of Contamination	*where that is not practicable minimise radioactive contamination of land and groundwater, whilst allowing disposals of radioactive waste."*

References

1 Defra, DECC and WAG (2010). Environmental Permitting Guidance. Radioactive Substances Regulation For the Environmental Permitting (England and Wales) Regulations 2010. March 2010, Version 1.1

2 OSPAR (1992). Convention for the Protection of the Marine Environment of the North-East Atlantic. Text as amended on 24 July 1998, updated 9 May 2002, 7 February 2005 and 18 May 2006. Amendments to Annexes II and III adopted at OSPAR 2007. For current full text [Appendix 1 provides the definition of BAT] see http://www.ospar.org/html_documents/ospar/html/OSPAR_Convention_e_updated_text_2007.pdf

3 Environmental permitting guidance, http://www.environment-agency.gov.uk/business/topics/permitting/32320.aspx

4 Annex II Environmental Permitting (England and Wales) Regulations 2010, www.defra.gov.uk/corporate/consult/env-permitting/annex2.pdf

5 Environment Agency. Radioactive Substances Regulation Environmental Principles (REPs), April 2010 http://www.environment-agency.gov.uk/static/documents/Research/updated_2068897.pdf

6 Environment Agency (2010). RSR: Principles of optimisation in the management and disposal of radioactive waste.

Appendix 2. Illustrative Multi-Attribute Analysis to Identify BAT

A2.1 Criteria and Attributes

In order to identify a preferred option from a range of alternatives, the benefits and detriments for each approach can be evaluated against appropriate performance measures or attributes (which may be grouped as higher level criteria). Key areas to consider when defining criteria and attributes include:

- impact of routine discharges and disposals on the public and the environment;
- impact of potential accidents on the public and the environment;
- occupational doses; and,
- waste arisings.

The number of criteria and attributes considered can be variable and examples are provided in the table below. The actual range of impacts considered should be consistent with the issue at hand and the list below is not exhaustive, nor is it prescriptive.

Table A.2 Example criteria attributes and definitions

High Level Criteria	Attributes	Definition
Safety	S1. Public Dose.	The dose to the critical group arising from operations. This includes exposure due to discharges, waste transport and disposal.
	S2. Operator Dose.	The dose received by workers for all operations, including transport and disposal. This extends to workers on site, not involved with the project.
	S3. Radiological Safety / Risk.	Addresses the radiological consequences and risks of an accident during implementation and operation, including public and operator dose.
	S4. Conventional Safety.	Involves the risk to operators and to the public from accidents during implementation and operation, including transport.
Technical	T1. Development Status.	Involves consideration of the strategic disadvantages to adopting plant designs or ideas which require further development work before they can be implemented.
	T2. Ease of Deployment.	The relative ease of installing, commissioning and operating the required plant or equipment.
	T3. Project / Implementation Time.	The anticipated implementation time, including option development and design; authorisation and Regulatory consultation; construction and commissioning etc.
	T4. Compatibility with Existing Plant / Processes.	Compatibility and potential competition for assets with existing and future systems, Dependency of an option on external factors is perceived to be a disadvantage.
	T5. Process Flexibility.	The ability to process wastes etc. where the condition and composition of the waste may vary significantly from that predicted.
	T6. General Applicability	The ability of plant and equipment, where appropriate, to deliver requirements beyond the scope of the project under specific consideration.
	T7. Waste Form Disposability.	Relates to the waste being in an acceptable state to be finally disposed to meet disposal criteria.
	T8. Maintenance.	Consideration of the ease of maintenance over the operational lifetime of plant, facility or equipment.

High Level Criteria	Attributes	Definition
Environmental	EN1. Radiological Disposals: gaseous, aqueous or solid	Performance in relation to radiological disposals, whether of airborne, liquid, or solid wastes; includes judgements on waste minimisation.
	EN2. Non-Radiological Discharges: gaseous, aqueous or solid	Performance in relation to physical and chemical properties of disposals, whether as airborne, liquid or solid materials.
	EN3. Nuisance / Disturbance (noise, odour, visual).	Consideration of disturbance or nuisance to the environment; for example, non-radiological impacts on fisheries, leisure activities or transport.
	EN4. Resource Use (e.g. energy & water).	Evaluation of the performance of each option in relation to material and energy use.
	EN5. Transport	Consideration of the environmental and social impacts of transport of waste. It does not include safety as this is addressed in S4 above.
	EN7. Impacts on Biodiversity.	Consideration of the impacts on flora and fauna, and in particular those that fall under protection of any kind.
Regulatory	P1. Impact on Regulatory Permissions	Involves consideration of the requirements for, and the potential complexity of securing, EPR permits, EIADR99 consents, planning permissions, Article 37 Opinion etc.
Social and Economic	SEC1. Effects on local economy.	Potential positive and negative impacts on the local economy.
	SEC2. Lifetime Costs.	The total cost, in current monetary values; including capital, operating, decommissioning, storage and waste disposal.
	SEC3. Financial Risks.	Relates to potential difficulties associated with facility or plant construction, commissioning and operation, and uncertainties in storage and disposal costs.

For each attribute, a clear description should be provided to avoid unintentional 'double counting' of performance. This is particularly important where multiple views could exist as to the meaning or application of an attribute.

A2.2 Scoring

Criteria and attributes are scored for each short-list option, allowing direct comparison. The scoring system can vary depending upon the assessment context, but should be designed to elicit views on both benefits and detriments associated with each option.

It may be appropriate, where existing processes or plant are in operation, to score options relative to the impacts associated with the current practice (i.e. encompassing positive and negative scores relative to a baseline performance). Alternatively, a scaled system can be applied, for example where lower numbers may be associated with detriment and high numbers represent benefits. Generally there is merit in simplicity of approach as this promotes understanding by non-technical reviewers. Misleading precision in scoring should be avoided. Where options are similar discrimination between options should not be introduced artificially, particularly where uncertainty is an important factor. In some cases it may help to assess options as high, medium or low.

Whatever system is adopted, it must be ensured that the approach is transparent and clearly documented. A range of stakeholders may be invited to score options in order to elicit a range of views with regards to the benefits and detriments associated with short-list options. Ideally this should be conducted during a focused workshop and it is recommended that early consideration be given to the scoring process, to allow for consensus to be gained on the approach prior to its implementation.

Impacts should be scored in relation to the construction, operational and decommissioning phases. This avoids the introduction of measures that have short term benefits, but which may lead to long term problems. Such a lifecycle approach should also be applied to financial costs and any potential financial benefits or savings.

Where attributes are grouped within higher level criteria, it is recommended that scores be 'normalised' (averaged across criteria) to reduce bias which might arise from attributes with unequal numbers of criteria.

Normalisation

Statistical normalisation allows data on different scales to be compared, by bringing them to a common scale. For instance, when undertaking a numerical analysis of criteria to assist in identifying BAT, it is possible that differing numbers of attributes will apply, as presented below. In this illustration, one option may score highly for technical feasibility, but less so for socio-economic performance, whilst another option may exhibit the reverse performance. Due to the different number of attributes to identify either criterion, an unintentional bias in interpreting the scoring may be introduced.

Criterion	**Attribute**	**Score**		**Normalised score**	
		Option 1	*Option 2*	*Option 1*	*Option 2*
1. Socio-economics	Effects on local economy	3	8	3	8
	Lifetime costs	3	8	3	8
	Financial risk	3	8	3	8
	Average score criterion 1 (A)	-	-	3	8
2. Technical feasibility	Development status	8	3	8	3
	Ease of deployment	8	3	8	3
	Project time	8	3	8	3
	Compatibility with current facilities	8	3	8	3
	Process flexibility	8	3	8	3
	General applicability	8	3	8	3
	Waste form disposability	8	3	8	3
	Maintenance requirements	8	3	8	3
	Average score criterion 2 (B)	-	-	8	3
	Total score all attributes	73	48		
	Total average score all criteria			A+B = 11	A+B = 11
	Average score all attributes	73/11 = 6.6	48/11 = 4.4		
	Average score all criteria			11/2 = 5.5	11/2 = 5.5

If the summated or averaged score across all attributes is determined, then option 1 appears to be perform better. However, by averaging the scores across the criteria, it can be seen that options 1 and 2 perform equally well.

A2.3 Weighting

If used as part of the analysis, weightings need to be systematically derived and justified. As one example, a scale of 1 to 5 may be applied, where 1 is regarded as a low ranking criterion or attribute and 5 as high ranking.

Some criteria and attributes may differentiate more readily between options than others and weightings can be applied to take this into account. Alternatively, judgement may be required about the relative significance of attributes, for instance to take account of the different values society at large may have on the acceptability of different types and levels of risks and impacts. Accordingly, two principal weighting approaches may be applied - preference weighting and swing weighting. The approaches are not mutually exclusive and both weighting systems may be employed.

A2.3.1 Preference weighting

Preference weighting takes account of individual beliefs as to the relative importance of different attributes. Two broad approaches can be applied, and in both instances, weightings should be agreed in advance of the options identification process. This form of weighting is therefore sometimes referred to as 'blind preference weighting'*.

In the first approach, generic weightings are applied that are independent of the study. For example, safety attributes may be considered more important than cost.

The alternative approach is to apply study-specific weightings. Such weightings are tailored to the assessment, but are still determined prior to the study being undertaken to prevent bias. This approach enables project-specific factors to be taken into account, for example the need to provide a solution within a short timescale.

A2.3.2 Swing weighting

Swing weighting is applied subsequent to the scoring process. This approach focuses on those attributes for which the greatest span of scores has been awarded to determine their influence on the outcome of the options appraisal. That is, swing weighting is assigned according to how much an attribute discriminates between options and not how important it is in terms of people's values. For example, if all options are assigned similar scores as a measure of performance against an attribute, it is clear that little discrimination can be made between the options. However, where options range in scores from low (e.g. 1) to high (e.g. 100), as a measure of performance against an attribute, then the attribute offers a potential means to differentiate between the options.

Statistically, swing weighting can determine how robust the initial identification of BAT is. However, it does not replace a more logic based analysis to determine the importance or credibility of assigning different weights.

A2.4 Sensitivity Analysis

Sensitivity analysis is the study of how uncertainty in the output of a mathematical model can be apportioned, qualitatively or quantitatively, to different sources of variation in the input of a model.

In more general terms uncertainty and sensitivity analyses investigate the robustness of a study when the study includes some form of mathematical modelling. While uncertainty analysis studies give the overall uncertainty in the conclusions of the study, sensitivity analysis tries to identify what source of uncertainty weights more on the study's conclusions.

A2.4.1 Randomised sensitivity weighting

Randomised sensitivity scoring provides a probabilistic means of weighting criteria and attribute scores. The approach involves randomly varying weightings on each attribute to determine a probabilistic distribution function for the preferred option. The outcome is a statistical identification of the robustness of the preferred option, but the approach does not take into account the appropriateness of variations in attribute weightings.

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* Strictly, scoring is only 'blind' when those doing the scoring are unaware of the weightings, otherwise scores can be given that participants know will result in preferred options getting good weighted scores (and vice versa). The degree to which scoring and weighting require separation will be determined on a case by case basis, although it is important to document the approach used.

A2.4.2 Targeted sensitivity weighting

Targeted sensitivity weighting involves assigning weight ranges to attributes and identifying constraints on combinations of attributes. The output is therefore a narrower, but potentially more realistic, range of probability distribution for the preferred option.

A2.4.3 'What if' weighting

The 'what if' approach to weighting involves challenging the scoring of attributes. The overall weightings of criteria and attributes are not challenged using this approach, rather the scores assigned are altered to determine the impact upon the robustness of the option selected as BAT. For example, if an attribute was assigned an average score of 3, the 'what if' approach would look at the impact on BAT of applying a score of 2 and 4.

Although this approach is sometimes applied, there is an argument that it negates the usefulness of an expert panel for the scoring process. Its principal use is to reflect key areas of uncertainty identified in the scoring process which may affect the final outcome.

Appendix 3. Cost Benefit Approach - Appraisal and Evaluation in Central Government

The UK Government[1] through HM Treasury has developed guidance on options appraisal and value assessment which it has published in 'The Green Book' and is intended to support proportional and balanced decision making. This guidance is mandatory on all government departments, and Non Departmental Public Bodies. The Green Book provides clear guidance on how most financial effects should be appraised and the impact of time on these. However, it also states that these are not the only consideration when determining value and that other benefits and detriments should be factored into any analysis.

The Green Book provides a range of examples of benefits and detriments that might be considered and splits these into two types:

- Tangible benefits and detriments – i.e. those which can be measured and ideally to which a monetary value can be assigned; and,
- Intangible benefits and detriments – i.e. factors that are important and need to be considered, but which cannot be readily quantified.

The Green Book represents general guidance and cannot cover all aspects of value across all spheres of Government activity. Therefore, it requires individual organisations to develop their own guidance, on what they value and how to measure it.

An example of the application of the Green Book methodology in a nuclear context is the Nuclear Decommissioning Authorities Business Case guidance and Value Framework[2] which provides monetary values for a range of factors relevant to site remediation, and fuel and nuclear materials management options[3]. Factors considered within the scope of the Value Framework are:

- Hazard Reduction;
- Safety;
- Environment;
- Cost;
- Income; and,
- Socio-economics.

References

1 HM Treasury (2010). The Green Book. Appraisal and Evaluation in Central Government. Treasury Guidance. London, The Stationary Office.

2 NDA Guidance for the Production of Business Cases; www.nda.gov.uk/documents/upload/EGG08-NDA-Guidance-for-the-production-ofbusiness-cases-Rev-6.pdf

3 Wareing M (2009). UK Nuclear Decommissioning Authority – Value Framework, its development and role in decision making. Proceedings of the 12th International conference on environmental remediation and radioactive waste management / nuclear decommissioning, ICEM'09. October 11-15, 2009, Liverpool, UK. ICEM2009-16399.

Appendix 4. Membership of the BAT Working Group

Working Group Members

Lise Stoyell	AWE (Chair)
Gemma Parkes	AWE
Anna Morris	Rolls-Royce
Jake Manson	Sellafield Ltd
Brent Wright	Babcock International Group (Marine Division)
Marc Murray	Dounreay Site Restoration Ltd (to July 2010)
John Disbury	Dounreay Site Restoration Ltd (from July 2010)
Kevin Dodd	Studsvik
Graeme Stonell	Research Sites Restoration Ltd
Lynda Fryer	Research Sites Restoration Ltd
Simon Hunter	LLWR
Phil Kruse	EDF Energy (from March 2010)
Joe Roberts	EDF Energy (from November 2009)
Matthew Castle	Magnox North Ltd
Chris James	Magnox South Ltd (from January 2009)
Stuart Woodings	EDF Energy (from June 2009)
Alistair King	GE Healthcare (from June 2009)

Stakeholders

John Garraway	Environment Agency
Linda Buchan	Scottish Environment Protection Agency
Andrew Craze	Nuclear Decommissioning Authority (to November 2009)
Mark Wareing	Nuclear Decommissioning Authority (from April 2010)

Secretariat

Anna Morris	Rolls-Royce, Group Secretary
Duncan Jackson	RPS (Eden Nuclear & Environment from June 2010), Technical Author