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SUMMARY

This Integrated Waste Strategy Document (IWS) outlines the current strategy for managing radioactive and non-radioactive wastes arising from the construction, operation and decommissioning of the UK European Pressurised Reactor (EPR) nuclear power station as described in the EDF/AREVA technical documentation submitted to the Regulators in the framework of Generic Design Assessment (GDA).

This IWS is based on the expected waste and spent fuel generation and management practices throughout the UK EPR lifecycle.

It shows that there is a management strategy for all the waste streams produced by the EPR design and that they have been suitably planned for. The IWS refers out to a range of other UK EPR GDA submission documentation which provide more details on the how, why and when waste management strategies on the EPR are developed.

The document shows that waste management strategies have been developed using a standardised approach which takes into account all relevant factors including:

- Delivery of compliance with relevant regulatory obligations (e.g. licence conditions, authorisations and permits) and Government policy (e.g. a progressive reduction of discharges).
- Consideration of a full range of health, safety, environmental, security, economic and social issues.
- Minimisation of waste via implementation of the waste hierarchy.
- Application of Best Available Techniques (BAT).

The IWS identifies uncertainties and assumptions that may influence the implementation of an EPR's waste management strategy in the UK and also recognises the risks and opportunities within the strategy. By integrating the waste management strategies for all the different waste streams produced by an EPR power station, the overall strategy for waste management that minimises environmental impact can be demonstrated. This is achieved through adherence to the waste hierarchy and employment of the Best Available Techniques (BAT) to concentrate and contain radioactive waste. This document and its supporting references therefore provide confidence that the challenges associated with the management of wastes and spent fuel from the UK EPR are fully understood and that solutions are available within the envelope of current UK and international experience.

This IWS is based on the Flamanville 3 Reference Case of the UK EPR GDA design submission and will assist owner/operating companies including those who may have chosen other waste management options in developing their own IWS documents as their EPR stations evolve through their lifecycle from commissioning through operation to decommissioning and final site clearance. It is a tool which helps to demonstrate that wastes produced by an EPR can be appropriately managed and informs the operating companies and other stakeholders of what work is required to fully develop and implement waste management strategies on a new EPR power station.

GLOSSARY

ALARP	As Low As Reasonably Practicable
BAT	Best Available Technique
BPEO	Best Practicable Environmental Option
BPM	Best Practicable Means
CfA	Conditions for Acceptance
DAW	Dry Active Waste
DECC	Department of Energy and Climate Change
DEFRA	Department of Environment, Food and Rural Affairs
DSRC	Design Safety Review Committee
DWMP	Decommissioning and Waste Management Plan
ETB	Effluent (Waste) Treatment Building
EA	Environment Agency
EPR	European Pressurised Water Reactor
EPRI	Electric Power Research Institute
FDP	Funded Decommissioning Programme
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
HSE(NII or ONR ¹)	Health & Safety Executive, Nuclear Installations Inspectorate or Office for Nuclear Regulation
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
IRWST	In-containment Refuelling Water Storage Tank
IWS	Integrated Waste Strategy
LLW	Low Level Waste
LLWR	Low Level Waste Repository
LoC	Letter of Compliance
LRWS	Liquid Radioactive Waste System
NDA	Nuclear Decommissioning Authority
NDA RWMD	NDA Radioactive Waste Management Directorate
NSSS	Nuclear Steam Supply System
NWAT	Nuclear Waste Assessment Team
OECD	Organisation for Economic Cooperation and Development
OSC	Operational Service Center
OSPAR	Oslo Paris Convention
PCER	Pre-Construction Environmental Report
PCSR	Pre-Construction Safety Report
PPC	Pollution Prevention and Control
PWR	Pressurised Water Reactor
RBS [EBS] ²	Extra Boration System

¹ The Office for Nuclear Regulation (ONR) was created on 1st April 2011 as an Agency of the Health and Safety Executive (HSE). It was formed from HSE's Nuclear Directorate and has the same role. In this report, we therefore generally use the term "ONR", except where we refer back to documents or actions that originated when it was still HSE's Nuclear Directorate.

RCV [CVCS] ²	Chemical Volume Control System	
RSA 93	Radioactive Substances Act 1993	
RPE [NVDS] ²	Nuclear Vent and Drain System	
RWMC	Radioactive Waste Management Case	
SRWSR	Solid Radioactive Waste Strategy Report	
TEG [GWPS] ²	Gaseous Waste Processing System	
TEP [CSTS] ²	Primary Effluent Treatment System also known as Coolant Storage and Treatment System	
TEU [LWPS] ²	Spent Effluent Treatment System also known as Liquid Waste Processing System	
TES [SWTS] ²	Solid Waste Treatment System	
VLLW	Very Low Level Waste	

² The two acronyms correspond to the ECS (EDF Coding System) and to the EPR acronym respectively.

1. INTRODUCTION

This Integrated Waste Strategy Document (IWS) outlines the current strategy for managing radioactive and non-radioactive wastes arising from a new UK EPR nuclear power station as described in the EDF/AREVA technical documentation submitted to the Government's new nuclear build Generic Design Assessment (GDA). The document takes into account the political, regulatory and business requirements associated with the operation of new nuclear power stations in England and Wales, however it does not consider the site specific or procedural issues on which it will be the responsibility of individual station operating companies to make decisions.

1.1 PURPOSE AND OBJECTIVE

This explicit IWS document is based on the expected waste and spent fuel generation and management practices throughout the UK EPR lifecycle. The document will act as a stand-alone strategy report, whilst drawing substantially on existing documents:

- UK EPR Pre-Construction Environmental Report (PCER);
- Solid Radioactive Waste Strategy Report (SRWSR) (Reference 1);
- UK EPR Pre-Construction Safety Report (PCSR).

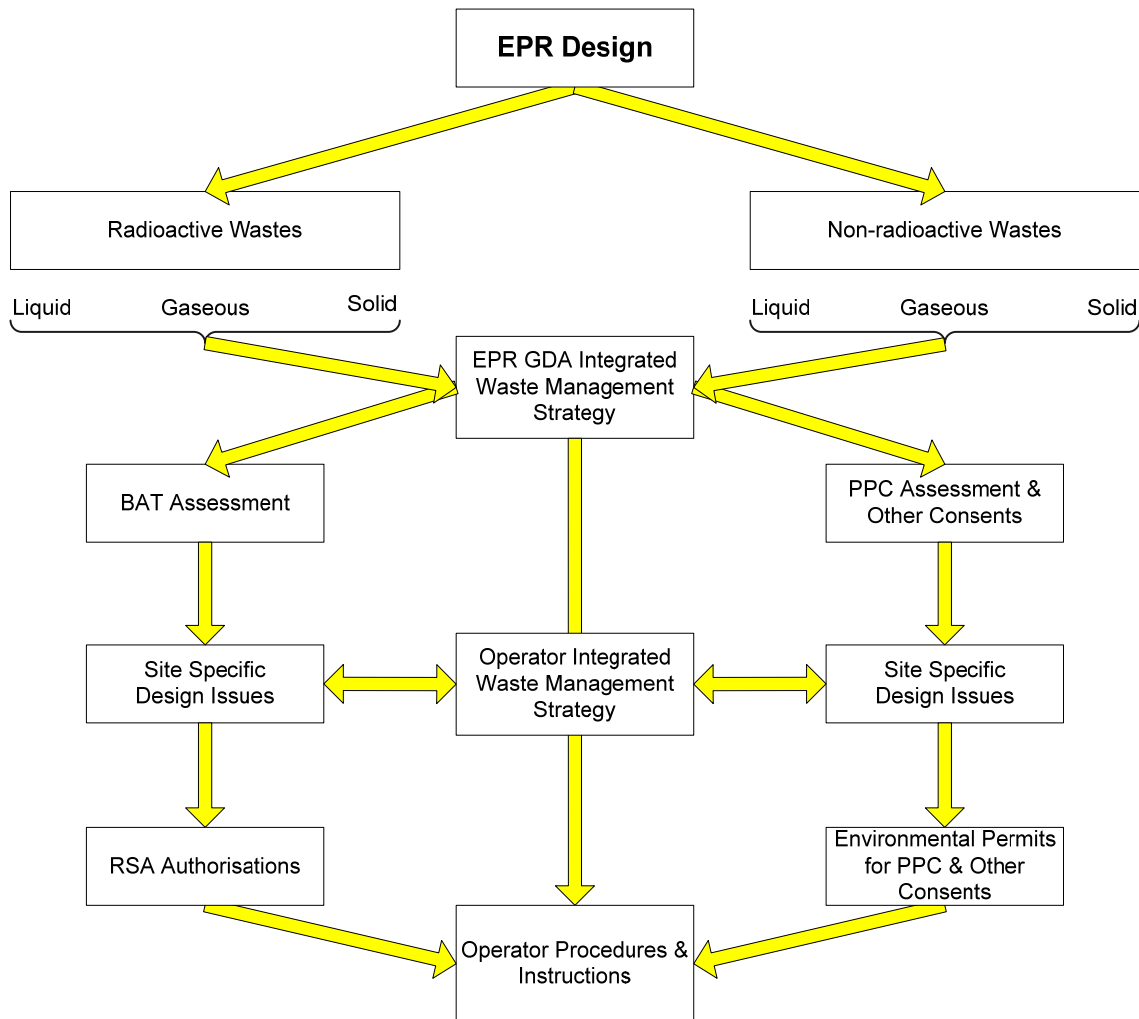
The objective of the IWS is to help ensure that a consistent and safe approach is adopted in the taking of all decisions on waste management matters for the power station, as well as compliance with environmental protection principles for all waste types inclusive of material that may become waste in the future. It shows how all aspects related to the design of the power station can potentially have an impact on waste management strategy and therefore need to be taken into account in its development. This involves ensuring that the design includes protection of the public, workers and environment through keeping radiological doses and environmental impact ALARP and minimising discharges/waste arisings through the use of the Best Available Techniques (BAT).

This document presents the strategy for the management of all wastes (radioactive and non-radioactive) from an EPR power station in the UK and shows how it is developed and optimised in an integrated manner.

The IWS is a live document which presents a summary of a station's potential waste inventory and strategies for its management, and describes how it is determined which strategy should be used. The document will thus evolve with any changes to the EPR design as the submission progresses through the GDA process. As such, the IWS provides an overview of the management of waste on an EPR power station for stakeholders interested in the power station's design, in particular the regulators. The IWS is at the centre of a framework of design submission documentation (Figure 1) that provides the waste management strategy for the EPR in the UK together with the BAT Assessment, as presented in Chapter 8 of the Pre-Construction Environmental Report (PCER) (Reference 2) and in BAT forms which describe the application of BAT for radionuclides assessed to be of particular significance (Reference 3). It points to how the design processes interact to optimise waste management strategy.

This IWS document will also be of benefit to future operating companies in producing their own company and site specific IWS documents which will be required to support submissions for Discharge Authorisations under the Radioactive Substances Act 1993 (RSA 93) and other environmental permits for any new EPR power stations.

Figure 1: The Role of an IWS in the EPR Generic Design Assessment Process



1.2 SCOPE

The scope of the IWS includes the management of all radioactive and non-radioactive waste and emissions arising from all activities undertaken over the life-cycle of the power station, including wastes produced during construction and decommissioning. Unlike previous IWS and other waste management strategy documents produced for nuclear power stations, in line with stated Government Policy for new reactor build the IWS for an EPR considers the strategy and implications for the management of spent fuel as a waste/special nuclear material.

The document is structured on the guidance document produced by the Nuclear Decommissioning Authority (NDA) "Specification for the Content and Format of a Site Integrated Waste Strategy Document" (Reference 4).

The document describes an IWS that is for the "Reference Case" for the UK EPR design as discussed and developed over a period of 15 years by EDF, AREVA and the French and German Regulators.

As mentioned in PCER Sub-chapter 6.2 (Reference 5), section 3, the ‘Reference Case’ solid radioactive waste and spent fuel strategy is based on the waste and spent fuel management practices and arrangements of the UK EPR reference plant at Flamanville 3. This strategy is supported by a BAT analysis (PCER Chapter 8, Reference 2) and impact assessments (PCER Chapters 9, 10, 11 and 12, respectively References 6, 7, 8 and 9).

Changes to this “Reference Case” Design configuration may result from different sources:

- Changes to the Flamanville 3 design, which include experience feedback from both EDF and international nuclear power plant and also from the Technical Codes updates;
- Specific changes resulting from interactions with the UK Regulators and with UK national standards and industrial safety policies.

In addition, it is recognised from experience from other EPR and AREVA projects worldwide that other potential UK EPR operators may wish to adopt alternative spent fuel and waste management arrangements. These possible options to the reference case are presented in a Solid Radioactive Waste Strategy Report (SRWSR, Reference 1). The SRWSR does not provide respective BAT assessments for the options but there is a high degree of confidence that such cases can be made by potential UK EPR operators.

At the GDA stage of the new UK nuclear reactor licensing process, the intention is to preserve as much flexibility as possible in the strategy to enable decisions to be made by future licensees within site-specific submissions.

1.3 PLANT DESCRIPTION

The EPR is a pressurised water reactor (PWR) similar to other units currently in operation worldwide (PCER Sub-chapter 1.3 (Reference 10) provides technical information on the EPR and compares it against French and German reactors of similar design). As mentioned in PCER Sub-chapter 1.2 (Reference 11), the functioning of the nuclear production unit is based on three systems:

- (i) A Primary System.
- (ii) A Secondary System.
- (iii) A Cooling System.

The EPR layout locates the reactor building at the centre of the Nuclear Island and houses the main equipment of the Nuclear Steam Supply System (NSSS) and the In-containment Refuelling Water Storage Tank (IRWST).

The Fuel Building is located on the same basemat as the Reactor Building and two of the four safeguard buildings. It houses the fresh fuel, the spent fuel in an interim fuel storage pool and associated handling equipment. The mechanical floor houses the Fuel Pool Cooling System, the Extra Boration System, and part of the Chemical and Volume Control System. The location of, and further description of, the Nuclear Island buildings and others on the nuclear site are provided in Sub-chapter 1.2 of the PCER (Reference 11).

The main facilities required on a UK EPR site for the processing and interim storage of waste are listed below.

- The Reactor Building, Fuel Building, Nuclear Auxiliary Building, the Safeguard Building, the Effluent Treatment Building and Operational Service Centre (OSC), for the “Reference Case” design, contain treatment systems capable of treating all waste forms. The RPE [NVDS] is a system for collecting and channelling liquid and gaseous waste from the primary circuit and related facilities to the appropriate treatment system e.g. the TEP [CSTS] (Coolant Storage and Treatment System, system for treatment of recycled primary liquid effluent), 8TEU [LWPS] (Liquid Waste Processing System for non-recycled effluents) and TEG [GWPS] (Gaseous Waste Processing System). The TES [SWTS] (Solid Waste Treatment System) is a system for the management of solid wastes in the Nuclear Auxiliary Building and the 8TES [SWTS] is a system for the management of solid wastes in the Effluent Treatment Building. Further information on these waste treatment systems are provided in Sub-chapter 6.4 of the PCER (Reference 12). Other facilities in the Conventional Island deal with the management of non-radioactive wastes and effluents.
- An ILW Interim Store to store all ILW generated by reactor operations for up to 100 years after first fuel loading. Further information on the design choices of the store are provided in Sub-chapter 6.5, section 3, of the PCER (Reference 13).
- A Spent Fuel Interim Store to store all spent fuel assemblies generated by the reactor for up to 100 years prior to final disposal. The design of this store to provide adequate space and handling for safe operation and monitoring of the condition of spent fuel is described in Chapter 6.5, section 4, of the PCER (Reference 13).

Other ILW and Spent Fuel Interim Store options are presented in the SRWSR (Reference 1).

2. WASTE MANAGEMENT POLICY, ORGANISATION AND ARRANGEMENTS

2.1 NATIONAL REGULATORY CONTEXT

Responsibility for managing wastes on a nuclear licensed site in the UK is shared between the Government, the regulators and the waste producers/site licensee. The Government determines policy, giving consideration to relevant international agreements. The Government policy is currently enforced by the regulators and implemented by the licensees of the waste producing installation.

The main regulatory policies and principles relating to waste management which must be complied with are identified within this section. The principal statutory legislation that must be complied with are defined below and discussed in detail in Sub-chapter 1.4, section 3, of the PCER (Reference 14):

- The Health and Safety at Work Act 1974 (HSWA 74), which rests the duty with the licensee to comply with a range of safety requirements and protect both employees and members of the public from health and safety risks arising from its activities;
- The Nuclear Installations Act, 1965 (NIA 65), the purpose of which is to ensure the safety of nuclear installations by provision of a licence and ensuring compliance with licence condition definitions;

- The Ionising Radiation Regulations, 1999, governing the radiation exposure of the public and workers, ensures that radiation doses are ALARP;
- The Radioactive Substances Act 1993 (RSA 93), which regulates the keeping, use, accumulation and disposal of radioactive wastes, whether in gaseous, liquid or solid form;
- The Control of Pollution Act 1974 (CoPA 74) and The Environment Act 1995 (EA 95), requires an operator to obtain consents (from EA or SEPA) to discharge non-radioactive effluent and surface waters from the outfalls, into the sea. Such discharges are also controlled by these Agencies under the Water Resources Act 1991;
- The Environment Act 1995 (EA 95), which created the EA in England and Wales and SEPA in Scotland, amends CoPA 74 and the Environmental Protection Act 1990 (EPA 90), also amends the RSA 93 and provides a statutory framework for contaminated land;
- The Pollution Prevention and Control (England and Wales) Regulations 2000 (PPC 2000). This implements the EC Directive on Integrated Pollution Prevention and Control (96/61/EC) in the UK and applies an integrated environmental approach to the regulation of certain industrial activities (such as the operation of standby diesel generators) meaning that emissions to air, water (including discharges to the sewer) and land, plus a range of other environmental effects, must be considered together.
- The Waste Management Licensing Regulations 1994 (as amended) require that a licence is held by operators of sites that keep, treat or store waste. The Hazardous Waste Regulations 2005 implement the Hazardous Waste Directive (91/689/EEC) in the UK. The regulations identify which wastes are classed as hazardous, and control the movement and disposal of hazardous waste.

As of April 2008, separate regulation regimes for non-radioactive waste management and PPC activities were replaced, with both now being regulated by way of Environmental Permits issued under the Environmental Permitting Regulations 2007. Environmental Permits are issued by the Environment Agency and work to ensure that the authorised activities do not cause harm to the environment or endanger human health.

The management of radioactive waste on nuclear licensed sites is regulated by the Health and Safety Executive's (HSE) Nuclear Installations Inspectorate (NII) under the Nuclear Installations Act 1965 (as amended). The discharge and disposal of radioactive wastes in England and Wales is regulated by the Environment Agency (EA) under the Radioactive Substances Act 1993 and the EA grants Certificates of Authorisation under RSA 93. The NII grants a Nuclear Site Licence for each nuclear site under the Nuclear Installations Act, which sets out a number of conditions with which the licensee must comply, a number of which are of specific relevance to the management of radioactive waste. There is a Memorandum of Understanding between the NII and the EA that ensures co-operation and efficient regulation.

The development of UK policy on radioactive waste management has been an ongoing process since the start of the nuclear industry in the 1940s. The existing Government policy is set out in the Government White Paper, Review of Radioactive Waste Management Policy Cm2919, as amended (Reference 15). The fundamentals of the policy are that Government will maintain and continue to develop a policy and regulatory framework which will ensure that:

- Radioactive wastes are not unnecessarily created;
- Such wastes that are created are safely and appropriately managed and treated;

- They are then safely disposed of at appropriate times and in appropriate ways; so as to safeguard the interests of existing and future generations and the wider environment, and in a manner that commands public confidence and takes due account of costs.

In addition to this in 2007 the Government published a specific policy statement for the management of solid low level radioactive waste (LLW) which covers all aspects of the generation, management and regulation of solid LLW (Reference 16).

Government policy on the discharges of liquid and gaseous radioactive wastes is set out in the UK Strategy for Radioactive Discharges (Reference 17). This aims, in part, to deliver the UK's obligations under the OSPAR Radioactive Substances Strategy, in respect of progressive and substantial reductions in radioactive discharges. The objective of the OSPAR strategy is to prevent pollution of the maritime area covered by the OSPAR Convention (Convention for the Protection of the Marine Environment of the North-East Atlantic) from ionising radiation.

The Nuclear Decommissioning Authority (NDA) has been given the tasks of defining the radioactive waste management strategies for ILW and LLW and developing/implementing disposal options by Government in fulfilment of the relevant Government policy statements. The NDA's Radioactive Waste Management Directorate (NDA-RWMD) has an important role in setting the standards for the acceptability of higher activity radioactive wastes for final disposal in an anticipated national repository (known as the Geological Disposal Facility (GDF)) and in assessing proposed arrangements presented by the waste producers for meeting these standards through application of the Letter of Compliance (LoC) process. The EA's Nuclear Waste Assessment Team (NWAT) provides regulatory oversight of the work of NDA-RWMD on higher activity wastes.

The HSE, EA (and the Scottish Environmental Protection Agency) have jointly issued guidance on the management of higher activity radioactive waste on nuclear licensed sites, which for the EPR will include ILW and spent fuel (Reference 18). The guidance recommends the preparation of a Radioactive Waste Management Case (RWMC) which addresses the management of higher activity wastes throughout their lifecycle including long term safety and environmental issues such as storage and disposal.

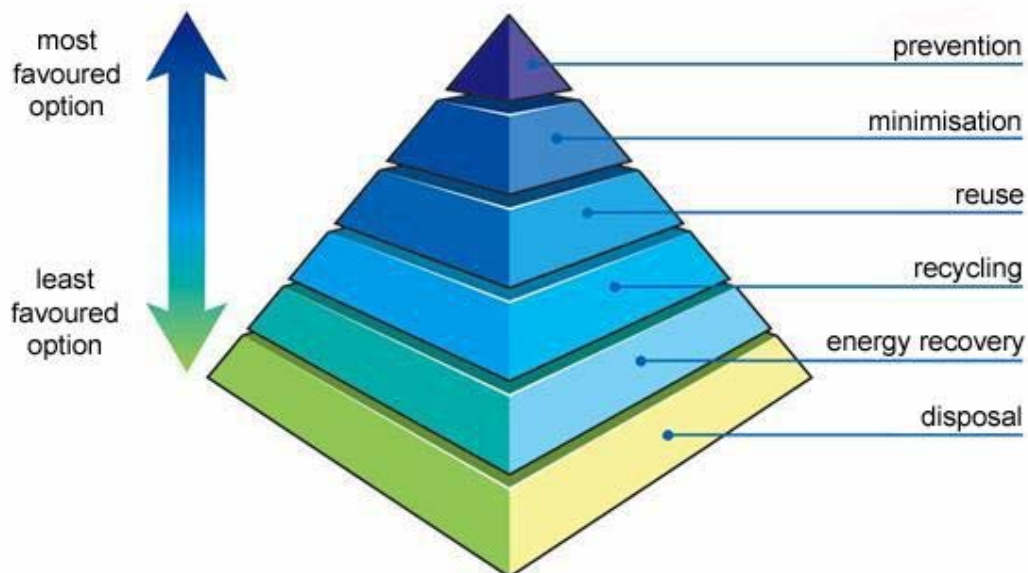
2.2 STATEMENT OF EDF AND AREVA'S POLICY AND PRINCIPLES

The construction and operation of an EPR power station will have an impact on the environment because of the use of natural resources and generation of wastes and discharges. It has been the policy during the design of the EPR to make an effort to minimise these impacts as far as possible consistent with sustainability principles. With respect to the environment and waste management, it is the policy of EDF/AREVA to show compliance with all environmental legal requirements in the EPR design and an improvement of the design's overall environmental performance compared to existing nuclear power stations.

All the organisations that have been involved in the design of the UK EPR, including sub-contractors, have been strongly committed to developing and maintaining a focus on good environmental practices and to ensure that the design does not adversely affect people or the environment. The waste management policy for the EPR design is based around implementation of the waste hierarchy. This requires avoidance of waste in the first instance and reducing as far as possible the volume requiring disposal once the waste has been produced. The waste hierarchy gives an order of preference for waste management options to minimise the volume for disposal, as shown in Figure 2. The main principles of the waste hierarchy are:

- Waste should be prevented or reduced at source as far as possible.

- Where waste cannot be prevented, waste materials or products should be reused directly or refurbished and then reused.
- Waste materials should be recycled or reprocessed into a form that allows them to be reclaimed as a secondary raw material.
- Where useful secondary materials cannot be reclaimed, the energy content of the waste should be recovered and used as a substitute for non-renewable energy resources.
- Only if waste cannot be prevented, reclaimed or recovered, should it be disposed of into the environment and this should only be undertaken in a controlled manner.

Figure 2: The Waste Hierarchy

Use of the waste hierarchy has been fundamental in the design of the EPR. This can be seen by comparison with the key environmental principles and policy objectives to be achieved by installations using Best Available Techniques (BAT) as set out in the IPPC Directive (Reference 19). This suggests that waste management strategy can be broken down into four key environmental principles, which are:

- The use of low-waste technology;
- The efficient use of resources;
- The prevention and reduction of the environmental impact of emissions; and
- The use of less hazardous substances.

Not every waste management practice can achieve all of these principles, but consideration of them against the EPR design shows how the design has tried to be optimised to reduce environmental impact.

Evolutionary design changes focused on environmental performance compared to existing French and German reactors, will achieve significant waste management improvements from the operation of an EPR. These include a significant reduction in radioactive liquid effluents from their elimination at source and optimisation of the treatment, storage and discharge of both gaseous and liquid effluents. Reductions of radioactive solid wastes are achieved by the plant layout and room zoning, combined with a detailed analysis of the operating procedures and waste inventory of existing power stations.

2.3 WASTE MANAGEMENT ORGANISATION

A detailed description of the whole UK EPR project organisation is given in Chapter 2 of the PCER (Reference 20). This outlines:

- the organisation for GDA project management;
- the main organisational arrangements made to control the construction of a new plant in accordance with the applicable standards and regulations.

All the organisations involved in the EPR design are aware of their environmental responsibilities, and leaders and managers are periodically trained and reminded of the potential environmental effects of their team's activities. Strong emphasis is also placed on the development of capabilities and the decision-making process associated with the activities carried out by the UK EPR teams and partners.

Managers at all levels are encouraged to develop strategies, policies, plans, systems, goals and standards for environmental protection and to ensure that these are applied throughout the whole organisation. A representative from the quality department of each of the co-applicant organisations is assigned to a team for the implementation and maintenance of Management System.

2.4 WASTE MANAGEMENT ARRANGEMENTS

During the design of the EPR and throughout the GDA process, Management Systems have been in place in each of the partners' organisations. Teams have been set up to ensure that Management Systems are adequately established, documented, maintained and continually improved. In addition, certification by certified bodies provides strong evidence of the compliance of the partners' organisations and activities with international laws, regulations and best practices. In particular, EDF, AREVA NP and AMEC all hold the ISO Standard 9001: 2008 Quality Management Systems - Requirements certification, also hold the ISO Standard 14001: 2004 (Environmental Management Systems – Requirements with guidance for use) certification. The arrangements in place in each organisation are described in detail Chapter 2 of the PCER (Reference 20).

The environmental management systems of the organisations involved in the design of the EPR have been routinely discussed during meetings and inspections as part of the GDA process. A clear and logical system for keeping records of data such as policies, roles and responsibilities, targets, procedures, results of audits or results of reviews is in place.

All technical reports undergo technical and language review by competent persons from the co-applicant organisations, and subcontractor if required, to check the accuracy, consistency and compliance with the project requirements. In addition, submission documents relating to safety and/or addressing specific UK design are transmitted for review to an Independent Nuclear Safety Assessor (INSA); submission documents relating to environment undergo an independent peer review (IPR). The INSA recommendations are analysed by a Design Safety Review Committee (DSRC) set up to offer advice to the UK EPR Project on whether the INSA recommendations should be followed or not. A decision is made and recorded by the Project on whether to follow the DSRC advice or not. For the environment submission, all IPR comments are reviewed and addressed as needed. The waste management practices and plant described in the PCER have been reviewed as part of this process with respect to the methodology adopted, the completeness of the justification presented, and the validity of the results.

3. FORMULATION OF INTEGRATED WASTE MANAGEMENT STRATEGY

3.1 INTRODUCTION

When developing waste management strategies there is a need to make trade-offs between the treatment of one waste form and the generation of other environmental impacts, such as increased arisings of other wastes or greater use of energy. To produce a truly optimised integrated waste management strategy for a nuclear power station requires not only consideration of the management of radioactive substances and the resulting radiation doses but also take account of safety considerations, security, wider environmental considerations (e.g. climate change) and social and economic considerations.

The key factor underpinning the formulation of the integrated waste management strategy is the EA's requirement that Best Available Techniques (BAT) be used to minimise the production and discharge or disposal of waste. The integrated waste management strategy for the EPR has been developed utilising the methodology described in the following sections.

For the ongoing application of BAT and optimisation of waste management strategies during the design of the EPR power station, EDF/AREVA has adopted an approach based on the statement in the latest BAT guidance consultation document (Reference 21) from the EA and that BAT is:

“broadly equivalent to Best Practicable Environmental Option (BPEO) plus Best Practicable Means (BPM), so that operators already meeting BPEO and BPM criteria are meeting or exceeding initial BAT criteria and should continue to follow existing processes”.

The concept and use of regulatory guidance for the demonstration of BPEO is mature and well established in the UK nuclear industry (Reference 22).

3.2 METHODOLOGY FOR STRATEGIC OPTIONS STUDIES

3.2.1 Methodology for identification of Best Available Techniques (BAT)

The methodology used for the evaluation of waste management options at the design stage of the EPR was based upon on a holistic approach with ambitious objectives in terms of nuclear safety, radiation protection and environmental performance. This involved a step-by-step approach by means of working groups, the “EPR environment” design review (2004), an action plan and task forces which identified the factors influencing environmental performance and further feasible improvements.

The assessment of strategic options was not undertaken in accordance with the methodology for BPEO studies set out in the EA’s regulatory guidance (Reference 22) by the EPR design team. There are a number of reasons why this methodology was not formally applied to the “Reference Case” EPR design, which include:

- The EPR design already exists and the “Reference Case” for the assessment of BAT is based on Flamanville 3;
- It is reasonable and appropriate to take full account of the review of operational experience and feedback which has enabled the identification and incorporation of a number of improvements and refinements into the EPR design in comparison with other PWRs operated by both EDF and others. Whilst the EPR is “new” within the context of the UK, its design is based on the “evolution” of the design of PWRs which are operated successfully throughout the world. There is extensive knowledge and experience, both inside and outside EDF/AREVA, which underpins the waste management practices incorporated into the EPR design. This is considered to provide a robust basis for the demonstration of BAT.
- Future operators are expected to require some flexibility with respect to the management of wastes to meet regulatory requirements on a site specific basis. It is recognised that some waste management issues will be site specific and that it is not possible at this time to fully identify the strategies that will be applied by operators at a specific location. As such the benefits of generic strategic option studies would be limited by the absence of site specific information which could affect the outcome of any assessments. If there are any significant changes in waste management strategy at the site specific stage then the demonstration of BAT would be reviewed as necessary. This will be the responsibility of future licensees to demonstrate to the regulators.

The approach taken to the selection of waste management options selection has taken the following factors into account:

- EDF/AREVA have used an optimisation approach that is consistent with and complies with the principles of BAT as set out in the IPPC Directive;
- The environmental performance of the EPR focuses on the prevention, i.e. the reduction of waste at source, which is the best way to minimise waste and discharges as identified in the waste hierarchy;
- As noted above, the EPR design has been developed using operational feedback from the accumulated experience of EDF and AREVA from numerous French and German plants. In particular, attention has been given to reducing the production of waste and liquid and gaseous discharges, together with reducing as far as possible the radiological impacts to the worker, public and the environment.

For each significant waste stream generated, the methodology used for the selection of a waste management strategy has allowed the determination of the means and management processes to minimise waste arisings and discharges from the power station as a whole rather than looking at each waste stream in isolation. This has allowed the expected performance and maximum discharges for the EPR to be determined for all wastes arisings, taking into account a full set of operational and safety considerations.

A fundamental principle of the BAT concept is that the best option available to achieve a high-level of protection of the environment taken as a whole should be chosen. However, as described in section 3.1, because the environmental impacts of nuclear power are not narrowly confined to radiological effects alone, strategies to achieve BAT must consider a wide range of factors. Fifteen optimisation factors which cover the full range of optimisation factors associated with nuclear installations as identified by the OECD (Reference 23) and which have been taken into account in the assessment of BAT in Sub-chapter 8.1 of the PCER (Reference 2), are shown in Figure 3. These underpin the four key environmental principles outlined in section 2.2 of this document.

Each single optimisation factor is not necessarily satisfied by every waste management strategy. However, compliance with several of these helps to demonstrate that the reactor design and waste management strategy is BAT. Some of the factors can be seen as conflicting with each other, so in making decisions on waste management strategies a judgement has to be made on what are the most important factors relating to the minimisation of the power station's environmental impact, for example, progressively reducing emissions whilst minimising the generation of solid radioactive waste produced.

When considering the options for treatment of individual waste streams, the preferred approach used for the EPR design involves consideration of the balance between gaseous and liquid discharges, and the generation of solid wastes, whilst favouring a strategy of 'concentrate and contain', as stated in the UK Radioactive Discharges Strategy (Reference 17). Final treatment choice results from consideration of the following: worker dose, practical feasibility of concentrating and containing all streams, BAT/ALARP principles and costs.

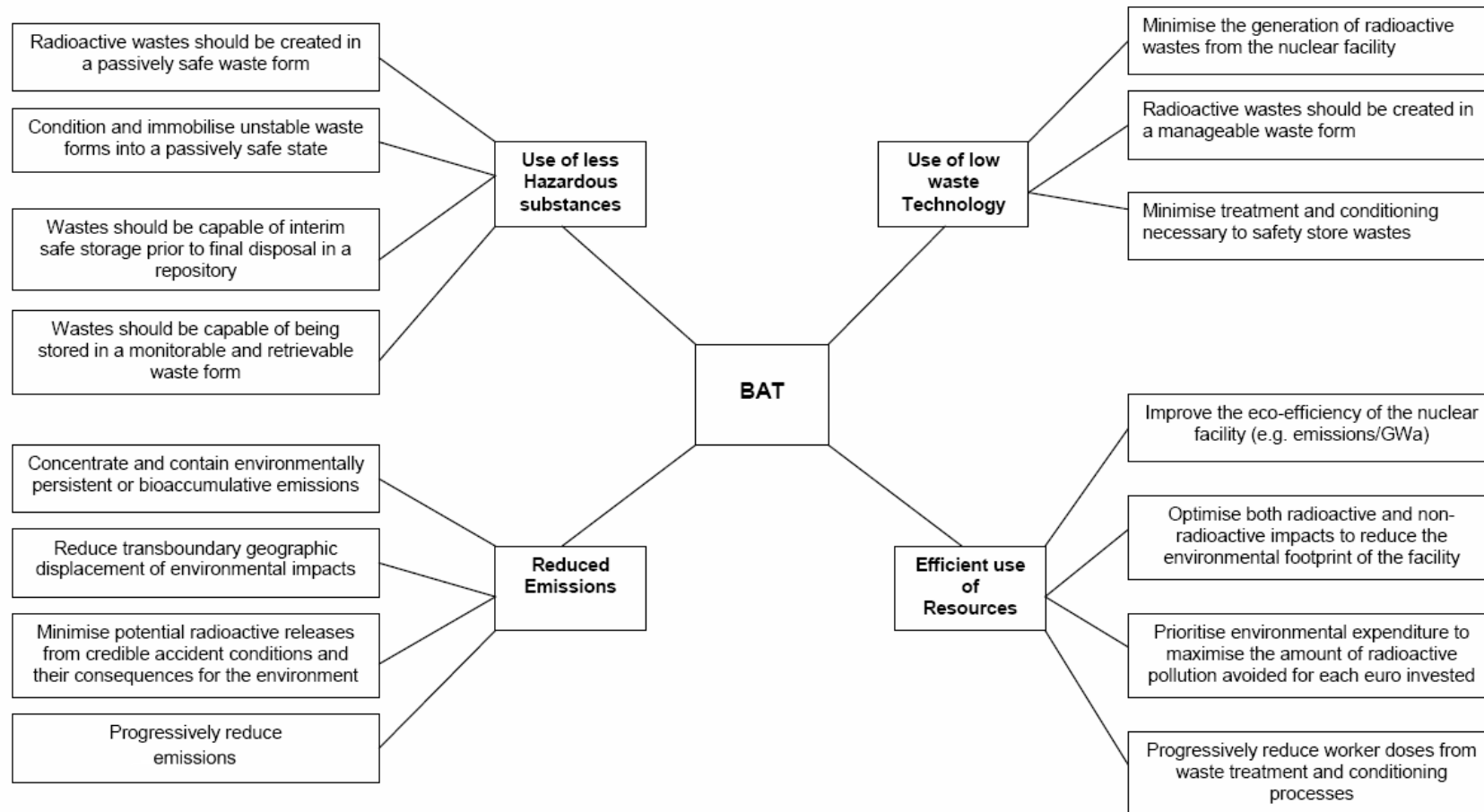
The methodology for the design of the EPR has allowed the determination of, for each significant waste stream generated:

- Design features, the means and management processes to minimise waste arisings and discharges;
- The setting of expected performances and maximum discharges.

This process has effectively implemented the Best Practicable Means (BPM) component of BAT. BPM is influenced by the implementation of the waste hierarchy, including source reduction, operational practices involving recycle and reuse and administrative controls of waste management optimisation.

As outlined in section 2.2 of this document, the waste hierarchy places a clear emphasis on planning and management to eliminate or avoid (if practicable) the generation of radioactive waste. Where it is not possible to eliminate arisings it is important to manage and dispose of the material in a careful manner so as to minimise releases to the environment as far as is practicable. When BPM was reviewed for the EPR waste management design, comparison of the potential management practices of existing 1300 MW(e) PWR power stations was made against any identified potential improvements in practices, in order to determine whether a change in practice represents BPM. The output of the review was used either as a justification for maintaining current practices or to identify required changes.

Figure 3: BAT Optimisation Factors for the Development of the UK EPR Design



Chapter 8 of the PCER (Reference 2) demonstrates the application of BAT standards and good practice in the design process for the EPR. In addition Reference 3 contains BAT forms for radionuclides, which have been identified as being significant with respect to limiting discharges and waste disposals from an EPR power station. The specific radionuclides have been selected on the basis of review of a number of issues, including half-life, magnitude in the source term and in discharges, contribution to radiation doses and whether the radionuclide is an indicator of plant performance. The BAT forms provide detailed information on:

- the source and physical/chemical forms of the radionuclide;
- the source term;
- the techniques used to minimise at source;
- the impact of the use of these techniques in terms of minimising the source term;
- options for preventing or minimising discharges to the environment and how preferred management options were selected;
- the waste treatment techniques used to prevent, minimise and render harmless the discharges from the plant.

These forms provide detailed evidence that the optimisation approach complies with the principle of BAT.

In summary, the optimisation approach applied by EDF/AREVA in the design of the EPR complies with the principles of BAT set out in the IPPC Directive for individual radionuclides, for individual waste streams and for the design as a whole. This provides the basis for the integrated waste management strategy.

3.3 WASTE MANAGEMENT CONSTRAINTS AND DEPENDENCIES

3.3.1 Regulatory Constraints and Dependencies

The UK regulatory framework for the management of waste and special nuclear materials is complex, with a myriad of legislation and policy covering solid radioactive waste and radioactive discharges, general waste management, decommissioning, sustainable development, health and safety, and security. There are a number of regulatory constraints that affect waste management on an EPR power station and which are taken into account in the UK EPR design; these are presented in section 2.1 of this document and also in Reference 14.

The EPR power station design has been heavily influenced by the development of French/German policy and regulation. In particular, radioactive discharges under normal operating conditions have been subject to the setting of initial expectations and the specification of safety requirements by the French and German nuclear safety authorities. French national regulations for the management of radioactive waste require that the environment should be protected against the effects of discharges and that the environmental site-specific characteristics should be taken into account in the limitation of discharges. Objectives are stated in letters from the French Nuclear Regulatory Agency (ASN) (Reference 24) which place emphasis on radioactive discharges and waste activity:

“...ensure that the Preliminary Safety Report presents quantitative objectives regarding the reduction of the activity and volume of radioactive waste and effluents within the scope of a global optimisation process ... and ... describe the measures adopted to achieve these objectives”.

“Another objective, based on operating experience feedback, is to take into account operating constraints since the design stage ... so as to limit radioactive releases and the quantity and activity of the waste produced”.

To progress these objectives, an optimisation and experience feedback process has been applied to the following areas: specification of materials, primary coolant chemistry, reduction of corrosion deposits, treatment of liquid and gaseous radioactive effluents and solid radioactive waste.

In addition to the objectives described above, the EPR has been designed to comply with the more general French regulations for nuclear installations and the protection of the environment. These regulations aim to reduce the impact of discharges and nuisances incurred by industrial activities and, therefore, protect both populations and the environment. They are consistent with UK regulation for the same purposes.

3.3.2 Financial Constraints and Dependencies

The operator of any new nuclear power station in the UK will be required by law to have secure financing arrangements in place to meet the full costs of decommissioning and their full share of waste management costs. This is to ensure that despite any changes in for instance, energy prices or the cost of materials, these liabilities do not end up having to be covered by the Government, and is achieved by having in place a Funded Decommissioning Programme (FDP). This has to be approved by the Secretary of State for Energy and Climate Change, before construction of the new power station begins and compliance with this programme thereafter. The UK EPR GDA documentation, supported by this IWS, will assist operators in producing their Decommissioning and Waste Management Plan (DWMP) on which a station's FDP is based.

3.3.3 Timing Constraints and Dependencies

The EPR lifecycle is focussed around a 60-year operational period. During this period, waste will be processed on a continuous basis. The strategy for the management of LLW outlined in the EPR GDA submission relies on the transfer of the waste to the LLWR for disposal as it arises. The LLWR has a current estimated lifetime shorter than the operation of a new EPR. It is assumed that as stated in Government policy (Reference 16), a new similar disposal facility will be provided by the NDA after the LLWR has ceased to receive waste. If the new disposal facility is not provided at the required time, this will force the station to implement appropriate storage on site until it becomes available. However the EPR design incorporates a buffer zone in the Effluent Treatment Building.

The disposal of ILW from an EPR in the UK is dependent on the construction of a national Geological Disposal Facility (GDF) and the timing of it being able to receive waste from the EPR. Because of the extended timescales and the uncertainties involved, the station will have the capability to store ILW for 100 years after the first waste is put into store. As part of the FDP, there is an agreed schedule for the Government to take title to and liability for the waste if the construction of GDF is not complete and ready to accept the waste at the agreed scheduled date. In these circumstances the Government would have to provide waste management services for further interim storage of the waste on site, transport to the geological disposal facility and decommissioning of the interim store.

In its Nuclear White Paper (Reference 25), the Government stated that any new nuclear power stations should proceed on the basis that spent fuel will not be reprocessed. The UK EPR design allows for spent fuel to be stored in an on-site fuel store designed to accommodate the station's lifetime arisings pending the availability of a GDF. The interim storage facilities provided by the station will be safe and secure, and designed so that they are technically capable of being maintained or replaced to last for at least 100 years from the time when spent fuel is first emplaced in them. Wastes arising from the operation of the spent fuel store will require appropriate management as for similar wastes produced by the operation of the station.

3.3.4 Sustainability Constraints and Dependencies

Sustainable development is taken into account in the development of waste management strategies for the EPR as recommended in the Environment Agency's draft Radioactive Substances Regulation Environmental Principles (Reference 21). All option studies undertaken as part of the design process considered the implications of strategies on future generations. This covered optimising the use of resources, including waste disposal facilities, and applying the waste hierarchy. The EPR is designed to minimise waste arisings and impact on the environment so that there is no undue burden on future generations. The financial arrangements to be made under the FDP ensure that all waste and decommissioning liabilities are covered by a programme which can be implemented and has secured financing underwritten by the Government.

3.3.5 Other Constraints and Dependencies

The EPR power station is dependent on the availability of suitable waste disposal routes, both for radioactive and non-radioactive wastes. Where disposal routes are available, such as for LLW and hazardous waste, disposal of wastes from the station can be progressed. However where these are not available at present, such as for ILW and spent fuel, suitable storage arrangements for the wastes have to be provided on the station.

In line with the Government's LLW policy (Reference 16), it is assumed that a Very Low Level Waste (VLLW) disposal route of controlled burial to landfill will be available in the future and provide a viable management option for a range of EPR waste streams, particularly those arising from decommissioning. If not available, these wastes will have to be disposed of as LLW, which will increase costs and put an added burden providing adequate UK disposal capacity for this type of waste.

To assist in implementing a strategy of waste minimisation of LLW and hazardous wastes, the UK EPR design strategy is for appropriate wastes to be transferred off-site for incineration. Until these wastes are produced and can be fully characterised it cannot be guaranteed that they will meet the acceptance criteria of existing incineration facilities. However, pursuit of the strategy of incineration is aligned with the emerging National Low Level Waste Strategy to minimise disposals to the LLWR, it is used widely abroad and is already being used in the UK by the Sizewell B PWR (and other nuclear licensees).

3.4 ASSUMPTIONS, RISKS AND OPPORTUNITIES

It is assumed that new nuclear power stations will be built in the UK and all the disposal routes discussed above will be available within the timescales required by a new station, as given in the base case assumptions that the Government have given for operators to develop their Decommissioning and Waste Management Plans (References 25, 26 and 27). If this is not the case it poses a risk to the operation of the power station, if appropriate on-site storage or other solutions for management of the wastes cannot be found. A number of specific assumptions and risks are presented in Table 1. A set of detailed assumptions are also contained in section 10.2 of the SRWSR (Reference 1).

Table 1: Assumptions and risks relating to waste management

Assumptions	Reasoning and Impact on Integrated Waste Strategy/GDA design
Spent fuel will be declared as waste and will not be reprocessed.	<p>This assumption is set out in UK Government policy as described in the White paper on new nuclear build.</p> <p>The design of the EPR takes account of the need for appropriate storage capacity for spent fuel for the lifetime of the station.</p>
Spent fuel will be stored on site followed by disposal of to the proposed Geological Disposal Facility (GDF) at the appropriate time.	<p>This assumption is set out in UK Government policy. Spent fuel will be stored and packaged/conditioned on the site by means which will enable it to be disposed of to the GDF. As the timing of the availability of the GDF is not known sufficient storage capacity is incorporated in the design of the EPR to store all arisings of spent fuel over the lifetime of the station. The management of spent fuel over its lifecycle is described in a range of supporting documentation which is referenced in the Radioactive Waste Management Case (RWMC).</p>
ILW will be stored on site until the GDF is available for its disposal.	<p>In the UK ILW is normally stored on the sites at which it arises as there are no alternative storage locations. The design of the EPR incorporates sufficient storage capacity for ILW arisings over the design lifetime. The management of ILW over its lifecycle is described in a range of supporting documentation which is referenced in the Radioactive Waste Management Case (RWMC).</p>
ILW and spent fuel can be conditioned and packaged into forms which meet the standards required by NDA-RWMD for disposal at the proposed GDF.	<p>The GDF is the only envisaged disposal route for ILW and spent fuel in the UK and is based on UK waste management policy. The design of the EPR incorporates the necessary processing capacity (and capacity for storage of packaged and conditioned wastes) for spent fuel and ILW. A key part of the waste strategy is the programme for obtaining the necessary Letters of Compliance (LoC) for packaging and conditioning of wastes at an early stage to ensure both certainty in waste disposal costs and that the processing capacity will be fit for purpose in producing wastes that can be disposed of in the GDF. These aspects are dealt with in supporting documentation which is referenced in the Radioactive Waste Management Case (RWMC) for the EPR, including the PCER.</p>

Table 1: Assumptions and risks relating to waste management (continued)

Assumptions	Reasoning and Impact on Integrated Waste Strategy/GDA design
<p>Authorised disposal routes for LLW will be available throughout the design life.</p>	<p>This assumption is based on review of UK LLW policy and strategy. This assumption means that capacity for long term storage of large volumes of LLW on site is not required in the design of the EPR. Sufficient short term storage capacity has been allowed in the design, based on the waste estimates based on operational experience at reactors across Europe.</p>
<p>Appropriate radioactive wastes can be disposed of by incineration.</p>	<p>A number of radioactive wastes arising from nuclear power operations are already disposed of by incineration both in the UK and elsewhere in Europe. The strategy takes account of the need to ensure that wastes meet the conditions for acceptance for incineration routes in the UK. It is noted that wastes from Sizewell B are already disposed of by incineration in the UK.</p>
<p>A VLLW disposal route will be available during the design life.</p>	<p>This is based on the UK LLW strategy. Availability of a disposal route for VLLW will reduce waste disposal costs and enable more effective segregation of radioactive wastes, thereby minimising future LLW disposals.</p>
<p>Waste volume estimates are based on the EPR reference case.</p>	<p>These estimates determine the design capacity for waste storage and processing facilities for the design. They are based on extensive review of PWR operating experience for EDF stations in France and more widely across Europe and take account of best practice in PWR operation.</p>
<p>Risks</p>	<p>Impact on strategy and potential mitigation measures</p>
<p>Waste arisings are higher than estimated.</p>	<p>This risk will arise beyond the GDA stage. Realisation of this risk could result in a requirement for additional storage capacity. The waste estimates produced for the reference case for the GDA are considered to be robust, as they are based on extensive review of PWR operating experience. The application of minimisation at source and review of operating experience in developing the waste estimates for the EPR design are of benefit in mitigating this risk. However it is noted that the generation and management of future waste arisings will be the responsibility of the licensee.</p>

Table 1: Assumptions and risks relating to waste management (continued)

Assumptions	Reasoning and Impact on Integrated Waste Strategy/GDA design
Loss of an authorised disposal route (e.g. incineration or VLLW)	This could result in higher than estimated waste disposal costs and in a requirement for additional storage capacity pending availability of an alternative route. This risk is mitigated by ensuring that a range of routes are available and that a watching brief on waste disposal routes is maintained. For example a fallback strategy for the loss of incineration would be to dispose of waste to the LLWR. Again this is a risk that will arise beyond the GDA stage and it will be for the licensee to address this risk should it occur.

In terms of opportunities, the waste treatment market is currently recognised as being dynamic and may be even more so in the future. The market could make available a range of on and off-site treatment options and also the possibility of sending waste overseas for processing (e.g. metals for recycling). The EPR GDA submission is based on waste treatment processes currently considered to be available. Consideration of the use of any future management strategies will be considered by the operator when they become available and can be clearly justified.

3.5 STAKEHOLDER ENGAGEMENT

EDF/AREVA recognises the importance of engaging with both internal and external stakeholders on environmental and waste management issues related to environmental and waste management issues associated with the EPR design. It is appreciated that only by working closely with Stakeholders, the optimum solution for current and future generations, locally, nationally and globally can be secured.

Dialogue between EDF, AREVA, UK Regulators and potential waste service providers is ongoing. This communication was established and is maintained to agree the potential means of disposing of the UK EPR radioactive waste streams through established routes and those future disposal routes being implemented by the UK Government (e.g. the Geological Disposal Facility). It also considers treatment and disposal of non-radioactive waste streams. There is an Interface Protocol document (Reference 28) that EDF/AREVA NP and the Regulators follow with respect to their communications with each other throughout the GDA process.

The EPR design team recognises that good communication and transparency in the development of waste management plans are central to ensuring the successful implementation of these strategies. Where stakeholders understand the decision making process and a mechanism is put in place to allow individuals perspective and priorities to be fed into the process there is a higher chance that strategies are likely to be accepted. It is on this basis that EDF/AREVA have fully supported the UK regulators in making GDA design submission information readily available to interested parties on the UK Nuclear Regulators’ New Reactors Assessment website (Reference 29) and in producing their own website (Reference 30) which allows the public to be kept up-to-date with GDA submissions.

4. OVERVIEW OF APPROACH TO WASTE MANAGEMENT STRATEGY

4.1 INTRODUCTION

This section on the overview of approach to waste management strategy describes the guiding principles used in the EPR design to manage both radioactive and non-radioactive wastes, before discussion of waste stream specific strategies in section 5.

4.2 RADIOACTIVE WASTE

The following key elements form the strategic approach that has been taken for the management of radioactive waste on the EPR. The text in italics provides information on how the key elements are incorporated into the waste management strategy.

- (i) To maintain radiation doses to the workforce and the general public from radioactive waste management operations, including disposal, within legal limits and As Low As Reasonably Practicable (ALARP).

Safety is be given the foremost priority, and the ALARP principle is the fundamental principle against which the adequacy of safety provisions, including those relating to waste management, has been assessed.

- (ii) To maintain the Radioactive Waste Management Strategy to ensure that it is consistent with Government Policy, regulatory constraints, the availability of radioactive waste storage and disposal facilities, advances in waste management technologies and any internal changes in operating conditions.

During the design process waste management strategies have been subjected to periodic review and revision as necessary to ensure that they are consistent with UK Government policy, regulatory requirements, the availability of radioactive waste storage and disposal facilities, advances in waste management technologies and any internal changes in reactor design.

- (iii) To minimise the generation of radioactive wastes as far as is reasonably practicable.

This is consistent with the general principles of Government policy and regulatory guidelines. Waste minimisation has been taken into account in the application of the ALARP process applied to the selected waste management strategies for the management of radioactive gaseous and liquid effluent discharges to the environment. The waste management strategy for a new EPR power station will be based on implementation of the waste hierarchy, taking account of care for the environment and ensuring that BAT (BPEO and BPM) is used to ensure solid waste arisings from the management of discharges are optimised.

- (iv) To dispose of all wastes as soon as practicable where a safe and economic route has been established.

This is consistent with UK Government policy that early disposal of radioactive waste is preferred to storage. For existing power stations, apart from routine discharges of liquid and gaseous wastes to the environment after treatment, the only disposal route currently available is for LLW. The majority of LLW is disposed of at the national Low Level Waste Repository (LLWR) near surface disposal facility with a small quantity being transferred by approved routes for incineration. The new EPR power station will follow the same strategy, unless clear justifiable reasons can be given for not pursuing the early disposal of LLW. The EPR will use VLLW and ILW disposal routes as and when they become available.

- (v) To store safely all wastes for which a safe and economic disposal route has yet to be established.

As far as practicable, treatment of waste for storage should not preclude a future disposal option. This is consistent with the NII Guidance for Inspectors, which states that "Radioactive material and radioactive wastes should be managed in a manner which minimises the need for future processing, and that is compatible with anticipated facilities for ultimate disposal or, in the case of radioactive materials, its end-use. The strategies ensure that waste management problems, which cannot be resolved using current techniques or techniques which could be derived from current lines of development, are not created".

- (vi) To have adequate safety cases for all waste management activities including handling, accumulation and storage of wastes on site.

These are required to demonstrate for the GDA that all the site licence conditions for managing radioactive wastes on an EPR station site can be met and the wastes managed safely.

- (vii) To co-operate with other UK waste producers on radioactive waste policy and strategy issues, and manage major stakeholder relationships effectively.

EDF/AREVA participate in several industry groups, and maintain a view of policy and strategy developments through responses to Government consultations, interfaces with other waste producers and attendance at relevant industry forums, seminars and workshops.

4.3 NON-RADIOACTIVE WASTES

Management strategies are given in the UK EPR GDA submission for the control and discharge or disposal of all non-radioactive solid, liquid and gaseous wastes from an EPR power station. As a minimum, the techniques and good practices proposed to reduce the impacts of the EPR will be compliant with EA requirements and regulatory guidance notes. In general, they involve:

- Waste management practices that take into account personnel safety, environmental protection and planning authority requirements whilst seeking to minimise any accrual of on-site waste accumulations.
- Non-radioactive wastes will be managed in accordance with the waste hierarchy; waste reduction will be a key element of waste control, for all waste forms. Wherever possible, non-radioactive waste will be source segregated and treated to maximise recycling and recovery, thus minimising the quantity of waste destined for disposal.

- Release of potentially harmful materials to ground will be prevented, suitable storage areas for wastes will be provided which will minimise or prevent leaks and spills from contaminating the ground.

In order to comply with the requirements of the Environmental Permitting Regulations, an appropriate site permit and registrations will need to be obtained from the regulatory authorities for any EPR constructed. These may include Hazardous Waste registrations. The production of wastes on an EPR power station will be an inevitable consequence of the construction of a power station and operation and management of the site, however, the design will facilitate reducing arisings at the point of origin, including through the careful choice of raw materials. This is discussed for the operational phase of an EPR in Chapter 3 of the PCER (Reference 31) and for the construction phase in Chapter 4 of the PCER (Reference 32).

5. INTEGRATED WASTE MANAGEMENT STRATEGY

The following sections summarises the strategy for specific groups of radioactive and non-radioactive waste and provides an overview inventory of waste arising from the construction, operation and decommissioning of a station based on the “Reference Case” UK EPR. These sections do not take into account waste management options for other utilities which are described in the SRWSR (Reference 1).

By integrating the waste management strategies for all the different waste streams produced by an EPR power station in one document, it allows for the bigger picture to be observed, thereby allowing common waste issues to be addressed and important problems, such as the management of different waste streams interfering with each other, to be identified and resolved.

5.1 CONSTRUCTION WASTES

A description of the various activities that take place during the EPR construction phase in PCER Sub-chapter 4.2 and PCER Sub-chapter 4.3 focuses on the aspects of the construction phase that have a bearing on the terrestrial and aquatic environments respectively (Reference 32); i.e. the interface of the plant construction, erection and commissioning with the environment in terms of needs and outputs that might impact the existing environment. In particular water abstraction, discharge of contaminants and the non-radioactive waste strategy are highlighted. Excavation spoil will be one of the main sources of waste during construction. The impact this will have on the environment will be site specific.

The data presented in the PCER are those related to the EPR Flamanville 3 construction. Data concerning the site preparation works (such as volumes of soil and rocks to be excavated, volumes of soil substitution by weak concrete, water pumped from seepage, water intake and discharge structures) is given for illustration purposes, since the figures will be highly site specific. Data concerning the EPR buildings construction and commissioning tests may be regarded as representative for the UK EPR.

PCER Sub-chapter 4.3 (Reference 32) also mentions where applications for environmental permits and other consents may be necessary, under UK or local regulations.

Assessment of the impacts on the overall site environment is addressed in PCER Chapter 12 (Reference 9).

5.1.1 Solid Construction Wastes

During construction a wide range of wastes will arise in addition to excavation spoil, which include:

- Packaging;
- Chemicals (material coating, surface treatment) and chemical containers;
- Off spec raw material (wood, plastics, metals).

Excavation of the site, including rock crushing and concrete manufacturing, will lead to the production of dust and other particulates. Demolition of any existing buildings will also contribute to the production of dust.

5.1.2 Liquid Construction Wastes

During construction, chemicals discharged to the sea fall into two categories:

- Discharges associated with the preparatory works and the main building erection and the presence of construction staff on site, which may contain suspended solids or hydrocarbons.
- Discharges associated with the commissioning tests, which involve other chemicals (boron, phosphates, iron, morpholine, bromoform and oxidants) required for or arising from commissioning of the EPR.

Effluent collected from the construction process and discharged to the sea include rainwater and grey and black wastewater collected at the outlet to purification stations.

Commissioning tests will utilise demineralised water. The volume of demineralised water needed for the EPR commissioning tests is estimated to be 72,500 m³.

5.1.3 Gaseous Construction Wastes

During commissioning (testing), insulation surrounding the equipment and hot piping undergoes thermal decomposition during the first time that the temperature rises, and this releases formaldehyde vapour into the reactor building. This decomposition may also result in the formation of carbon monoxide.

5.2 OPERATIONAL RADIOACTIVE WASTES

Operational radioactive waste streams from an EPR power station are considered under three main headings:

- solid waste (including mobile wastes; such as ion exchange resins and sludges from liquid effluent treatment);
- liquid waste; and
- gaseous wastes.

As described in Sections 3.2 and 4.2 of this document, the EPR management strategy for radioactive wastes is based on implementation of the waste hierarchy, taking account of care for the environment and ensuring that BAT (BPEO and BPM) is used to ensure solid waste arisings from the management of discharges are optimised. This is undertaken and balanced across the three waste headings listed above through utilisation of the principles of 'concentrate and contain' and 'delay and decay'.

5.2.1 Solid Wastes

Solid waste will be disposed of as soon as practicable where an appropriate disposal route is available. Waste for which there is no available disposal route will be accumulated and stored as appropriate pending the availability of a disposal route. The ultimate disposal of the waste can follow one of three main routes depending on the radioactivity level of the waste produced:

1. Landfill for Very Low Level Waste (VLLW) disposal.
2. Low Level Waste Repository (LLWR) for Low Level Waste (LLW).
3. Geological Disposal Facility for higher activity wastes (ILW and spent fuel).

Packaging of the waste will be required to meet either the Letter of Compliance (LoC) requirements of the NDA Radioactive Waste Management Directorate (RWMD) if they are ILW or spent fuels or the LLWR CfA if they are VLLW or LLW. Achieving these requirements is discussed in PCER Sub-chapter 6.5 (Reference 13).

The volume of solid radioactive waste produced by the station depends on the future management of the various systems by the operator. Table 2 provides, by volume, the annual estimated production of raw waste (prior to conditioning) for each type of waste for one EPR Unit as predicted in the UK EPR GDA submission. This volume estimate is based on review of the best recent historic performance of existing French nuclear reactors of similar power rating to the EPR, in terms of waste arisings. It is considered to provide a robust basis for the estimate.

Based on review of waste arisings across the whole PWR fleet in France it is anticipated that the rate of arisings of most wastes will be largely independent of the age of the plant. Annual arisings would thus not be expected to increase significantly as the plant ages, with the exception of dry active wastes which arise as a result of maintenance programme and major outages. This information is of benefit in supporting the estimates in the design for waste storage capacity.

It is noted that for some waste streams the volumes relate mainly to the design of the reactor (e.g. spent ion exchangers or filters) while the volume of other wastes (e.g. used personal protective equipment or wastes arising from maintenance operations) relate mainly to the practices and procedures to be applied by the operator. The quantitative impact of measures to minimise waste arisings such as recycling and reuse, beyond those already incorporated in the design, is considered to be primarily an operational issue and is largely outside the scope of the integrated waste strategy for the GDA. However, the design of the EPR incorporates a number of measures aimed at minimising solid wastes by facilitating the segregation and volume reduction of solid wastes, taking account of review of the performance and operating experience of existing reactors. Examples include:

- Control of the source term to minimise corrosion products which contribute to solid waste arisings;
- Improved efficiency of recycling (e.g. coolant) and effluent processing systems to reduce solid waste volumes associated with the treatment of coolant and effluents;

- Optimisation of the “zoning” of rooms and controlled areas to maximise the segregation of radioactive and non-radioactive wastes and thus minimise radioactive waste arisings.
- Facilities to segregate wastes and reduce volumes in the Effluent Treatment Building prior to consignment of wastes from the controlled area.

Further information is provided in Sub-chapter 6.3 of the PCER (section 3.1 of Reference 33).

By consideration of the proposed management strategies for the different waste streams, as shown in Figure 4, the distribution of LLW and ILW in terms of the volume of packages to be disposed of or to be stored per year has been estimated and is also shown in Table 2 (taken from section 3.2 of Reference 33). Some ILW will decay during interim storage on site into LLW which could potentially be disposed of at LLWR. Some of the LLW packages included in the LLW volume could potentially be disposed of as VLLW.

Table 2: Estimated annual volumes of solid radioactive wastes produced during operation of a single EPR Unit showing the distribution of ILW and LLW

	Type of waste	Estimated gross annual volume (m ³)	Volume of final packages (m ³)	Route (%) at generation time	
				ILW	LLW
Process Waste	Ion-exchange resins from the nuclear island	3	15.5	100%	
	Low activity APG [SGBS] ion-exchange resins (without regeneration)	7.5	0.3		100%
	Wet sludge (sumps, tanks)	1	3.2	49%	
			4.8		51%
	Water filters from effluent treatment	5	11.4	100%	
			12	98%	
		0.2			2%
Evaporator concentrates	3	0			
Non-compactable air and water filters (85%/15%)	4	5.5		100%	
Operational waste	Pre-compactable operational waste (apparent density. 0.5) and non compactable: maintenance (excluding metals), rubble, decontamination operations, insulation	50	11.4		100%
			3.8		100%
	Oils (and solvents)	2	0		
	Metal waste from maintenance (Scraps)	6	0.5		100%
	Other Operational waste	1	4.1	93%	
0				7%	
TOTAL		82.5 m³	71 m³	46.2 m³	24.5 m³

The following strategies are used for the management of each reference case solid radioactive waste stream to achieve the packaging and ultimate disposals described. They are discussed in more detail in PCER Sub-chapter 8.2 (Reference 2). It may be noted that there is not an exact correspondence between the types of wastes described in Table 2 and the descriptions of the waste streams below. Dry Active Wastes (DAW) corresponds to operational wastes.

PROCESS WASTES

1. IER (Ion-Exchange Resins)

These wastes are classified as ILW. Ion-exchangers resins are embedded in a polymer matrix (epoxy). Mobile units will be used for the conditioning. Polymer matrices and more particularly epoxy matrix have been selected as the waste management strategy because of the excellent behaviour of the final package with respect to containment and ageing requirements. A cement matrix may be considered as an alternative if this is required to meet either NDA RWMD or LLWR LoC requirements.

2. Steam generator blowdown ion exchange resins

These are very low level wastes (average mass activity < 10 Bq/g) which are where possible disposed of by controlled burial to landfill as VLLW or otherwise shipped to the LLW. Minimisation of the volume of waste disposed of to the LLWR is achieved by mixing them with other wastes with greater voidage (pipes, rubbles etc) or volume reduction by incineration.

3. Wet sludges (sumps and tanks)

Sludges are expected to be classified as both LLW and ILW with approximately 50% of the volume in each category. Sludges are transferred by pump into a concrete container or a metallic drum (depending on their radioactivity levels) and then mixed with mortar (cement and sand) and as necessary the addition of slaked lime to inhibit the retarding effect of boron and zinc on the mixture hardness so that the package meets LoC requirements for ILW as necessary. LLW sludges will be packaged to meet the CfA for LLWR.

4. Primary circuit water filters from effluent treatment (Dose rate > 2 mSv/h)

These wastes are predominantly classified as ILW. Water filters are withdrawn from operation on the basis of clogging and/or dose rate. They are removed from the circuits via a lead shielded cask. They are "laid" into a concrete container pre-equipped with biological protections if needed and placed in a shielded cell. The filters are then capped by mortar and sealed. The wastes will be packaged to meet LoC requirements for ILW.

5. Evaporator concentrates

Evaporator concentrates which contain on average 40,000 parts per million of boron and a total salinity of 300 g/L, are liable to crystallise. In France they were initially mixed with a mortar inside concrete containers but since 2001 they have been incinerated. There is uncertainty as to whether the incineration management option will be available in the UK for this waste stream, so the fall back option of encapsulation in cement and disposal as solid waste to the LLWR is being kept open.

6. Liquid effluent filters and air filters (Dose rate < 2mSv/h)

Air filters (pre-filters, absolute filters, iodine traps) and lower dose rate water filters are dismantled (separation of metallic frames from other parts) or shredded and put inside metallic drums. Water filters with plastic frames are incinerated and air filters, of which the average mass activities are typically a few Bq/g, are shipped for high-force compaction followed by disposal to the LLWR.

OPERATIONAL WASTES**7. Dry Active Waste (DAW) (Dose rate > 2 mSv/h)**

These wastes are ILW and are conditioned in concrete containers prior to on-site storage and eventual disposal to the GDF. This type of waste will include highly activated core components, such as those associated with reactor control rods. These wastes will be packaged to meet LoC requirements.

8. Dry Active Waste (DAW) (Dose rate < 2 mSv/h) and liquids

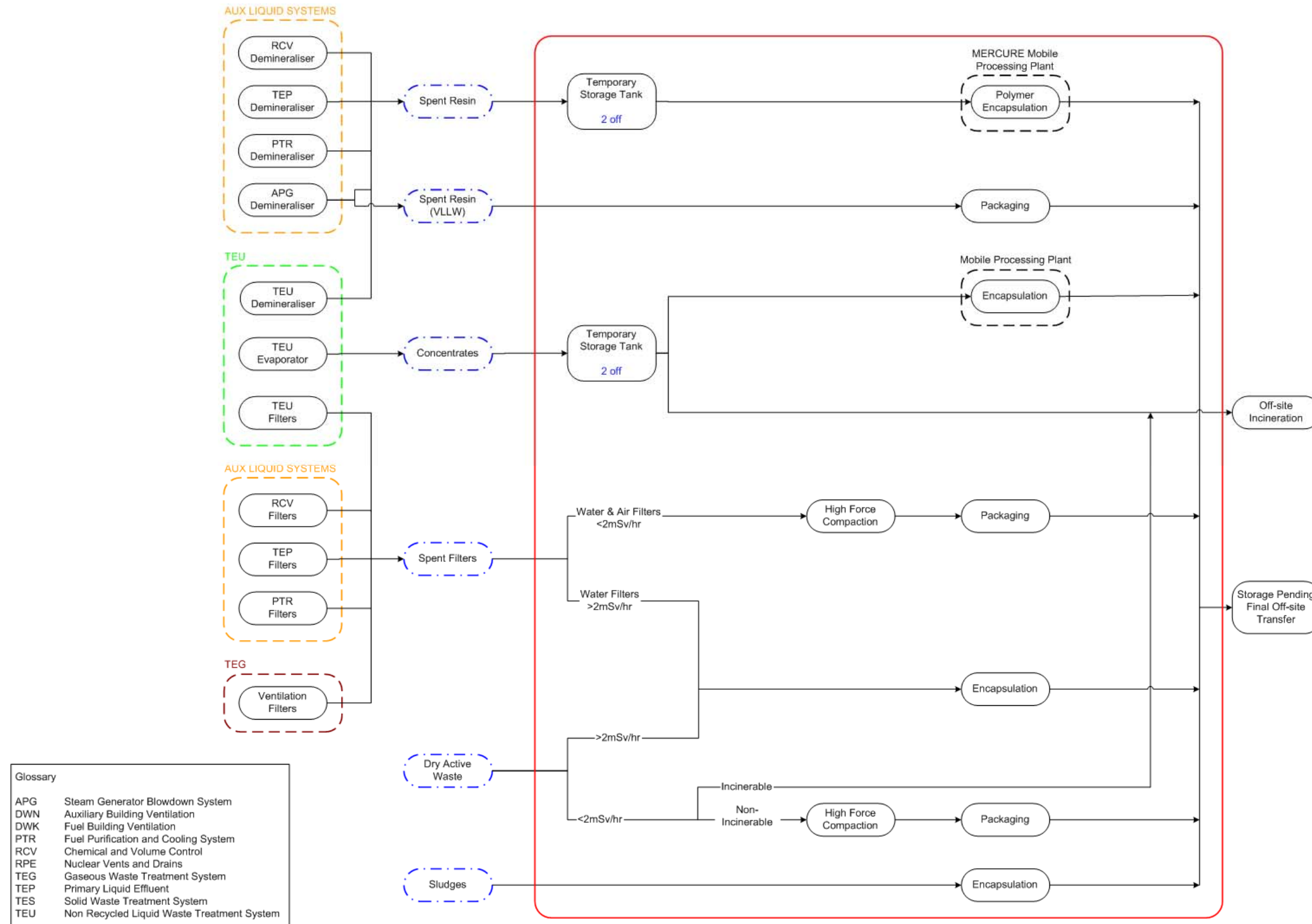
The combustible part of these wastes (80 weight % of the overall DAW) and liquids (oils, solvents, chemical cleaning solutions and decontamination solutions) are incinerated. Plastic drums are used where possible for DAW because of easier incineration processing and minimisation of residues in comparison with the use of metallic drums.

The non combustible portion of these wastes (insulators, rubble, air filters) is compacted in metallic drums on site; then the drums are shipped for high-force compaction prior to sentencing to the LLWR.

9. Scraps and other metallic wastes (Dose rate < 2 mSv/h)

Scraps are generally cut down to sizes to be accepted by the Metal Recycling Facility at Lillyhall. Ingots produced are disposed of depending on the final activity content achieved. However, the main goal is to recycle the materials where practicable. The strategy of recycling is of benefit in minimising the volume of waste to be disposed of the LLWR and recycling is higher in the waste hierarchy than disposal.

Figure 4: Solid Waste Management System Flowsheet



5.2.2 Liquid Radioactive Wastes

The strategy for the management of liquid radioactive wastes for the Reference Case is based on:

- Minimising the production of effluents at source,
- Optimum use of segregation and effluent treatment systems,
- Optimum use of suitable storage systems for the site.

Efforts have been focused at the design stage on reducing/minimising the production of effluents at source, taking account of operational feedback and experience from the experience of EDF and AREVA. A number of recommendations from the EPRI (Electric Power Research Institute) have also been taken into account, such as the improvement of collection and effluent treatment systems. In addition, mitigation measures for the treatment of the effluents before discharge and the methods of storage and discharge have been optimised in the light of the best techniques currently available. The techniques applied within the effluent treatment systems of the EPR correspond well with recent operating feedback and technologies (e.g. effluent treatment techniques).

The approach and the processes implemented constitute the best available technique for the management of liquid radioactive effluents as determined in the BAT Assessment presented in Sub-chapter 8.2 of the PCER (Reference 2). This has been determined against achieving a balance between the worker doses incurred in treatment and costs compared to the public doses and other environmental impacts incurred by discharge as described in section 3.2.1.

The EPR reduces the production of liquid radioactive effluent at source by:

- The choice of materials which result in the process generating radioactive elements (reducing stellites, for example, a source of cobalt which produces cobalt-60).
- Reinforced leak-tightness requirements for active parts (pumps and valves) and the recovery of primary coolant leaks.
- Choice of a specific primary coolant chemistry control regime which minimises corrosion processes and the build-up of activated particulate material which contributes to the radioactivity present in effluent.
- Enhanced coolant clean-up systems.
- Optimal recycling of borated primary coolant.

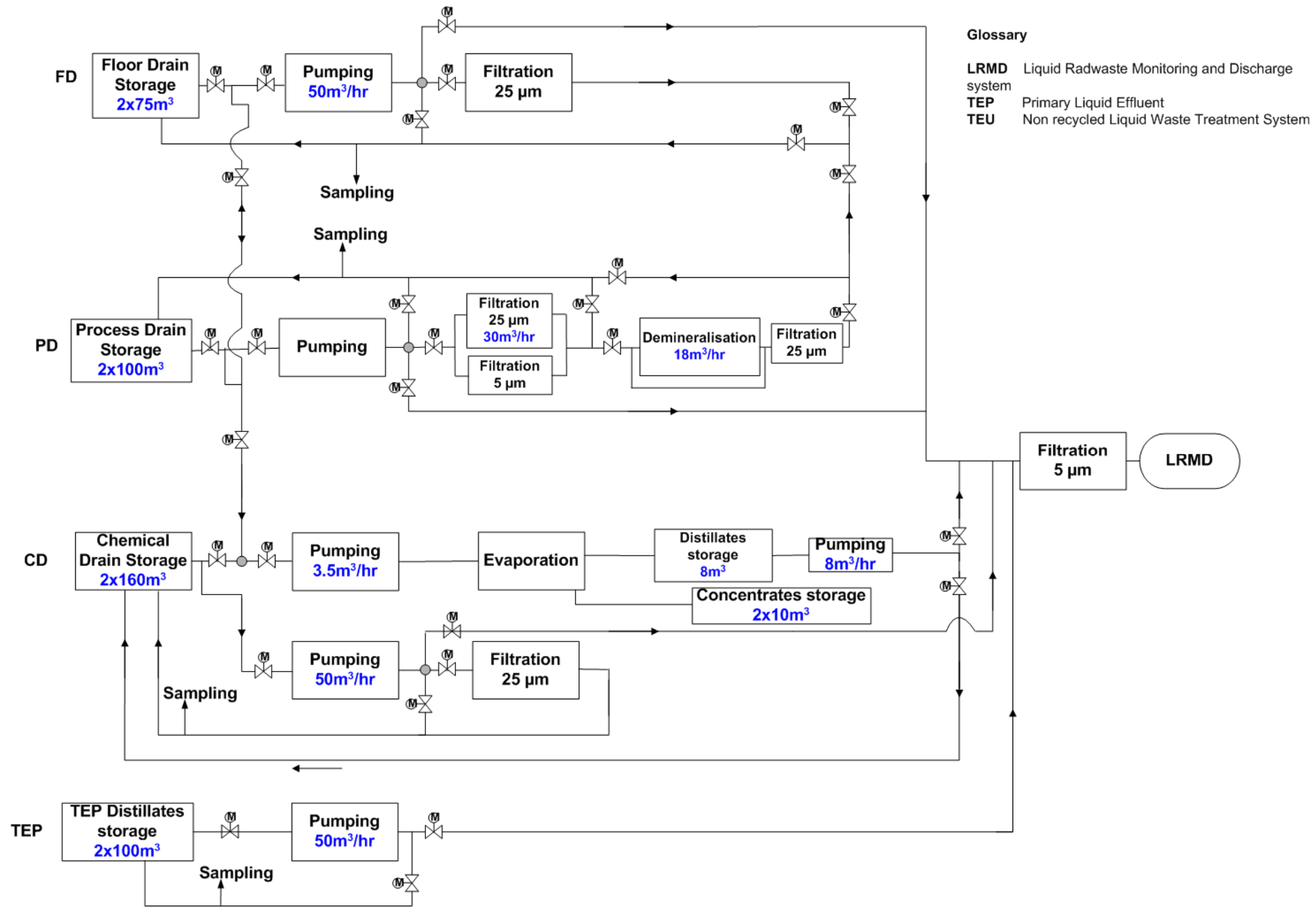
These are discussed in detail in PCER Sub-chapter 8.2 (Reference 2).

In addition, operational and management controls add to optimisation via the rigorous management of effluent which minimises the volumes and activities of waste at source and controls and optimises treatment and decisions regarding their discharge. These management procedures are used at all stages of plant start up, operation at power and unit shutdown and refuelling.

The concentration and containment of the radioactivity contained in liquid effluents is a guiding principle of the management strategy. The treatment of the effluent results in the concentration of activity in the form of solid waste and monitored and controlled residual radioactivity in liquid form, which can be discharged to the environment in compliance with the RSA Authorisation.

The availability of separate collection systems for the different liquid effluent streams (process drains (PD), chemical drains (CD) and floor drains (FD) which collect low contaminated/ uncontaminated effluents) in the Liquid Waste Management System allows effluents of different characteristics to be treated separately by the most appropriate methods (Figure 5). These systems include the floor drain channels which collect leaks and spills from the various plant areas. The segregation of effluents minimises the activities and volumes of radioactive effluents discharged (the treatment of less dilute effluents improves the decontamination that can be achieved) while optimising the production of solid radioactive waste from the effluent treatment systems (filters, concentrates and resins).

Figure 5: The Treatment of Non-Recycled Liquid Effluents – Preliminary values for FA3 EPR



Glossary

- LRMD** Liquid Radwaste Monitoring and Discharge system
- TEP** Primary Liquid Effluent
- TEU** Non recycled Liquid Waste Treatment System

The techniques implemented in the treatment of radioactive liquid effluents help to minimise discharges into the environment, either directly by treatment of the effluents prior to discharge, or indirectly by reducing the activity in the primary circuit. The techniques used for the treatment of the EPR liquid effluents include, for example:

- Enhanced filtration systems for removal of active particulate materials from solution;
- Ion exchange systems for removal of selected dissolved active materials.

These techniques are described from a BAT perspective in Sub-chapter 8.2 of the PCER (Reference 2). More details on the treatment plants and systems implemented in the EPR as shown in Figure 5 are available in Sub-chapter 6.2 and Sub-chapter 6.4 of the PCER (References 5 and 12). The BAT forms in Reference 3 present information on the strategies used for the management of identified specific radionuclides, and how they are partitioned between gaseous, liquid and solid wastes.

The established technologies used for the treatment of the radioactive effluents (filtration, demineralisation and evaporation) are all in current use in the nuclear industry worldwide. They have various efficiencies on treating different types of effluent and, in particular, some radionuclides are better removed than others by the different treatment processes. They are generally recognised as BAT independently of each other, and have been identified as relevant and reliable. In addition, substantial advantages and higher decontamination factors are achieved by where required selecting a combination of two or more processes and their consecutive or simultaneous application for treatment of the effluent. This approach allows discharges to be reduced as far as practicable.

The way in which the effluent treatment plant provided in the EPR design is used will be a strategic decision for the operating company of any EPR, depending of where they see the appropriate balance between reducing discharge activity and generating solid wastes, costs and operator dose. For example, to date the use of evaporation to manage power station effluent streams in the UK has not been demonstrated as BAT. Studies for Sizewell B showed that its use was not BPM (Reference 34). Many US PWRs no longer use their liquid waste evaporators because of operational problems, operator dose and costs (Reference 35).

The management strategy to limit radioactive liquid discharges from the operating activities of the EPR is based on the design of the plant and the operational practices to be implemented. The design features use BAT to minimise liquid discharges at source and similarly the wastes arising in abatement plant, and to balance worker doses and costs incurred during treatment in the plant with public doses from discharges. Systems and plant are managed and used in a manner so as to minimise the environmental impacts of discharges, and it is ensured that all discharges are monitored and recorded to demonstrate that they fall within the authorised limits.

The first column of Table 3 presents the expected annual radioactive liquid discharges (excluding contingencies for transient plant conditions) from an EPR Unit as predicted in the EPR GDA submission. The second column shows the estimated maximum discharges of radioactive liquids from the EPR Unit including normal operating contingency that covers all foreseeable situations that are likely to be encountered during normal operation.

Table 3: Expected EPR annual performance (excluding contingency) for liquid radioactive discharges & Maximum annual liquid radioactive discharges

Radionuclide/Group of Radionuclides	Expected annual performance (excluding contingency) for liquid radioactive discharges	Maximum annual liquid radioactive discharges
Tritium	52,000 GBq	75,000 GBq
Carbon-14	23 GBq	95 GBq
Iodine isotopes	0.007 GBq	0.05 GBq
Other fission or activation products emitting beta or beta/gamma radiation (excluding Tritium, Iodine or Carbon-14)	0.6 GBq	10 GBq

5.2.3 Radioactive Gaseous Wastes

Gaseous radioactive discharge falls into one of three categories:

(i) Gaseous Effluent from the Primary Circuit

This effluent comes from degassing in either the primary-effluent degassers in the TEP [CSTS] (Primary Effluent Treatment System), or in the head spaces in facilities containing primary coolant or primary effluent. It comprises mainly hydrogen, nitrogen and the gaseous products of fission and activation, and therefore is radioactive. Nitrogen sweeping is used to maintain low levels of hydrogen and oxygen. Primary gaseous effluent is discharged directly to the Gaseous Effluent Treatment System (TEG [GWPS]) and is discharged by means of a discharge stack, together with other gaseous discharges from the EPR.

(ii) Gaseous Effluent from Ventilation.

Exhaust from ventilating areas that may be contaminated or have an iodine risk in the Nuclear Auxiliary Building, the Fuel Building, the Safeguard Buildings, the Reactor Building, the Operational Service Centre, the Access Building and the Effluent Treatment Building. It is essentially air that may be polluted with radioactive gases. Air is collected in the ventilation circuits of the different buildings of the Nuclear Island, where it is filtered using High Efficiency Particulate Air Filters (HEPA filters) and if necessary iodine traps before being discharged into the stack.

(iii) Gaseous Effluent from the Secondary Circuit.

Gaseous radioactive effluent from the secondary circuit is largely air that may be polluted with radioactive gases, particularly tritium, in the event of leakage from the primary circuit into the secondary circuit at the steam-generator tubes level. Gas is collected in the condenser vacuum system (CVI) and then sent to the Nuclear Auxiliary Building ventilation system (DWN), where it is filtered before being discharged into the stack.

The radioactive gaseous effluent produced as a result of the above processes from the three sources requires collection. The RPE [Nuclear Vent and Drain System, NVDS] liquid and gaseous waste collection system contributes to the containment of radioactive substances and limits releases into the environment. Gaseous effluent is segregated at source and treated in different systems depending on its nature. The gaseous effluent portion of this system collects gases from the RPE [NVDS] tanks of the Reactor Building and the Nuclear Auxiliary Building that receive recyclable bleeds and venting from safety valves, primary leaks and degassing of the pressuriser. The radioactive gaseous processing system is described and discussed in detail in PCER Sub-chapter 6.2 and Sub-chapter 6.4 (References 5 and 12).

The management strategy to limit radioactive gaseous discharges from the operating activities of the EPR is based on the design of the plant and the operational practices to be implemented. The design features use best available techniques to minimise gaseous discharges at source and similarly in abatement plant, and balance worker doses and costs incurred during treatment in the plant with public doses from discharges. Systems and plant are managed and used in a manner so as to minimise the environmental impacts of discharges, and it is ensured that all discharges are monitored and recorded to demonstrate that they fall within the authorisation limits.

Various provisions allow gaseous radioactive waste to be reduced in the EPR design. These centre on reduction at source (waste minimisation), containment within plant and recycling where possible. Once the liquids pass from the primary coolant system into other systems and outgassing occurs, a range of design features ensure abatement of the gases and associated discharges. The EPR's Gaseous Waste Processing System (TEG [GWPS]) is similar to that of Konvoi reactors. In particular, this system has the advantage of being able to treat aerated gases and to operate in an almost closed loop in normal operation.

In addition, treatment of potentially radioactive gases is implemented to ensure that most hazardous isotopes are removed from effluent streams and contained within solid filters. The gaseous abatement techniques implemented by the EPR are focused upon technologies considered as best available technologies as identified by the OECD (Reference 23). These are primarily:

- Dry high efficiency particulate aerosol (HEPA) filtration to remove particulate actinide aerosols;
- Carbon adsorption technologies (carbon filter beds) to hold-up for decay or remove volatile chemically reactive gases such as iodine.

As noted above, BAT forms have been prepared which describe the management of identified specific radionuclides, such as carbon-14 and tritium, in gaseous radioactive effluents and discusses how their discharges are minimised and how they are distributed between gaseous, liquid and solid wastes (Reference 3).

Suitable final monitoring is carried out and residual gaseous effluents are discharged via a stack designed to ensure maximum rapid dispersion and dilution in the air. The height of the discharge stacks is determined for adequate diffusion of these discharges and takes account of local site topography and wind patterns.

The estimated maximum discharges of radioactive gas from a single EPR Unit, including normal operating contingency intended to cover all foreseeable situations that are likely to be encountered during normal operation are shown in Table 4.

Table 4: Expected EPR annual performance for gaseous radioactive discharges

Category	Annual expected performance excluding contingency	Maximum annual gaseous radioactive discharges
Tritium	500 GBq	3000 GBq
Carbon-14	350 GBq	700 GBq
Iodine isotopes	0.05 GBq	0.4 GBq
Noble gases	800 GBq	22500 GBq
Other fission or activation products emitting beta or beta/gamma radiation (Excluding Tritium, Iodine or Carbon-14)	0.004 GBq	0.120 GBq

5.3 OPERATIONAL NON-RADIOACTIVE WASTES

5.3.1 Non-Radioactive Solid Waste

Non-radioactive solid wastes arise during the operation and maintenance of the process plant (e.g. maintenance of pipes and equipment), and as the result of a number of routine activities (e.g. removal of algae from the water abstraction structure, maintenance of control rooms equipment, activities in the workshops, waste from office work, packaging and from the canteen). The range of wastes is very large.

The non-radioactive wastes consist of "industrial waste" (chemical and material additives, effluents, materials), "inert waste" (rubble) and "Commercial waste" (canteen, office waste). Several of these waste types arising will be classed as hazardous under the Hazardous Waste (England and Wales) Regulations 2005 (as amended) and require special storage and treatment arrangements in accordance with the relevant legislation in order to minimise their impact. Hazardous wastes include solids (batteries, aerosol spray cans, electrical equipment), liquids (solvents, oils) and sludge (paint residues, decontamination products). A more detailed identification of the wastes with reference to the European Waste Catalogue and the types of waste found on other nuclear power stations is given in PCER Sub-chapter 3.3 (Reference 31).

The non-radioactive solid waste management strategy is designed to comply with the requirements of the Waste Framework Directive as implemented in the UK by the Environmental Permitting Regulations incorporating the PPC Regulations 2000, Waste Management Licensing Regulations 1994 and the Environmental Protection (Duty of Care) Regulations 1991. By ensuring compliance with these regulations in terms of minimising waste production, storing and transferring waste responsibly, the requirements of the Waste Framework Directive will be upheld. Comprehensive waste management procedures will be implemented for all waste streams through the site Environmental Management System (EMS).

The way that daily operation and maintenance activities are organised on the power station is important in minimising the amount of non-radioactive wastes produced. Waste production is minimised through effective implementation of the waste hierarchy. Where possible, potential waste will be re-used on site. Where it is technically and economically feasible, potential waste will be recycled. Waste may be sent for energy recovery; it will only be disposed of to landfill or to incinerator as a final option, where no other reasonably practicable option exists. PCER Sub-chapter 3.3 (Reference 31) provides information on the volumes of wastes that are disposed, recycled or recovered at other stations. Wastes that are recycled or recovered include batteries, packaging and mixed metals. Wastes arising from the EPR will be recycled where appropriate routes are available in the UK. It is noted that arisings of non-radioactive wastes are largely determined by operational procedures and practices and are not solely dependent on the design.

Table 5 gives an estimate of the annual arisings of the main different types of non-radioactive waste.

Table 5: Estimate of EPR Annual Arisings of Non-Radioactive Wastes

Waste type	Annual quantity (Tonnes)
Inert waste and commercial waste	470
Hazardous (non-radioactive) waste	100
Total arisings (annual)	570

5.3.2 Non-Radioactive Liquid Waste

The non-radioactive chemicals associated with liquid radioactive effluent derive from various lay-up processes within the primary circuit, the secondary circuit and the nuclear and conventional auxiliary circuits and active laundry. These include:

- Boric acid for its neutron-absorbing properties;
- Lithium hydroxide to offset the acidity of the boric acid, to keep the pH slightly alkaline and prevent equipment corrosion and which is discharged in only very small quantities;
- Ammonia for pH control;
- Amine compounds (morpholine, ethanolamine) used to prevent equipment corrosion in secondary circuits;
- Various metals (aluminium, copper, chromium, iron, manganese, nickel, zinc, copper, aluminium and lead) from corrosion;
- Phosphates;
- Detergents.

As for radioactive liquid discharges, chemical discharges are also subject to a systematic approach to optimisation and reduction. For various operational and maintenance reasons, the chemicals cannot be retained within those systems. The main systems used to treat and discharge these chemicals are the same as for radioactive effluent. However, the design of the EPR incorporates a number of improvements in comparison with other PWRs of similar power capacity which will reduce non-radioactive chemicals associated with radioactive effluent. These include reduced discharges of boron and lithium to the environment as a result of increased recycling of primary circuit liquid effluents, the use of ion exchange to minimise lithium in discharges and reduced discharges of phosphates (used in the inhibition of corrosion) as a result of improved design of secondary cooling systems.

Chemicals not associated with radioactive discharge come from the conventional parts of the station, mainly:

- Discharges from demineralised-water production;
- Discharges from biological fouling treatments (including trihalomethanes arising from seawater chlorination);
- Water collected from rainwater drains and black and grey wastewater (effluent from purification units and the sewage network);
- Water contaminated with oil from processes collected in the Turbine Hall.

The treatment and management of non-radioactive liquid wastes from the operation of an EPR is discussed in detail in Sub-chapter 3.4 of the PCER (Reference 31). The volume of discharges will in part depend on a range of operational and site-specific factors and are not solely dependent on the design of the EPR.

The discharge of non-radiological chemicals to the marine environment from an EPR will be undertaken under consent obtained from the relevant regulatory authority. The consents are expected to regulate parameters including temperature, composition and flow discharges. Limits will be agreed with the Environment Agency, after a priority assessment has been carried out.

5.3.3 Non-Radioactive Gaseous Waste

Potential sources of gaseous non-radioactive discharge linked to the process include:

- Sulphur and nitrogen oxides in the exhaust gases from engines of the backup electricity generators during periodic tests;
- Formaldehyde, that may in turn produce carbon monoxide, emitted by the thermal decomposition of insulation material when the plant goes back into operation after maintenance (every 18 months at the most);
- Ammonia discharged as the temperature rises in the steam generators during start-up.

Determining the quantities of these gaseous that are released to the atmosphere is complex; release rates and estimates of total volume discharged are discussed in detail in PCER Sub-chapter 3.2 (Reference 31).

The discharge of gaseous non-radiological emissions from processes is regulated under an Environmental Permit. They will be minimised by the implementation of BAT and through the application of the Site Environmental Management System (EMS).

5.4 SPENT FUEL

Spent fuel assemblies are discharged from the reactor and placed into the spent fuel pool to cool and decay for a period of about 10 years before being moved to an interim storage facility. The decay heat generated by an EPR spent fuel assembly, which has undergone four 13 month reactor cycles and 10 years of cooling in the spent fuel pool, is approximately 1,400 Watts at the time of interim storage.

The UK EPR is designed for an operational life of 60 years. At any given time the operational reactor will contain around 127 tonnes of enriched uranium fuel. Reactor refuelling will take place at the end of reactor cycles, which can range between 12 and 22 months depending on the fuel management regime adopted. The quantities of spent fuel discharged from the reactor during refuelling can reach up to 80 assemblies.

A bounding value for the total number of spent fuel assemblies produced at the end of the reactor life is set to 3400 units. More information on the quantities of spent fuel arising and its characteristics are given in PCER Sub-chapter 6.3 (Reference 33) and Sub-chapter 4.2 of the PCSR (Reference 36).

The interim storage facility will be designed to be in operation for up to 100 years. The safety and design approach and assumptions to be applied for the facility and its auxiliaries will be consistent with the ones presented in Sub-chapter 3.1 of the PCSR (Reference 37), including the ALARP requirement. The BAT approach will be applied in the design regarding the minimisation of the environmental impacts associated with spent fuel storage.

Interim storage for spent fuel is practiced worldwide. Such facilities are based on either wet or dry storage concepts. For the latter, two approaches are of interest to operators: storage of fuel assemblies in metal casks or alternatively in a vault type storage facility.

Description of the wet type Interim Storage Facility is summarised in PCER Sub-chapter 6.5 (Reference 13). The dry storage technologies are described in the Solid Radioactive Waste Strategy Report (Reference 1).

The long-term strategy for the management of spent fuel is that it will ultimately be disposed of in a geological disposal facility. A similar conceptual LoC process as for ILW is being adopted in order to assess the disposability of spent fuel and detailed information has been submitted to the NDA RWMD to obtain a view from them on the disposability of UK EPR spent fuel. The information provided to the NDA includes:

- A summary of the UK EPR reactor core and fuel assemblies
- The main geometrical characteristics of the fuel assemblies and individual fuel rods
- Chemical compositions
- Radiological and thermal characteristics, and
- Expected quantities of spent fuel.

The NDA RWMD assessment of spent fuel will be reported in the Disposability Report and detailed Assessment Report. The management of spent fuel (and ILW) is described in a range of supporting documentation which is referenced in the Radioactive Waste Management Case (RWMC).

5.5 DECOMMISSIONING WASTES

The decommissioning strategy for the EPR is based on a phased immediate dismantling of the whole plant following cessation of electricity generation. This assumes that the final site end state will be such that all, hazardous wastes have been disposed, all station buildings and facilities have been removed, and the site returned to a state agreed with the regulators and the planning authority and released from the control of the nuclear site licence. This is likely to be a state similar to “greenfield”, depending on the state of the site in question prior to construction of the station. The UK EPR decommissioning strategy is described in PCER Chapter 5 (Reference 38).

Measures included in the EPR design to facilitate the unit decommissioning mean that the following two main aims can be fulfilled at an acceptable cost:

- Reduction of the radioactive dose received by workers;
- Reduction in radioactive waste and hazardous material;

The measures adopted at the design stage principally include:

- Reduction of activation by eliminating the use of certain material (e.g. cobalt and antimony);
- Strengthening fuel cladding to avoid contamination from fission products;
- Minimisation of the use of hazardous materials;
- Avoiding the use of porous materials that can become readily contaminated.

The full range of waste minimisation methods will be used to reduce amount of waste produced during decommissioning to as low a level as possible, including decontamination, volume and size reduction and appropriate segregation of the waste to enable:

- The maximum use of recycling of materials, with or without the need to demonstrate their suitability for re-use,
- Minimal production of waste which is difficult to dispose of, particularly, long-lived, high activity waste and chemically hazardous waste,
- Minimal production of 'secondary' waste (equipment used for the decommissioning phase and contaminated during the operations).

By treatment of the surface of contaminated material, the amount of waste, which has to be provided for final disposal, can be reduced substantially. In particular, the use of chemical cleaning or blasting of the surface and melting of metallic material can increase the amount of material suitable for unrestricted or restricted release. The use of these methods will have to be balanced against possible liquid and gaseous discharges arising from their use.

Besides the handling and treatment costs, the specific cost structure for storage of waste in the final repository is an important factor. Therefore, selection of the treatment measures may also be influenced by cost-effectiveness considerations.

Uncertainties in waste characterisation will be reduced to a minimum to avoid unnecessarily high categorisation of waste. This applies, in particular, to the unnecessary classification of non-radioactive hazardous waste as radioactive waste.

Table 6 presents an estimate of the amount of waste produced during decommissioning, based on the designed service life of 60 years and a decommissioning strategy of immediate dismantling. These are discussed in PCER Chapter 5 (Reference 38).

Table 6: EPR Raw Volumes of Decommissioning Waste

	ILW (tonnes, m³)	LLW (tonnes)	VLLW (tonnes)	Conventional (tonnes)
Primary Circuit	623	2735	1 898	-
Decontamination	40	-	-	
Nuclear Steam Supply System (NSSS) Equipment	-	2,259	-	
Basic Nuclear Installation (BNI) Equipment	-	2,824	2,605	978
Concrete due to clean up of BNI	-	75	455	-
Total	623 tonnes, 40 m³	7,893	4,958	978

5.6 MONITORING ARRANGEMENTS

Approaches to the monitoring of radioactive and non-radioactive discharges to the environment (water and the atmosphere) from the EPR are detailed in PCER Chapter 7 (Reference 39). The environmental monitoring programme at the GDA stage is described in PCER Sub-chapters 11.4 (Reference 8) and 12.6 (Reference 9), respectively for radioactive and non radioactive monitoring. The operator, through implementation of a discharge control and environmental monitoring programme, fulfils statutory requirements for the monitoring of any discharges.

The aim of the monitoring is to check and demonstrate that the values prescribed in the authorisations or permit (for non radioactive materials monitoring) are respected in relation to water intakes and thermal discharges, and radioactive, liquid chemical or gaseous discharges. The techniques of assessment are kept under review to take account of experience and technical developments to ensure that the Best Available Techniques are used to maximise this assessment accuracy provided that they are cost effective. BAT assessment is also used to ensure that any radioactivity discharged is not underestimated. Sub-chapter 8.4 (Reference 2) of the PCER demonstrates that:

- The EPR’s monitoring arrangements are sufficient and adequate;
- The EPR’s monitoring procedures are consistent with EU requirements and EA Guidance Notes;
- The BAT has been taken into account in the activities related to monitoring.

Therefore, it is concluded that the EPR uses Best Available Techniques for monitoring activity in the primary coolant and other process systems to ensure compliance with normal operating envelope and early detection of faults within the plant. Other systems ensure sampling and analysis in all downstream systems and in the radioactive treatment plants (for liquids, gases and solid wastes). Sampling and analysis systems are supplied on the discharge points to ensure compliance with limits and authorisations and demonstration to the EA that discharges to the environment are minimised as low as possible and that any excursions in these due to faults can be detected early and appropriate actions taken.

The range of nuclides and detection limits are in compliance with EU recommendations and expected nuclide patterns from other PWR plant. The range of nuclides and methods used for analysis and the data quality objectives that will be used for the EPR are broadly consistent with those already applied on the UK's current operating PWR at Sizewell B. Several separate assessments have been carried out to show that the methods used at Sizewell over the last 20 years have ensured that short and long term trends in discharge data can be recorded and used to show the extent of compliance with the plant's discharge authorisations and that short term trends have allowed full fault identification.

An environmental monitoring programme for radioactive substances is described in Chapter 11.4 (Reference 8) of the PCER that meets the following main purposes:

- It must demonstrate that the allowed discharges continue to have a minimal effect on the most exposed individuals that is broadly acceptable and within public limits relating to annual exposure;
- It must provide reassurance that allowed discharges continue to be estimated correctly and are within allowable limits;
- It enables the early recognition of unusual discharges to the environment.

Monitoring and sampling regimes will vary from site to site and year to year, and will be selected to be representative of existing exposure pathways. Knowledge of these pathways is developed from regular surveys of local peoples' diets and way of life. Routine monitoring will be supplemented by additional monitoring where necessary, for example in response to incidents or reports of unusual discharges of radioactive material.

Beyond the sampling and analysis systems in downstream systems and in radioactive waste treatment plants, the monitoring of solid wastes for off-site disposal can be considered to be largely an operational issue rather than a fundamental design issue. The monitoring and clearance procedures for solid wastes will meet the requirements of the relevant authorisation/permit and the conditions for acceptance for the waste disposal route (e.g. LLWR). The disposal of solid wastes as exempt wastes will be carried out taking account of the UK Nuclear Industry Code Clearance and Exemption Principles, Processes and Practices (Reference 40) as necessary.

6. AREAS REQUIRING FURTHER DEVELOPMENT AND ACTION PLAN

EDF participates in several industry groups, such as EPRI, and maintains interfaces with other waste producers and attendance at relevant industry forums, seminars and workshops. EDF and AREVA will continue to closely monitor the availability of new national and international waste management options to determine their suitability for use on the EPR. They continue to contribute to the support of a significant programme of research and development in the field of radioactive waste management. This programme is ongoing to improve existing or develop new treatment methods for potential future implementation in the EPR.

A regular dialogue will be maintained with NDA RWMD throughout their assessment process of the UK EPR's proposals for the disposal of ILW and spent fuel, in order to provide any necessary clarifications and supplementary information to ensure that their Assessment and Disposability Reports are satisfactorily completed and LoCs granted.

Dialogue will also be continued with LLWR to ensure that there are no problems with UK EPR LLW meeting their CfA for disposal. Work will be carried out to ensure that combustible radioactive wastes from the EPR are suitable for incineration routes either in the UK or elsewhere.

Normally an integrated waste strategy is prepared for an operational site in which case there is access to site specific operational data. For the UK EPR such site specific information is not available yet. It is anticipated that a site specific Integrated Waste Strategy Document will be prepared for each site at an appropriate point in the development of the site by the site licensee. At that point the IWS will provide summary information relating to:

- Characterisation of the relevant site;
- The description and justification of the chosen solution for the management of spent fuel;
- The provision of evidence for Letters of Compliance (LoC) underwriting the disposability of ILW and spent fuel in the proposed UK Geological Disposal Facility;
- The development of the Radioactive Waste Management Case(s) (RWMC) for the relevant site, which takes into account the chosen solutions for management of ILW and spent fuel;
- The development of site specific BAT assessments where required;
- The production of waste characterisation documents to meet LLWR's CfA requirements for the disposal of LLW;
- The production of waste characterisation documents to meet the CfA for incineration of combustible LLW.
- The production of waste characterisation documents to meet the requirements of a disposal facility for VLLW.

As other utilities interested in the EPR technology have their own preferred management options it can be anticipated that alternative IWS will be developed.

7. CONCLUSIONS

This IWS provides a baseline summary document of the waste management strategy presented in the UK EPR GDA submission. It shows that there is a management strategy for all the waste streams produced by the EPR design and that they have been suitably planned for. The IWS refers to a range of other UK EPR GDA submission documentation which specify the how, why and when waste management strategies on the EPR are developed.

The document shows that waste management strategies have been developed using a standardised approach which takes into account all relevant factors including:

- Delivery of compliance with relevant regulatory obligations (e.g. licence conditions, authorisations and permits) and Government policy (e.g. a progressive reduction of discharges);
- Consideration of a full range of health, safety, environmental, security, economic and social issues;
- Minimisation of waste via implementation of the waste hierarchy;
- Application of Best Available Techniques (BAT)

The IWS identifies assumptions and risks that may influence the implementation of an EPR's waste management strategy in the UK and recognises opportunities within the strategy. By integrating the waste management strategies for all the different waste streams produced by an EPR power station, the overall strategy for waste management that minimises environmental impact can be demonstrated. This is achieved through adherence to the waste hierarchy and employment of the best available techniques to concentrate and contain radioactive waste. This document, together with its supporting references, therefore provides confidence that the challenges associated with the management of wastes and spent fuel from the UK EPR are fully understood and that solutions are available within the envelope of current UK and international experience.

This IWS is based on the Reference Case of the UK EPR GDA design submission and will assist owner/operating companies who adopt alternative waste management options to develop their own IWS documents as their EPR stations evolve through their lifecycle from commissioning through operation to decommissioning and final site clearance. It is a tool which helps to demonstrate that wastes produced by an EPR can be appropriately managed and informs the operating companies and other stakeholders of what work is required to fully develop and implement waste management strategies on a new EPR power station.

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