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UK ABWR

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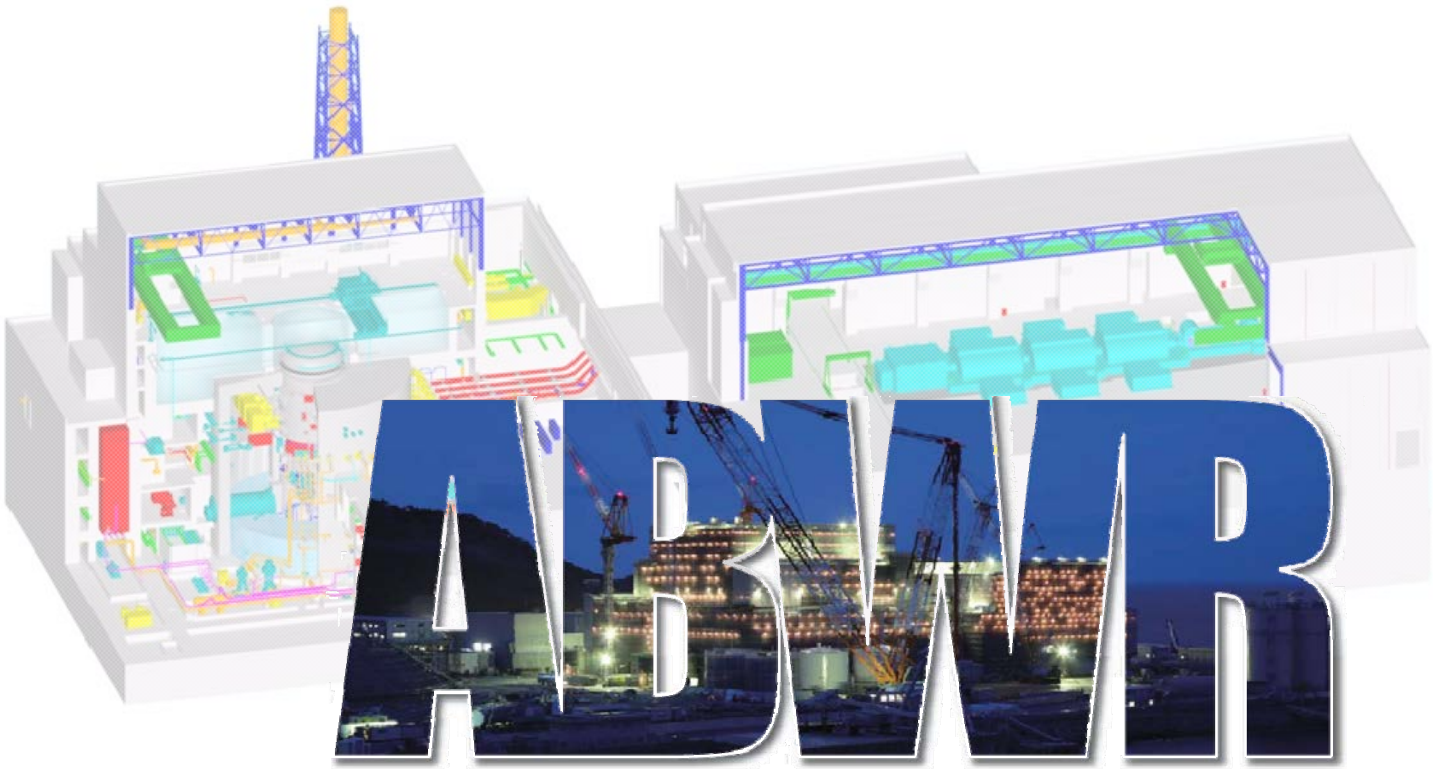
UK ABWR Generic Design Assessment

Preliminary Safety Report on Decommissioning



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Abbreviations and Acronyms

Abbreviations and Acronyms	Description
ABWR	Advanced Boiling Water Reactor
ALARP	As Low As Reasonably Practicable
AP1000	Advanced Passive Plant 1000MW
B/B	Back-up Building
BAT	Best Available Techniques
BoP	Balance of Plant
BWR	Boiling Water Reactor
C/B	Containment Building
CDM	Construction/Design & Management
CTS	Condensate Treatment System
EIA	Environmental Impact Assessment
EoG	End of Generation
EPR	European Pressurised Reactor
EPRI	Electric Power Research Institute
ETB	Effluent Treatment Building
FBSP	Fuel Building Storage Building
FSF	Fuel Storage Facility
GDA	Generic Design Assessment
Hex/B	Heat Exchanger Building
Hitachi-GE	Hitachi-GE Nuclear Energy
IAEA	The International Atomic Energy Agency
IC	Intelligent Customer
ILW	Intermediate Level Waste
ISF	Interim Storage Facility
IT	Information Technology
LLW	Low Level Waste
NDA	Nuclear Decommissioning Authority
NEA	Nuclear Energy Agency
NI	Nuclear Island
NPP	Nuclear Power Plant
NSL	Nuclear Site License
NWRF	Nuclear Waste Research Forum
OECD	Organisation for Economic Co-operation and Development
ONR	Office for Nuclear Regulation
O & M	Operation and Maintenance
PCER	Pre-Construction Environment Report
PCSR	Pre-Construction Safety Report
POCO	Post-Operation Clean-Out
PPE	Personnel Protective Equipment

PSR	Preliminary Safety Report
QA	Quality Assurance
R&D	Research and Development
R/B	Reactor Building
RCA	Radiation Controlled Area
RIP	Reactor Internal Pump
RPV	Reactor Pressure Vessel
Rw/B	Radioactive Waste Building
RWMS	Radioactive Waste Management System
SF	Spent Fuel
SFF	Spent Fuel Facility
SQEP	Suitably Qualified and Experienced Personnel
T/B	Turbine Building
VLLW	Very Low Level Waste
WANO	World Association of Nuclear Operators
WBS	Work Breakdown Structure

1. Introduction

1.1Introduction

This document is a Preliminary Safety Report (PSR) related to decommissioning of UK Advanced Boiling Water Reactor (ABWR), including considerations of design phase, Operation & Maintenance (O & M) phase and decommissioning phase. And the contents of this report needs to be taken into account to the design of UK ABWR.

This PSR is a topic report to provide high levels claims for the decommissioning of the proposed UK ABWR. The purpose of this PSR is to present the high level information regarding the decommissioning principles and plans for the proposed UK ABWR. The following buildings include the following structures/facilities/equipment that will be the target for decommissioning of the UK ABWR:

- ✓ Main buildings (include Power Block).
  - ✓ Reactor building (R/B).
  - ✓ Control building (C/B).
  - ✓ Heat exchanger building (Hex/B).
  - ✓ Back-up building (B/B).
  - ✓ Filter vent building.
  - ✓ Turbine building (T/B).
  - ✓ Radioactive waste building (Rw/B).
  - ✓ Service building.
- ✓ Buildings and facilities related to storage.
- ✓ Buildings and facilities related to water treatment.
- ✓ Buildings and facilities related to electric components.
- ✓ Other auxiliary buildings and facilities.
- ✓ Buildings and facilities related to office.

And high level claims have been developed such as: safe decommissioning design, adequate preparation of an Initial Decommissioning Strategy and adequate evidence and preparation of a Decommissioning Plan.

The Generic Design Assessment (GDA) Pre-Construction Safety Report (PCSR) on Decommissioning sections and sub-sections will be developed to achieve and meet both the expectations and requirements of the Office for Nuclear Regulation (ONR) and the Environment

Agency these are described in section 2 of the PCSR on Decommissioning.

The scope of the PCSR on Decommissioning report will be developed by benchmarking the content against previous GDA submissions, such as the UK European Pressurised Reactor (EPR) & Advanced Passive Plant AP1000 PCSR/Pre-Construction Environment Report (PCER)'s and supporting documentation that have already met ONR/EA expectations and requirements. This was then revised and aligned to the Hitachi-GE Nuclear Energy (Hitachi-GE) requirements for decommissioning.

The decommissioning of the UK ABWR will be the responsibility of the future Licensee. However, as required by the GDA process, Hitachi-GE need to demonstrate that the UK ABWR can be decommissioned in a safe and environmentally acceptable way.

International guidance suggests that decommissioning nuclear power stations would be made easier if this aspect is considered during the design and operation of the plant. Planning for decommissioning results in lower worker doses and reduced costs. Therefore, decommissioning will be addressed at the design stage and the preliminary decommissioning plans for provision as an input to the licensing process, and thus meeting regulatory requirements and expectations. [Ref.1, p.5] [Ref. 2, sec.5.4, p.10]

1.2 GDA PCSR on Decommissioning: High Level Claims [Ref. 3]

1.2.1 The UK ABWR is designed to ensure safe decommissioning

1.2.1.1 Designed to minimise activation and contamination

Minimisation of activation can be achieved by optimised material selection to avoid radionuclide generation (e.g. low-Cobalt content materials.). Minimisation of the contamination of facilities and equipment can be achieved by designing for easy decontamination and prevention of the spread of contamination.

- ✓ As Low As Reasonably Practicable (ALARP) consideration will be included in the UK ABWR decommissioning plan.
- ✓ Baseline principles, including special design requirements, dose reduction and waste reduction, will be adopted in the UK ABWR and to support decommissioning.
- ✓ Design principles to minimise activation and contamination are applied.

- ✓ Best Available Technique (BAT) will be applied to the UK ABWR to support the ALARP argument in order to minimise activation and contamination.

1.2.1.2 Designed to facilitate decommissioning

The UK ABWR will be designed with decommissioning in mind. That means the plant will be designed so that it can be decommissioned as safely and environmentally friendly as possible. Several means will be recognized and implemented in the design stage to facilitate decommissioning. That will improve the radiation controlled working environment and reduce the necessary time to be spent in the radiation controlled area. Preparing a plan for dismantlement and transportation routes for removal of main equipment will also contribute to an optimized decommissioning process.

- ✓ Decommissioning requirements will be reflected in the UK ABWR design.
- ✓ Processes which have impact for decommissioning will be considered in advance.
- ✓ Design change management, records of operation and maintenance, operators learning from experiences, will be conducted beginning in the design stage though all the life cycle of the plant.

1.2.1.3 Designed to reduce dose to workers during decommissioning

Reduction of dose exposure will be included in the design by the preparation of the decontamination plan for highly contaminated equipment.

- ✓ The ALARP consideration shall be part of the UK ABWR decommissioning plan.
- ✓ Design principles to reduce dose, including decontamination adopted in the UK ABWR shall be applied.
- ✓ Management of radioactive wastes based on the concept of waste hierarchy will be defined.

1.2.2 An Initial Decommissioning Strategy has been prepared

1.2.2.1 Strategy: Compliance with UK guidance and legislation

To be compliant with UK guidance and legislation, an Initial Decommissioning Strategy shall be developed, including consideration of the following:

- ✓ UK guidance and legislation for decommissioning (License conditions for Nuclear Licensed Sites, ONR guidance, EA guidance, Construction/Design & Management (CDM) regulations, International nuclear decommissioning guideline) will be referred to the UK ABWR decommissioning plan.
- ✓ The UK ABWR disposability assessment will be reviewed in the context of UK guidance and legislation.

1.2.2.2 Strategy: Encompass anticipated timescale

Encompassing anticipated timescale for decommissioning recognises the full extent of the decommissioning process including operation, shutdown and decommissioning of all facilities on the site.

- ✓ Duration of the UK ABWR decommissioning stage will be optimized.
- ✓ Stages of decommissioning, such as phases and standard processes, will be defined.
- ✓ Influence of operation and maintenance on the baseline decommissioning approach will be estimated and options will be evaluated.

1.2.2.3 Strategy: Identify the decommissioning type

Identification of whether a prompt or deferred decommissioning strategy will be achieved and the resulting decision will be designed for.

- ✓ Baseline Principles, including the decommissioning strategy, to be adopted in the UK ABWR will be prepared to support decommissioning planning.
- ✓ Assumptions underpinning the baseline decommissioning plan and the scope of the baseline decommissioning plan will be included.

1.2.3 A Decommissioning Plan, supported by appropriate evidence, has been prepared

1.2.3.1 Plan: Define the Decommissioning Start and End-States

The Start and End-States of the UK ABWR will be defined.

- ✓ Assumption underpinning the baseline decommissioning plan and the scope of the baseline decommissioning plan will be included.

- ✓ Stages of decommissioning, such as phased and standard processes, will be defined. Influence of operation and maintenance on the baseline decommissioning approach will be estimated.
- ✓ UK ABWR disposability assessment will be reviewed in the context of UK guidance, regulations and requirements.

1.2.3.2 Plan: Demonstrate the safe decommissioning

Considering the main hazards in the decommissioning procedure, a safe decommissioning plan will be developed.

- ✓ Baseline decommissioning plan, including assumptions, preparatory work, fuel management, site operation and plant preparation, radioactive waste management and plant and reactor decommissioning, will be prepared.
- ✓ Utilisation of operation and maintenance experiences, including lessons learned from other decommissioning projects may be included.
- ✓ UK ABWR disposability assessment will be reviewed in the context of UK guidance, regulations and requirements.

1.2.3.3. Plan: Identification of waste to be managed from Decommissioning

Based on the Radioactive Waste Management System (RWMS) and the decommissioning plan, the waste arising during decommissioning will be estimated:

- ✓ Design principles adopted in the UK ABWR with regard to waste reduction and waste hierarchy will be considered to support decommissioning.
- ✓ Potential impact of operation and maintenance on the baseline decommissioning approach will be estimated.

1.2.4 Plan: The Data Gathering Method, for Decommissioning for future generation, has been prepared.

1.2.4.1 Method: Appropriate data gathering, storage and record keeping

Data gathering, information storage and record keeping shall be implemented and maintained throughout the life-time of the plant. This data management will be implemented with an appropriate Information Technology (IT) platform which will be established during the UK ABWR design stage.

- ✓ Knowledge management for decommissioning will be included and incorporated into the IT platform:
  - ✓ Retention and transfer of knowledge.
  - ✓ Retention and transfer of competency.
  - ✓ Management of records for decommissioning.

1.3 Sections included in the report

Section 2; Decommissioning Principles Underpinning the UK ABWR Design

This section will include a description of the decommissioning strategy, stages and baseline principles for the decommissioning of the UK ABWR, including the design principles and features developed to aid decommissioning. The plant design will also incorporate dose reduction and waste reduction, influence of operation and maintenance, operators learning from experience, and ALARP consideration.

Section 3; Decommissioning Plans for the UK ABWR

This section will include the development of the scope of the decommissioning plan including the assumptions and scope of the baseline decommissioning plan, preparation work, site operation and plant preparation, management of fuel and radioactive wastes and plant and reactor decommissioning. This section will also refer to the data gathering and recording for decommissioning.

2. Decommissioning Principles Underpinning the UK ABWR Design (Section 3 of PCSR on Decommissioning)

2.1 Decommissioning Strategy

The proposed decommissioning strategy is 'prompt decommissioning'; however, 'deferred decommissioning' is an available option for areas where 'prompt decommissioning' cannot take place. The strategy will take a balanced approach between prompt and deferred decommissioning on the basis of ALARP can involve a mix of the two approaches for different parts of the site.

2.2 Stages of Decommissioning

2.2.1 Phases

The final phase of decommissioning centres on the with draw of the Nuclear Site License (NSL), which takes place when the de-licensing criteria has been met. The effective use of the site will be considered after being subjected to such operations according to the decommissioning prescribed procedures.

There are several options on the method of decommissioning. The final states of the decommissioning are classified by the International Atomic Energy Agency (IAEA) [Ref. 4 sec. 2.1, p.3] as:

1) Safe enclosure with surveillance [Stage 1].
2) Extensive plant decontamination, partial dismantling and removal of plant systems. Limited site-release for non-nuclear use [Stage 2].
3) Decontamination and dismantling until site-release without limitation [Stage 3].

Site operator can select the decommissioning method from various options, such as safe enclosure and dismantling of the nuclear facilities. The decommissioning processes are classified as prompt decommissioning and deferred decommissioning, and some Nuclear Power Plant (NPP) will be put into safe store for a period of care and maintenance and after this period decommissioning will take place. With regard to the decommissioning of NPPs in the world, the process of decommissioning is selected flexibly in response to the situation of the plant status.

Decommissioning aspects have to be taken into account in all life cycle phases of the nuclear facility. Procedures of works related to the decommissioning are divided into the following phases:

1) Design phase

Careful selection of materials and optimization of the plant's design, layout and access route will be considered in the design phase, which include:

- ✓ Design requirement (Reduction of radiation sources, such as selection of material, Reduction of the degree of surface contamination, etc.)
- ✓ Consideration of dose reduction
- ✓ Consideration of waste reduction and waste hierarchy

2) Operation and maintenance phase

Details of the operating history of the reactor and details of modifications to the plant and maintenance experience will be recorded, which include:

- ✓ Maintenance record
- ✓ Environmental radiation monitoring
- ✓ Utilisation of maintenance records for decommissioning

3) Decommissioning phase

The decommissioning phase itself consists of several sequences which include:

- ✓ Pre-shutdown preparation.
- ✓ Post Operational Clean-Out (POCO)
- ✓ Decision to permanently shut down by operator.
- ✓ Removal of Spent Fuel (SF).
- ✓ Removal of fissile materials and radioactive liquids, whilst the nuclear side of the plant is still operational with the capability to maintain its safety systems operational.
- ✓ Decommissioning or re-equipment of non-nuclear plant essentials with the possibility to minimise the outskirts of the facility.
- ✓ Gradual dismantling of the activated and contaminated equipment in a safe manner (including nuclear safety and conventional safety consideration).
- ✓ Systems and components decontamination.
- ✓ Care and maintenance
- ✓ Period of safe storage at the Interim Storage Facility (ISF) if required.
- ✓ Dismantling of the remaining systems and structures, treatment and disposal of waste.

- ✓ Remaining structures and the site itself to be redeveloped/relocated according to the owner's requirements and obligations.

In the following sections, a more detailed explanation can be found. Once an operator will be able to show that there is "no danger" from the site or parts of it, the operator can apply for de-licensing (that means: "ending of the period of responsibility under the Nuclear Installations Act") the whole site or parts of it by shrinking the site boundary [Ref. 5, prg 6, p.2].

The decommissioning of an UK ABWR will be carried out in a manner of reflecting UK and Europe's requirements and standards. Prompt decommissioning after the end of operation is the preferred option in UK with respect of making an effective use of land with local community.

Waste generated during decommissioning will be temporarily stored and processed on-site and may be sufficiently low in activity concentration for regulatory control to be fully or partly removed from site. Radioactive solid waste will be processed in accordance with the characteristics and classifications of UK guidance, regulations and requirements and transported for disposal at the appropriate site [Ref. 6, prg.7.26, p.30].

2.2.2 Standard Process for Decommissioning the UK ABWR

The future operator will have to develop a decommissioning process to cover the following aspects in corresponding documents:

- ✓ The scheduling and nature of the dismantling works and the facility final state.
- ✓ The origin, characterisation, quantity, treatment, packaging, transportation, disposal and recycling of nuclear waste and other kinds of waste as well as the management of the aforementioned based on the concept of the waste hierarchy.
- ✓ The risks to the public and workforce and the measures taken to detect, prevent, limit and progressively reduce such risks.
- ✓ The maintenance requirements for the facility and the auxiliary buildings during the dismantling phases.
- ✓ The on-site emergency plan.
- ✓ The predicted impact of dismantling and the facility final state on the environment.

For the UK ABWR, the decommissioning related logistical challenges presented by the reactor design need to be understood at the design stage, in order to be able to demonstrate the credibility of the baseline decommissioning strategy and that it will be possible to safely decommission both the reactor and the associated interim waste and SF storage facilities.

Section 5 of PCSR on Decommissioning, will present the strategic decommissioning options with respect to logistical challenges, envisaged sequence and methodology including considerations such as safety, decontamination, space, access, supporting systems and infrastructure requirements. It demonstrates how decommissioning can proceed throughout the plant allowing the contaminated equipment to be decontaminated and subsequently decommissioned safely, and also provides decommissioning principles and considerations for the Intermediate Level Waste (ILW) and SF Storage Facilities.

The decommissioning process consists of the following stages:

1) Preparation of Decommissioning
These preparations are carried out after final reactor shutdown (where measures have been taken to not re-start operation. Refer to the section 3.2.3 “Preparatory work” for detailed information.

2) Decommissioning
Since it involves the risk of radiation exposure, it is noted that safety is taken into place regarding workforces during decommissioning and the surrounding public of decommissioning facilities. However, since the risk of the decommissioning is reduced in accordance with the progress of decommissioning, the performance of the facilities and/or equipment for the suppression or decrease of radiation dose is adjusted in accordance of the risk.

3) End of decommissioning
The completion of decommissioning is regarded as when the site has been returned to the agreed end state. The agreed end state is expected to be a greenfield site. The safety rules under decommissioning are based on the radiation protection plan and labour safety which will be covered in more detail in the PCSR on “Radiation protection”. The decommissioning plan will be prepared in order to safely complete the decommissioning of the plant, to meet the defined final state and to carry it out safely and economically.

The following describes technical requirements of the decommissioning plan:

- ✓ Assessment of situation for the facilities to start decommissioning;
- ✓ Management and transfer of the SF;
- ✓ Works of decommissioning;
- ✓ Disposal of waste contaminated by nuclear fuel material;
- ✓ Safety management during decommissioning.

In addition, following basic policies for decommissioning are established prior to the technical review of the decommissioning plan:

- ✓ Laws and regulations to be respected and guidelines to be adapted;
- ✓ Radiation exposure to the workforce and the public (ALARP);
- ✓ Facilities and equipment to be maintained during decommissioning;
- ✓ Equipment to be adopted during decommissioning;
- ✓ Safety activities and Quality Assurance (QA).

Facilities to be decommissioned are defined from the layout plan of the plant in the application of construction permit and permission of change, and buildings and facilities to be decommissioned are identified. Land of any factory or office in the construction site, the permissions are defined for decommissioning. In case of installing multiple commercial nuclear reactor units on one site, the handling of shared facilities will be discussed where possible.

Considering the aforesaid, decommissioning works, area diagram and drawings related to the site of decommissioning such facilities will be prepared.

2.3 Design Principles Adopted in the UK ABWR to aid Decommissioning

This section identifies the underpinning principles adopted in the UK ABWR design to allow the plant to facilitate decommissioning [Ref. 7, prg 4.21, p.8] and wastes to be managed, based on the policy [Ref. 8, IWS, p.8-9]. These are closely related to the reduction of dose. These principles are as following:

- ✓ Minimisation of the volume of radioactive structures.
- ✓ Minimisation of the toxicity of the waste.
- ✓ Minimisation of the activity level of irradiated components.
- ✓ Minimisation of the spread of contamination.
- ✓ Allow for easier decontamination.
- ✓ Ease of access to components to dismantle.

- ✓ Limit radiation dose received by the workforce.

Dose reduction implicitly contains principles such as;

- ✓ Minimisation of the intensity of sources to which operators are exposed;
- ✓ Minimisation of the time spent in proximity to these sources;
- ✓ Facilitating the replacement and final removal of equipment.

Waste reduction implicitly contains principles such as:

- ✓ Maximising the recycling of materials;
- ✓ Minimising the quantities of waste difficult to dispose of;
- ✓ Minimising the production of secondary waste.

2.3.1 Design Requirement

The following criteria is being taken into account in the design stage of the UK ABWR to facilitate the later decommissioning of the plant:

- ✓ The choice of materials with a minimal propensity to become radioactive through activation, by avoiding in particular the use of materials containing high concentration levels of additives or impurities which are likely to generate gamma emitters and long-lived radionuclides after irradiation;
- ✓ The use of shielding and barriers which minimise the radiation from contamination of equipment;
- ✓ The choice of materials and design of systems and rooms which aim to minimise the creation, transportation and deposition of contamination;
- ✓ Design of access points in nuclear areas, handling equipment and access routes, and use of equipment which is easy to disassemble and protective devices which are easy to clean, with the objective of reducing the expected duration of exposure of workforce to radioactivity and contamination;
- ✓ Complete design and construction documentation, providing with the operating instructions an accurate inventory and location of the radioactive and other hazardous materials at the end of reactor operation, and a decommissioning plan.

Aforementioned criteria have been established to design the UK ABWR with decommissioning in mind. The following present some more detailed design features examples to facilitate UK ABWR decommissioning:

1) Reduction of radiation sources

a) Reduction of the activation element in the construction material [Ref. 4, sec. 6.3.2, p. 56-57]
So as to identify the elements that form the daughter radionuclide of a long and short half-life, the contents of those elements are controlled. Stainless steels and Ni-based alloys with low-Cobalt contents in contact with the reactor water are applied to the structure.

b) Selection of material [Ref. 4, sec. 6.3.2, p. 56-57]
Alternate material of Stellite® alloy is applied to the structure. (refer to the PCSR on Reactor Chemistry)

c) Primary coolant
Corrosion resistant tubes will be employed to the Condensate Treatment System (CTS) to prevent leakage by seawater.

d) SF assemblies
The SF assembly has a high reliability by considering the results of fuel failure experience.

2) Reduction of the degree of surface contamination

a) Adoption of concrete surface for ease of decontamination [Ref. 4, sec. 6.3.2, p. 56-57]
The concrete surface of a possible contamination will be coated. In addition, lining will be employed to the surface of fuel storage pool.

b) Pre-treatment of metal surface for prevention of contamination
Surface polishing of the metal in some system will be implemented.

c) Containment of leakages
Design, such as curvature of concrete floor, floor slope, double valve of drain pipe will be conducted. Also, to the floor and the area of possible contamination, waterproofing treatment is applied as needed.

3) Shortening the time of dismantling for radioactive equipment

a) Employees accessibility to equipment

Panel structure, block out structure and hatch are taken into account from the view point of maintenance during operation. Furthermore, during consideration of space requirements, the 95% of Western European people's size characteristics will be taking into account. Exchange space considering maintenance during operation will be secured, and considered the utilisation in decommissioning. Walls surrounding decommissioning area will be considered to remove and decommissioning work space will be secured. And, spaces after removal of the equipment and/or instruments will be considered to utilise in decommissioning.

4) Simplification of waste management

a) Temporary waste storage facility

Temporary storage area for waste during decommissioning is planned to use the space in the existing building.

b) Reduction of hazardous material usage [Ref. 6, prg 5.14, p.16]

In the material selection period during the design stage, it is as much as possible to avoid the use of hazardous materials, such as oil, flammable paints, fiber materials and asbestos.

By referring to the results of useful decommissioning research and projects being pursued internationally, the interface between the features of UK ABWR and future decommissioning will be considered. Japanese ABWR experience of large core internal exchanges in the periodic inspection of operating nuclear power station will also applied. Moreover, the design method based on maintenance experience may be useful for the decommissioning planning.

2.3.2 Dose Reduction

The collective and individual doses are reduced to ALARP. All of the factors which contribute to the dose are considered in the fulfillment of this target, particularly:

- ✓ The intensity of the sources to which the workforce are exposed;
- ✓ The time spent in close proximity to these sources;
- ✓ The maintenance of the contaminated equipment (dose and potential of internal contamination);

- ✓ The provision of protective measures such as shielding.

Internal contamination is avoided without relying on measures which involve a large increase in the time spent in controlled areas. All measures to keep doses ALARP are described in more detail in the PCSR on Radiation Protection and these are also valid during the decommissioning phase.

Radiation exposure to the workers in the radiation environment and the surrounding public will be reduced to the reasonably practicable level. A decommissioning plan will be established to maintain the necessary function with respect to radiation protection to the workers and public during the decommissioning phase [Ref. 6, prg 7.12-15, p.26-27].

The following dose reduction methods will be used:

1) Decrease of the external exposure will be achieved in accordance with the following basic principles :
   - ✓ Removal of radiation sources;
   - ✓ Keep distance from radiation sources;
   - ✓ Minimisation of radiation exposure time;
   - ✓ Shielding of radiation dose.

   In case of decommissioning work in the high radiation environment area, reduction of external radiation exposure can be achieved by: remote dismantling devices, shielding devices, decontamination prior to the work and protective equipment will be employed. In addition, by installing the area monitor (including the portable monitoring devices) to the work area that the radiation dose level is affected by the decommissioning work, radiation dose will be monitored in the work area.

2) Decrease of the internal exposure during decommissioning work will be achieved in accordance with the following basic principles:
   - ✓ Elimination of radioactive materials by filtering;
   - ✓ Prevention of radioactive material inhalation by restricted access;
   - ✓ Prevention of radioactive material inhalation by supply of Personal Protective Equipment (PPE), such as protective eyewear, full face mask, protector, globes;
   - ✓ Prevention against injury of the workers, such as puncture wounds, cuts and scrapes

   To prevent the internal exposure, work method to suppress the radioactive dust generation will be employed. And, installation of shielding to prevent the spread of contamination,

local filter, local exhaust fan and PPE will be used in the highly contaminated area.

2.3.3 Waste Reduction and Waste Hierarchy

To avoid redundant waste production, all methods of waste minimisation including decontamination, volume and size reduction and re-categorisation are considered, particularly, based on the concept of waste hierarchy [Ref. 6, prg.2.20, p. 6-7] [Ref. 8, prg. 5.2, p.5]:

- ✓ Maximum use of material recycling 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 fibrous and chemically reactive waste;
- ✓ Minimal production of 'secondary' waste (equipment contaminated during the operation phase and the decommissioning phase).

Uncertainties in waste characterisation are reduced to a minimum as they could otherwise lead to an unnecessarily high categorisation of waste; this applies, in particular, to the unjustified classification of conventional hazardous waste as radioactive waste.

The waste generated during the decommissioning will be processed in accordance with the UK guidance and legislation. The amount of waste will be reduced by separation, segregation, volume reduction, decontamination [Ref. 6, prg. 7.21-22, p.28-29] [Ref. 9, pgf 43, p.14].

To manage the dismantled waste and radioactive waste properly, a process facility for such dismantled waste will be installed. After separation in accordance to the level of radioactivity and processing, based on its characteristics, radioactive waste will be disposed to the appropriate site.

With regard to the waste that does not need to be treated as radioactive waste (including wastes generated from outside of an RCA), such waste will be re-use as much as possible, or disposed of as industrial wastes.

Furthermore, the increase of the amount of unnecessary ILW will be suppressed by inhibiting the generation of unidentified wastes. Especially, the amount of radioactive waste generation will be suppressed by classification of radioactive waste and non-radioactive waste.

Radioactive waste generated during decommissioning will be addressed in the Section 8 of PCSR on Decommissioning.

2.4 Influence of Operation and Maintenance on the Baseline Decommissioning Approach

This section identifies some of the principles that should be adopted by the licensee in the operation and maintenance of the plant, that could influence from or upon the baseline decommissioning approach.

The UK ABWR design provides for optimal operation and maintenance of the plant. This may also be beneficial for later decommissioning tasks. However, in addition to these design features (provision of space, minimisation of doses and minimisation of waste…) operators have to adopt principles during the O & M tasks in order to prepare for the plant's future decommissioning.

It starts with the availability of the required information about plant design by feasible knowledge and data transfer between the designer and the utility.

Next, a comprehensive training programme for the future operator of the UK ABWR to facilitate the development of knowledge, competences, skills and attitudes required for the safe operation of the nuclear power station. These programmes are in accordance with IAEA methodologies (further details are provided in section 9 of PCSR on Decommissioning).

Further considerations are given to:

- ✓ The need of plant configuration management;
- ✓ Complete and accurate records keeping (e.g. physical and radiological configuration, leaks and other contamination incidents) on the operational phase attendant base (more details are covered in section 9 of PCSR on Decommissioning).

As a result, updates of the decommissioning plan would have to be based on:

- ✓ Changes to the plant as recorded in the documentation (as-built documentation);
- ✓ Records of environmental monitoring (especially for the soil and groundwater);
- ✓ Site history from regular surveys;
- ✓ Maintenance works (identification of modifications/improvements from the initial design);
- ✓ Incidents (e.g. spills or releases).

Preservation of the records of the physical configuration during the whole life of the plant requires clear definition of the storage media for records and of long-term responsibilities for maintenance of the records. More details relating to preservation of knowledge and records are provided in Section 9 of PCSR on Decommissioning. In addition, involvement of members of the operating team in the preparation of the decommissioning plan and in future decommissioning needs to be considered and anticipated.

In order to complete these records, plant operators need to give special attention to allow, through systematic approaches, collection, analysis, recording and preservation of the information, in particular for dismantling experience and contamination events that could have an impact on the demolition of the concrete structure. In addition, good working practices have to be considered in order to deal immediately with contamination from spills and leakage, and to respect delineation of zones and barriers.

Moreover, principles adopted for the reactor design have to be adapted to the O & M work and during the design and implementation process of modification of the facility; indeed these tasks have to be completed having in mind to address material selection for reduced dose, good surface finishing to facilitate decontamination of materials and keeping accessibility for removal of plant components.

Baseline of the decommissioning approach is to reduce dose and remove contamination as soon as possible by proceeding removal of higher to lower activity, – for instance this takes account of the building layout by starting from the reactor building and advancing to the outside to the auxiliary buildings. Facilities such as workshops for repairs, decontamination, clean zones and ventilation are used for this purpose. The decommissioning strategy will be harmonised with other onsite strategies, if relevant, and performed as soon as it is reasonably practicable by considering pertinent factors. The decommissioning plan must be prepared and regularly updated to demonstrate continued safe decommissioning, including record keeping as mentioned before.

Finally, dismantling lessons from similar plants should be incorporated during the whole lifecycle of the plant. Inspection and replacement of the facilities and equipment required for safety are performed in the regular inspection to maintain the safe NPP operation. The experience of this maintenance will be planned to reflect the decommissioning activity.

Considering the enclosure of radioactive materials in the facilities, required performance and function will be maintained and managed in the necessary facilities to ensure the safety during the decommissioning period for the required period.

2.4.1 Maintenance Records

Records are to be created, maintained and stored in a proper method. The types of records are plant modifications, environmental monitoring, regular inspections, maintenances and emergency events.

Building, facilities and equipment that are used during operation will also be utilised during decommissioning. To satisfy the required functions for radiation protection in each stage of decommissioning, a decommissioning plan is established to make effective use of the building, facilities and equipment having a function of shielding and confinement that are used in operation. Additionally facility structure is designed to be suitable for shielding and avoidance of spread of contamination, therefore these structures will be effectively utilised during decommissioning. It will be helpful for the periodical review of the decommissioning plan to keep the performance and function of the building and facilities, and keep the maintenance records.

2.4.2 Environmental Radiation Monitoring

For the Environmental Impact Assessment (EIA) and dose exposure control of the public and workforce, continuous in-service environmental monitoring equipment, to measure samples and monitor the air dose, is installed in the peripheral boundary area and working area to make sure that there is no abnormality in the levels of radiation.

2.4.3 Utilisation of maintenance records for decommissioning

The design records of facilities, modification records and operation records shall be reflected in the periodical review process of the decommissioning plan. Also, the organisation responsible of the

decommissioning planning should be made up of staff familiar with the decommissioning target facility and those familiar with the plant operation and/or maintenance.

2.5 Operators Learning from Experience

During the whole lifecycle of the facility, principles will be in place to encourage and facilitate the operator to learn from experience, to exercise industrial good practice and to obtain guidance. These principles can include (but not only) some or all of the following [Ref. 10, Sec. 5.7, p. 17]:

- ✓ Employment of Suitably Qualified and Experienced Personnel (SQEP). In particular, suitable and sufficient capability to allow the Utility to function and act as an 'Intelligent Customer (IC)' will be demonstrated for work that is to be carried out. Competence needs for personnel responsible for undertaking decommissioning activities will be identified and personnel will receive suitable training for carrying out their duties. Special attention will be paid to train the personnel regarding awareness of working in a nuclear environment, radiation protection, and required caution concerning dose, contamination and reduction of exposure to these.
- ✓ Maintenance of knowledge of best practice in all aspects of decommissioning, in particular by:
    - ✓ Being members of collaborative organisations sharing good practice and experience (such as World Association of Nuclear Operators (WANO) and/ or Electric Power Research Institute (EPRI));
    - ✓ Participating in membership of collaborative Research and Development (R&D) organisations, such as the Nuclear Waste Research Forum (NWRF);
    - ✓ Undertaking information exchange visits to other decommissioning sites;
    - ✓ Employing suitably qualified and experienced suppliers to undertake studies and implementation of decommissioning;
    - ✓ Participating in national and international decommissioning conferences, seminars and workshops;

- ✓ Collaborating with international organisations such as IAEA, Organisation for Economic Co-operation and Development (OECD)- Nuclear Energy Agency (NEA) for example.

- ✓ An operational experience database will be maintained to record lessons learned within the organisation and internationally during the operational life of the site. Dismantling experience will be collected, analysed and recorded so that lessons learned during decommissioning activities get incorporated in the future, in particular for the other UK ABWR.

In order to execute balanced and effective decommissioning, selection of the techniques from a wide variety of elemental technology, based on a broad spectrum of information provided by engineers, is important.

In order to improve engineering techniques during decommissioning, the following is required [Ref. 11, Sec.4.9, p.13]:

- ✓ SQEP are to be maintained;
- ✓ Usability and continuous acquirement of the plant specific information, for example, continued employment of key staff with thorough knowledge of site-specific status, will be taken into account;
- ✓ Especially, it is desirable for the administration organization to employ staffs in charge of the following technical areas:
  - ✓ Safety requirements for approval and license;
  - ✓ Radiation protection / physical protection;
  - ✓ System engineering of nuclear reactor / engineering support;
  - ✓ Quality control / QA;
  - ✓ Fuel handling;
  - ✓ Decontamination;
  - ✓ Robot and remote operation;
  - ✓ Decommissioning and dismantling of the building;
  - ✓ Waste management based on the concept of waste hierarchy.

The technique of the operation period will be applied to the decommissioning period. At this time, it is desirable to organize the team from the specialists of decommissioning and regular site-visits in order to manage the decommissioning project.

A basic database of elemental technologies necessary to decommissioning will be developed In order to maintain the knowledge of institutional on facilities and to ensure the accessibility, a range of measures will be implemented.

Records and reports holding on decommissioning, such as, utilisation and maintenance of facilities, events and accidents, inventory of radionuclide, radiation dose and contamination level, techniques applicable to decommissioning, radioactive wastes based on the waste hierarchy [Ref. 6, prg 6.1, p.19].

Suitable systems for record holding will be utilised:

- ✓ Lessons learned from experiences on decommissioning of domestic and international NPP;
- ✓ Education and training to maintain and advance the techniques and skills required for decommissioning.

In order to maintain and improve the technical capability required to achieve nuclear safety, an education plan for staffs in charge of, including the contents of education and the schedule, will be set up and the educations will be provided according to the education plan.

The decommissioning plan will be prepared, reviewed periodically and maintained based on the records on the design information of facilities, modifications and operation history [Ref. 6, prg 5.8, p.14].

2.6 ALARP Consideration

The regulation of radiation protection in the UK is governed by the Ionising Radiation Regulations 1999 (IRR99) [Ref. 12] and UK Health and Safety Executive provides guidance about what they should expect to see in dutyholders demonstrations that the risk has been reduced ALARP. The ALARP approach regarding decommissioning has the objective to minimise the radiation exposure of personnel during decommissioning as far as possible. This objective needs to recognise the following basic principles:

- ✓ Justification
- ✓ Optimisation
- ✓ Limitation (Doses are ALARP)
- ✓ Minimisation

General principles and procedures which are regulated in the IRR99 especially in Regulation 8 "Restriction of exposure" give guidance on approved code of practice on this matter which results into an approach to a hierarchy of hazard control shortly called "ERICPD" that means:

- ✓ Eliminate
- ✓ Remove
- ✓ Isolate
- ✓ Control
- ✓ Personal Protective Equipment
- ✓ Discipline

The UK ABWR design has been the result of combining the proven features of Japanese ABWR and previous Boiling Water Reactor (BWR) designs. As such, all practical measures installed to keep doses ALARP will be investigated as to their effectiveness based on the experience of these plants. Design features will be retained to reduce the dose to operators and to minimise waste, when proven to be effective.

The main philosophy behind ALARP is that the features reducing or avoiding operational dose due to maintenance, are also those features which assist decommissioning processes. Design provisions specific to decommissioning alone include designing structures for long-term integrity and including features aimed at minimising infiltration, containing spills and releases, and attenuating contaminant transport. All of these are features of the UK ABWR design and will contribute to the ALARP consideration.

The most important activity throughout the decommissioning is to further ensure the safety and protection of public, workforce, plant and environment. Therefore, promotion of safety and protection of the environment will be promoted on the basis of the ALARP argument of exposure reduction [Ref. 11, sec. 2.1, p.4].

The risk in the decommissioning period is less than that in the operational phase because operation of the nuclear reactor end and the nuclear fuel is removed from the reactor core. The measures of safety required during operation are the functions to stop the nuclear reaction; remove the generated heat and confinement of the radioactive materials. On the other hand, the measures of safety required in the decommissioning period are confinement of the radioactive materials, shielding of the radiation dose and radioactive waste treatment.

One of the design concepts for UK ABWR is the reduction of radiation dose. Adopting the Reactor Internal Pump (RIP) in place of the recirculation pipes will achieve the reduction of radiation dose. This contributes greatly to be ALARP of the workforce in charge.

The RIP is the equipment attached at the bottom of the RPV and has a role for circulating the reactor cooling water. By adjusting the rotational speed of this internal pump, the flow rate and void coefficients in the reactor are changed and the reactor power can be controlled. In addition, the adoption of internal pump is effective for the workforce to reduce exposure dose in the periodic inspection.

Furthermore, the reduction of dose exposure to workforce in charge of decommissioning the components will be carried out by the decay of radioactive material, that include, the radioactive materials deposited inside the pipes and vessels which are eliminated by system decontamination and the dismantling of the equipment around reactor core that is carried out after the dismantlement of the facilities around reactor. In this case, the decommissioning works will be carried out on the basis of method and proceeding based on the radiation protection, such as time, distance and shielding.

With regard to the gaseous radioactive materials, decommissioning work plans will be established not to compromise the function of the prevention of external diffusion from facilities by constructing the shielding by the existing buildings and structures, keeping the airflow from outside of the building by the ventilation system.

In case that the function for prevention of the diffusion in the existing facilities cannot be maintained, the function will be secured by the temporary supporting equipment. In case that decommissioning work is executed in the highly contaminated area, the prevention for diffusion of contamination in the facilities would be maintained by installing an appropriate shielding, local filter and local exhaust fan.

Existing radioactive liquid waste treatment facility will be utilised for the radioactive liquid waste resulting from decommissioning. In installation of the radioactive liquid waste pre-treatment equipment, measures of diffusion prevention will be considered by installing the tanks and/or prevention equipment of overflow stream.

Management plan for radiation will include the following items:

- ✓ Area management
- ✓ Access control
- ✓ Passageway management
- ✓ Restricted access
- ✓ Exposure management
- ✓ Exposure reduction measures
- ✓ Radiation measurement
- ✓ Working environment monitoring

Considerations in developing the decommissioning plan are as follows:

- ✓ Detailed radiation management plan should be developed to be applicable to the decommissioning work.
- ✓ Radiation management plan should be developed to be applicable to the unexpected radiation change in working environment
- ✓ Radiation management plan should utilise the radiation management method and results applied to the past similar work in the decommissioning period.

Area management, restricted access, passageway management and access control plans will be developed.

- ✓ Radiation management plan should include the radiation dose, radioactive material limit in the environment and liquid, designation of RCA's according to the surface contamination level.
- ✓ Radiation management plan should include the flexibility to change an RCA according to the progress of decommissioning.

Radiation exposure dose should be managed by planning the level of radiation exposure dose according to the appropriate work method.

- ✓ Management of external exposure: external exposure for the workforce in charge will be planned to manage by dosimeter depending on the working environment according to the in-service management method.
- ✓ Management of internal exposure: internal exposure for the workforce in charge will be planned to manage by whole-body counter measurement and/or necessary measurement depending on the working environment according to the in-service management method.

- ✓ Appropriate measures of exposure dose reduction: Measures should be planned to reduce the exposure dose of the workforce in charge.
- ✓ Prevention of spreading radioactive contamination: Plan for prevention of spreading radioactive contamination will be developed by installing the shielding and a ventilation system to the area where the contamination is expected. Where surface contamination is expected, in order to prevent the contamination expanding: the contaminated area will be restricted; access to the contaminated area will be controlled; and exchange of the protective clothing and shoes, body contamination measures and contamination surveys will be performed.
- ✓ Radiation measurement: Radiation measurement will be planned by utilising the same equipment from the operation period.
- ✓ Monitoring the working environment: The radiation monitoring plan will be developed to monitor the radiation dose level in each working area by monitoring each decommissioning task alongside regular daily monitoring. In addition, radiation dose, radioactive material concentration and surface contamination density will be monitored before, during and after the decommissioning work.

Effluent management

- ✓ Release management of radioactive liquid wastes: A sample will be taken from the final waste tank of the effluent system, to measure the radioactivity concentration in the water. This measurement can confirm that the radioactivity of the liquid waste in the tank is under the restricted level, therefore allowing the radioactive liquid waste will be released from the site. In addition, the plan to release liquid waste while monitoring the radiation level from an outlet monitor will be developed.
- ✓ Environmental radiation monitoring: For the EIA and exposure dose estimation to the public, the environment abnormalities will be examined by measuring the radiation dose by environment monitoring equipment installed near the site boundary and environment samples.

In addition, the work safety is based on general industry standards, and the safety plan should consider the radiation protection in the RCA.

- ✓ In planning, consideration should be given to the radiation protection of workforce engaged in decommissioning work, as well as understanding the characteristics of the work environment, non-radiological risk (toxic substances, vapors or flammable liquids, noble metal, asbestos), that is, potential risks that lead to work-related

accidents, should be considered. Execution, assessment and improvement of the plan will be defined in the regulations according to the work safety and maintenance code.

3. Decommissioning Plans for the UK ABWR (Section 4 of PCSR on Decommissioning)

3.1 Introduction

This section presents the decommissioning plan and programme for the whole of the decommissioning period. The principles, presented in PCSR on Decommissioning section 3, of the development of the decommissioning plan are as follows.

- ✓ Corresponding to the UK guidance and legislation and the disposability assessment.
- ✓ Development of the decommissioning plan covering the whole decommissioning period, including the interim storage of radioactive waste

Decommissioning plans are based on what is currently technically feasible, as the decommissioning plan may need to be executed earlier then currently envisaged. And the decommissioning plan refers to the plant status at the end of operations and it should be reviewed taking into account future technological advancements as well as knowledge and experience gained through the plant's operational period.

The periodical review of the decommissioning plan will note the following:

- ✓ Definition of the organisation to advance the decommissioning activities and its responsibilities;
- ✓ Definition of the final state of the site prior to the decommissioning activities;
- ✓ Recommendation of the re-utilisation for other purpose of the existing buildings;
- ✓ Plan to reduce the radioactivity in order to reduce risk;
- ✓ Minimum treatment and transfer of the radioactive wastes;
- ✓ Re-utilise the industrial wastes as a restoration material to the extent possible.

Since technology advances during the years of decommissioning, it is not necessarily reasonable to establish the finalized decommissioning plan for the whole decommissioning period at the beginning stage. Therefore, when planning, it is assumed to secure the initial projection over the whole schedule. Also, before the beginning of each decommissioning step, the decommissioning plan for that and future steps will be reviewed with the latest information.

It is noted that decommissioning is ultimately the responsibility of the reactor operator and that, as such, the decommissioning plan that is presented in PCSR on Decommissioning can only be

indicative at the current stage of development of the life-cycle of the UK ABWR and is also generic rather than Site Specific.

Moreover, decommissioning is executed to achieve a safer state by dismantling facilities on the site, but it is essential to ensure a considered implementation so as not to lose the shielding function and/or spread contamination.

The outline of the plan and programme for decommissioning the UK ABWR in this chapter is as follows:

- ✓ Scope of the Decommissioning Plan for the UK ABWR.
- ✓ Assumption Underpinning the Baseline Decommissioning Plan.
  - ✓ Overview of the Scope of the Baseline Decommissioning Plan.
  - ✓ Pre-Closure Preparatory Work.
  - ✓ Fuel Management.
  - ✓ Site Operation and Plant Preparation.
  - ✓ Management of Radioactive Wastes.
  - ✓ Plant and Reactor Decommissioning.
  - ✓ Review of the Scope of the Decommissioning Plan for the UK ABWR.
- ✓ Overview of the Decommissioning Plan and Programme.
  - ✓ Overview of the Development of the Decommissioning Plan.
  - ✓ Baseline Decommissioning Plan for the Nuclear Island.
  - ✓ Baseline Decommissioning Plan for the Turbine Island.
  - ✓ Duration of UK ABWR Decommissioning.
  - ✓ Indicative Summary Programme for Decommissioning of the UK ABWR.
- ✓ Review of UK ABWR Decommissioning in the Context of Government and the Disposability Assessment.

3.2 Scope of the Decommissioning Plan for the UK ABWR

3.2.1 Assumptions Underpinning the Baseline Decommissioning Plan

To develop the decommissioning plan of the UK ABWR in this report the following have been assumed:

- ✓ 60 years operation period of UK ABWR.
- ✓ After determination of permanent shutdown, various decommissioning works will be conducted when possible. There is no period of care and maintenance to allow

radioactive decay, this strategy is referred to as prompt decommissioning.

- ✓ The timing of decommissioning will be discussed in Section 6 of PCSR on Decommissioning.
- ✓ Existing buildings and facilities will be utilised for decommissioning purposes.
- ✓ The walls of buildings will be utilised as shielding in dismantling.
- ✓ After the generation of Low Level Waste (LLW) / Very Low Level Waste (VLLW) and industrial waste, they will be disposed of immediately.
- ✓ ILW will be temporary stored in the site for a period, and they will be transferred to the waste disposal site. This will allow decay of a number of packages to LLW during the storage period, as discussed in Section 8 of the PCSR on Decommissioning: "Disposability Assessment".

3.2.2 Overview of the Scope of the Baseline Decommissioning Plan

The overall period covered by the baseline decommissioning plan commences with a stage of pre-closure preparatory work which starts prior to the End-of-Generations (EoG) and ends when all station buildings and facilities have been removed and for a specific site would end when the site has been returned to the agreed end state.

For the purpose of planning the decommissioning of the plant, the process is divided into a number of activities which form the basis of a Work Breakdown Structure (WBS). This defines the work packages and the activities, which need to be carried out to decommission the UK ABWR and manage the associated decommissioning wastes. The elements of the work, presented below, can be regarded as generic to decommissioning the UK ABWR, noting that the detailed WBS will be Site and Operator Specific. These are as follows:

- ✓ Pre-Closure Preparatory Work (Section 3.2.3).
- ✓ Fuel Management (Section 3.2.4).
- ✓ Site Operation and Plant Preparation (Section 3.2.5).
- ✓ Management of Radioactive Wastes (Section 3.2.6).
- ✓ Plant and Reactor Decommissioning (Section 3.2.7).

Before permanent shutdown of the UK ABWR, the decommissioning plan will be further developed and reviewed by utilising best practices and experiences from research results and decommissioning projects all over the world. Knowledge accumulated during the operation period, design information of the facilities and records of operation, reconstruction and maintenance will be incorporated into

the decommissioning planning to improve the UK ABWR decommissioning plan robustness.

The scope of the decommissioning plan covers the management, disposal of radioactive and hazardous wastes until all plant, facilities and buildings have been decommissioned and all wastes, including SF, have been removed from the site. The scope therefore addresses the NPP and the ISF's for SF and ILW, noting that the choice of methods of interim storage of ILW and SF is made by the operator.

During the operational life of the UK ABWR it is anticipated that there will be systematic reviews of the decommissioning plan to take account of operational experience, not only of the UK ABWR but also the decommissioning experience of other reactors.

The objectives of development of the decommissioning plan are to proceed through the decommissioning activities with; safe dismantling of facilities, safe removal of all plant, equipment and wastes (radioactive and non-radioactive) from the site, utilising methods for dismantling, decommissioning and waste management based on the waste hierarchy for the safety of all workforce, public and environment [Ref. 2, Sec. 8.5, p.15]. These activities include the following.

- ✓ Preparatory work related to decommissioning, see Section 3.2.3.
- ✓ The decommissioning plan will be developed by conducting system engineering and estimation of the amount of waste as well as the evaluation of activation and contamination. The development of decommissioning plan of the UK ABWR will be carried out by considering the following 3 viewpoints:
  - ✓ Actions in decommissioning
  - ✓ Notes on decommissioning
  - ✓ Safety of decommissioning

  These 3 viewpoints are closely related to each other and should be included in the overall planning of decommissioning.
- ✓ During the preparation of the decommissioning plan, the types and amounts of radioactive materials (activated and/or contaminated equipment and structures) in the facilities will be determined by the detailed specific survey and records accumulated during the operation period. In addition, the method and procedure of the radiation survey and contamination survey (including the evaluation) is clarified to determine the characteristics of the inside/outside surface of the equipment and components.

The following outlines the overview of the decommissioning plan for the UK ABWR:

- ✓ Stop operation of the reactor.
- ✓ Removal and management of the SF.
- ✓ Transfer of spent and unused fuels to the storage facilities.
- ✓ Reduction of the radioactivity before dismantling.

  In order to facilitate the subsequent dismantling, radioactive materials remaining in the pipes and container in the facilities will be removed as much as possible by chemicals.
- ✓ Maintenance and improvement of the infrastructure base in the site.

  Including the activities related to the site safety, site monitoring and maintenance activities.
- ✓ Decommissioning and dismantling.

  The decommissioning work will be started from a relatively low area of radioactive concentration. So as not to scatter outside the radioactive materials, pipes and containers are dismantled and removed first. In the air and water environment where necessary, cutting and removal of the structure by direct or remote method will be performed. Then, the elimination of the radioactive materials on the floors and walls of the buildings will be conducted. After the confirmation of the removal of the radioactive materials, dismantling of the building will be performed.
- ✓ Management of waste (including the radioactive wastes and general hazardous waste).

  Waste will be classified by its activity level and properly stored, treated and disposed based on the concept of waste hierarchy. In addition, the wastes will be treated such as decontamination and/or solidification after dismantling as necessary and disposed.
- ✓ Activities of recovery from contamination in the site.

  If necessary, contamination will be removed by soil survey in-site after dismantling and removal of nuclear facilities.
- ✓ Utilisation of the land after decommissioning.

  Through the legal process and confirmation of the safety, the land can be utilised for a variety of applications
- ✓ Return of the license.

The decommissioning plan includes the removal of SF and decommissioning of buildings and facilities in the UK ABWR, and covers the activities of decommissioning and management of wastes. The scope of the decommissioning plan includes the interim storage of the SF and ILW.

Overviews of the decommissioning plan including the contents of each scope of work will be described in the following sections. Since the decommissioning plan is reviewed on the basis of the

findings during operation, the current decommissioning plan cannot be based on the detailed specification of UK ABWR and the history of operation. However, this plan includes the baseline contents as expected for the future UK ABWR decommissioning activities. Information on decommissioning logistics is provided in Section 5 of PCSR on Decommissioning. Final site environment remediation and return of license is not included in the GDA process, therefore their contents are not fully detailed within this report. Site remediation and return of license will be the responsibility of the operator and licensee at the time of decommissioning.

3.2.3 Pre-Closure Preparatory Work

Decommissioning plan will be approved before permanent shutdown and "Pre-closure preparation period" is defined from the time of receiving the approval of the decommissioning plan to the time of permanent shutdown. It is assumed that detailed preparatory work for the shutdown and decommissioning of the UK ABWR will commence prior to EoG. The following are the main activities conducted during the pre-closure preparation period to obtain the necessary permissions/consents for decommissioning to proceed in a timely manner, to undertake preliminary studies of each unit:

- ✓ Revision of technical procedures.
- ✓ Preparation of storage measures for un-used systems.
- ✓ Establishment of system engineering.
- ✓ Evaluation of radioactivity inventory.
- ✓ Safety Assessment.

1) Revision of technical procedures

Safety provisions relating to decommissioning will be revised. Revision will be conducted for the change of organization, responsibilities and facility management associated with the end of plant operation and pre-closure preparation activities.

2) Preparation of storage measures for un-used systems

With regard to the safety management for un-used equipment, rationalization of the operation and maintenance management will be carried out after the plant operation. For example, the extraction and removal of remaining water, gas, oil and chemicals in the pipe and equipment, isolation of the power supply and control power supply to the equipment, extinction of alarm system, isolation of the air supply for control of equipment.

3) Establishment of system engineering

Optimum decommissioning plan will be developed by assessment of the accessibility of areas and by utilisation of the various data accumulated from the weight of the equipment, inventory of radioactivity with decommissioning system engineering.

4) Evaluation of radioactivity inventory

The accurate assessment of the activation level around the reactor and contamination density of equipment in the decommissioning period will be evaluated to assist in: the selection of the method, the evaluation of radiation dose exposure and the prediction of the amount of treatment and disposal for radioactive wastes.

Contamination of the radioactive materials in the facilities at decommissioning will be investigated. The investigation will be conducted by the collection of related documents and surveys to confirm the type, amount and distribution status of radioactive materials.

Planning and implementing the survey will be developed and performed by referring to the existing records and operation experiences, and report will be developed by summarising the information and data obtained during work evaluation. This report will help the development of radiation mapping during the decommissioning work, decontamination planning and selection of the dismantlement procedures (further detailed information will be provided in PCSR on Radiation Protection).

Based on the building, facilities, equipment, materials and operation history records during decommissioning, the type, amount and distribution of the remaining radioactive materials will be investigated, and representative sampling points at operational status in the building, facilities, equipment will be selected to evaluate the composition and concentration of remaining radioactive materials.

5) Safety assessment

In the decommissioning of nuclear facilities, it is important to consider the schedule, process and method considering the evaluation results of safety in decommissioning work and to the public, the effect of the accident in the process of planning [Ref. 6, prg. 3.7, p. 8-9].

i) Exposure dose assessment to the public

a) Exposure dose evaluation of public during decommissioning period

Exposure dose will be evaluated by using the release amount calculated by assuming the meteorological conditions, shielding to prevent the contamination expanding, function of the equipment for the elimination of radioactive materials, such as filters in the exhaust system. In addition, direct radiation dose and sky shine radiation dose from the storage wastes during decommissioning will be evaluated.

b) Exposure dose evaluation of public in the accident

Assuming the accident of maximum release of radioactive material and calculating the amount of release of radioactive material to the surrounding environment, radiation exposure dose with meteorological condition will be evaluated. It is noted not to confer risks of radiation exposure to the surrounding public by necessary taking actions.

ii) Dosimetry assessment of the radiation workers

Based on the decommissioning plan, total exposure dose of radiation workers will be evaluated prior to the decommissioning works.

Furthermore, the details of safety assessment report and environment assessment report cannot be prepared during the decommissioning plan preparation for UK ABWR. The future operator has the responsibility of the preparation of these documents.

3.2.4 Fuel Management

(This sub-section will be revised based on the PCSR on SF storage.)

After the permanent shutdown of the reactor, the following measures are taken, regarding the nuclear fuels [Ref. 13]:

- ✓ The defueling of the reactor and storage of SF in the Fuel Storage Facility (FSF).
- ✓ The operation of the FSF until complete emptying;
- ✓ The transfer of the SF from the FSF to the Spent Fuel Interim Storage Facility (SFISF).
- ✓ The operation of the SFISF.
- ✓ The emptying of the SFISF and transport of the SF to the appropriate site.

Nuclear fuel will be distinguished between SF and new fuel in various locations and the number of fuel assemblies will be clarified. The plan will be prepared not to bring new fuel assemblies to the facilities to be decommissioned.

Following EoG, removal of the SF from the reactor will commence as soon as practicable. The SF will be removed from the reactor and transferred to the Spent Fuel Facility (SFF) before transfer to the ISF. The duration of storage in the SFF will depend on the mode of subsequent interim storage of SF. In case that the nuclear fuels are stored in the storage facility on-site, the nuclear fuels will be managed by the operator.

In handling and storage of the nuclear fuel, the plan will be considered to maintain and manage the facility used during the operation period with the necessary function of criticality prevention, decay heat removal, shielding and confinement to keep the safety.

Facilities used to manage the storage of radioactive waste on-site are as follows:

- ✓ The SFF is provided as an integral part of the UK ABWR Containment Building. Once SF is sufficiently cooled, the SF is removed to make way for SF from on-going refuelling outages.
- ✓ A SFISF will be built on the site to accommodate this fuel.
- ✓ This facility will be sized to accommodate the whole lifetime arising's of fuel from the operation of the unit.
- ✓ These facilities will implement adequate arrangements for regular and systematic examination, inspection, maintenance and testing of all facilities which may affect safety. [Ref. 14, LC28]

With a decrease of decay heat of nuclear fuel material or quantity of nuclear fuel material stored or storage, these facilities with the necessary functions will be considered to reduce the size of facilities, and this plan will be reflected in the nuclear fuel management plan.

The plan for the storage facility will be prepared not to exceed the maximum storage capacity during decommissioning. In case that there are a number of nuclear facilities on-site, based on the plan in the permission and licensing documents, utilisation of the facility to store nuclear fuel will be prepared. If the fuel can be stored in the common facility, the management of nuclear fuel will be reflected in the decommissioning plan.

The volume of the SF has been estimated so that it can be safely processed and thus retrieved, packaged and transported to the appropriate site. In transferring the fuel the following will be considered:

- ✓ In case of SF, the treatment method will be applied to that in the PCSR on SF storage.
- ✓ If there are multiple nuclear facilities in one site, nuclear fuels will be transferred from the facilities to be decommissioned, and the management of the fuel will be transferred.

When it is impossible to ensure an appropriate site, the following options will be considered in preparing the decommissioning plan:

- ✓ Closure of the facilities with safe condition and maintain the condition (safe storage);
- ✓ Dismantlement of the facilities and store the generated wastes to the ISF's.

Diversion whole or part of the facility to the storage or treatment facility

3.2.5 Site Operation and Plant Preparation

The work to be undertaken also includes the preparation of the Nuclear Island (NI) for decommissioning and includes:

- ✓ Post Closure Plant Operation, including operational waste management;
- ✓ Making Safe Redundant Plant and Equipment;
- ✓ Decontamination;
- ✓ POCO
- ✓ Installation of the appropriate supporting systems;
- ✓ Site maintenance and operations during decommissioning.

Various systems are required to remain operational to maintain the safe operation of the plant as defueling, Fuel Building Storage Pool (FBSP) operation, associated operational waste management and other decommissioning work proceeds.

Decontamination will be carried out to reduce the deposited contamination within the components. To facilitate decommissioning and the removal of some of the services, new alternative services will be installed as necessary.

To suppress the exposure dose to the public and workforce, and to maintain the safety during the various work in the decommissioning process, the required functions in some facilities and equipment will be maintained and managed in a planned period.

To maintain and manage, the following measures will be conducted:

1) Required measures to safety [Ref. 6, prg. 5.14, p.16]

a) Measures to prevent the illegal access.
Measures will be taken to prevent illegal access of third party to the reactor facilities dismantled. Further, the controlled area will be separated based on the possibility of radiation exposure and measures for safety will be prepared. To prevent the unnecessary exposure of the workforce, measures of the restriction to the controlled are will be taken during the decommissioning.

b) Measures on maintenance of nuclear reactor facilities under dismantlement.
Consideration will be given for the prevention of the leakage of the radioactive material remaining in the system. Appropriate measures, such as the isolation and/or closure of the system, will be taken in the case of malfunction and/or erroneous operation. In this case, remained radioactive gaseous material and radioactive liquid material will be removed from the system as much as possible.

c) Radiation monitoring.
To confirm the appropriate management of radioactive materials released to the surrounding environment, radiation monitoring according to the management of radioactive material release from the nuclear facilities and surrounding environment will be conducted.

2) Maintenance of building and structures.
With regard to the buildings and structures with systems and equipment including radioactive materials, shielding is used to prevent the release of radioactive material out of the facilities will be maintained and managed until these systems and equipment are dismantled and removed.

3) Maintenance of facilities related to the storage and handling of nuclear fuel
In the period for storing the new fuel and SF in the FSF, fuel storage facilities will be maintained so as to satisfy the required performance.

4) Maintenance of facilities related to the disposal of radioactive waste

Disposal facilities for radioactive waste will be maintained and managed. Radiation monitoring of nuclear facilities inside and outside for equipment related to exposure management of radiation workers involved in the controlled area in the work related to the release and management of radioactive material to the environment will be properly maintained.

5) Maintenance of facilities related to radiation control

Facilities related to the radiation monitoring inside and outside of the NPP, the management of release of radioactive material to the environment and exposure management of workers in the RCA will be maintained.

6) Maintenance of other facilities necessary during dismantlement

a) Ventilation equipment

i) In case of storage of nuclear fuels and treatment of radioactive waste.

ii) In case of purification of the environment to reduce the radiation exposure to the workforce.

iii) In case of prevention of release of radioactive materials off-site and prevention of the transfer to the other RCA's where the possibility of radioactive dust will be generated during the dismantlement and removal.

b) Power facilities

Temporary power system with required capacity will be installed to maintain the safety of the nuclear facilities under dismantlement in case of commercial power supply loss.

c) Other equipment

Other supporting equipment (lighting equipment, auxiliary cooling equipment) for the required safety will be maintained to keep the appropriate function.

7) Fire protection

From the point of view of the prevention of radiation hazards, facilities for fire protection

will be maintained. Further, appropriate protective measures will be taken to the storage area for combustible materials to avoid fire.

8) Testing and inspection

To maintain the required function and performance to ensure the safety during the planned period, each equipment and measures for nuclear safety during decommissioning will be tested and inspected with an appropriate frequency.

9) Setting and cancellation of controlled area

a) Classification of controlled area

An RCA will be divided according to the radiation dose, the concentration of radioactive material in air and water, the level of the surface contamination density. And, radiation management will be conducted corresponding to the requirement of each zone.

b) Setting and cancellation of controlled area

With the decrease of radioactive inventory as a resource of risk depending on the progress of decommissioning work, required functions for radiation protection will be gradually reduced depending on the risk of radiation exposure. For this reason, features that have been determined to be unnecessary due to the progress of decommissioning will be considered for potential eliminating from management.

3.2.6 Management of Radioactive Wastes

This section describes the radioactive waste generated during the decommissioning period of the UK ABWR. This section includes the following contents:

- ✓ Types, treatment and disposal of radioactive waste generated during the decommissioning period.
- ✓ Interim storage area for radioactive waste in the NPP.
- ✓ The retrieval, processing, transport and disposal of the final amounts of operational wastes present in the UK ABWR at the time of EoG;
- ✓ The processing, transport and disposal of secondary ILW arising during decommissioning;

- ✓ The transport and disposal of ILW which arose during the operational period and has remained in storage following the EOG;
- ✓ The operation of the Effluent Treatment Building (ETB) to treat liquid effluents until key decommissioning tasks have been completed.

With regard to the radioactive gaseous waste and radioactive liquid waste generated from dismantling work, the wastes will be properly processed and released from exhaust tower, waste volume reduction processing unit building exhaust tower and condenser cooling water discharge channel, based on the related laws, regulations and basic policy for decommissioning. In addition, based on the public notice and the related laws and regulations involved, removal of solid materials generated by decontamination and decommissioning work will be planned to be properly managed and processed. [Ref. 6, prg. 7.25, p. 29-30] [Ref. 10, sec. 5.9.1.5, p.20]

1) Management and monitoring of radioactive gaseous waste

The radioactive gaseous waste generated in the decommissioning period will be classified based on the method of handling in-service, treated by the equipment for the elimination of the radioactive materials with local exhaust filter and building exhaust filter, and released from the exhaust tower, as well as gaseous radioactive waste generated during operation of the reactor.

The processing of radioactive gaseous waste is carried out by temporary or existing treatment facility. In case the equipment used in the operation period is then utilised in the decommissioning period, measures to maintain the required functions of the equipment will be taken. (For example, the release of the exhaust from R/B and/or T/B will be conducted through a high-particle performance filter.)

In release, measurement and monitoring of the radioactive materials, confirmation of the concentration level less than the required level will be planned.

2) Management and process for radioactive liquid waste

For radioactive liquid waste generated in the decommissioning period as well as the in the operation period, the process will be carried out regarding the treatment and disposal in accordance with the type and properties. The types of radioactive liquid waste (including that generated during the preparation period) are as follows:

- ✓ Equipment drain
- ✓ Floor drain regeneration effluent

- ✓ Washing waste liquid
- ✓ Shower drain
- ✓ Liquid waste from system decontamination
- ✓ Decontamination waste solution after dismantling

The treatment of the radioactive liquid waste will be processed by a temporary and/or existing waste treatment facility. In case the facility used in the operation period continues to be used in the decommissioning period, measures will be maintained of the required function for the treatment.

When the liquid waste is released to the environment from the liquid waste treatment system, the concentration of the radioactive level to confirm that the radioactive material concentration at the outlet will not exceed the required level from UK regulation and the target level of concentration in the liquid waste will be set to manage the release.

3) Management and process of radioactive solid waste

Radioactive solid waste generated in the decommissioning period will be processed and managed in accordance with its type and properties. The waste generated during normal operation of the NPP is processed during normal operation. The types of radioactive waste (including that generated during the decommissioning preparation period) will be listed below:

- ✓ Waste liquid concentrator for liquid waste in the liquid waste treatment system
- ✓ Spent resin generated from filtration demineralizer
- ✓ Flammable miscellaneous solid waste
- ✓ Non-flammable miscellaneous solid waste (metal waste)
- ✓ Spent resin generated by system decontamination; liquid waste treatment after decontamination
- ✓ Dismantling of equipment and structures.

4) The treatment plan for the radioactive waste will be prepared for the following treatment:

i) Volume reduction

Radioactive solid waste will be processed to reduce its volume in line with the waste hierarchy. The main volume reduction methods are incineration, compression and fusion, and will be selected for each waste on a case-by-case basis.

ii) Stabilisation

Radioactive waste to be stabilised in its chemical form (incineration of oils).

iii) Solidification

The solidification of radioactive waste will be planned based on the technical guideline for the radioactive materials to be disposed of.

The treatment of radioactive waste during the decommissioning period will be considered based on the survey results of the contamination situation in the facility, as well as the consideration of dismantling method and process. In addition, the handling method in each step, such as generation, treatment and storage of radioactive material, will be carried out in the facility to prevent the diffusion of radioactive materials, expansion of contamination and recontamination.

The objective of the decontamination for the waste during the dismantling is to reduce the amount of radioactive waste with high radioactivity concentration as far as reasonably practicable, to reduce the cost of disposal in decommissioning. Therefore, the decontamination method selection enables decontamination of the waste to the VLLW level, and the amount of secondary waste generated according to the decontamination is small. In addition, in examining the decontamination method, it is noted that the method will be consistence with the dismantling process, radiation measurement before and after the decontamination.

Through the decommissioning period, the amount of radioactive waste expected will be planned considering the dismantling and removal, treatment, storage, transfer and disposal not to exceed the capacity of the storage facility for radioactive waste, interim storage area, or any newly developed facility designated for the treatment of waste generated during dismantling.

In case that the storage of radioactive material in the facility is needed according to the treatment schedule, transfer schedule and the disposal site and temporary storage area will be set up or the dismantling and removal plan will be reviewed.

3.2.7 Plant and Reactor Decommissioning

This chapter shows an overview of the various buildings and representative facilities/equipment. The following buildings include the following structures/facilities/equipment that will be the target for dismantling:

- ✓ Main buildings (include Power Block).
  - ✓ Reactor building (R/B).
  - ✓ Control building (C/B).
  - ✓ Heat exchanger building (Hex/B).
  - ✓ Back-up building (B/B).
  - ✓ Filter vent building.
  - ✓ Turbine building (T/B).
  - ✓ Radioactive waste building (Rw/B).
  - ✓ Service building.
- ✓ Buildings and facilities related to storage.
- ✓ Buildings and facilities related to water treatment.
- ✓ Buildings and facilities related to electric components.
- ✓ Other auxiliary buildings and facilities.
- ✓ Buildings and facilities related to office.

3.2.7.1 Preliminary / Enabling works

The whole plant and all of the equipment will have been isolated, drained or vented and made safe prior to its decommissioning, as part of Site Operation and Plant Preparation. A number of activities will have already been carried out after EoG in preparation for plant and reactor decommissioning, including the making safe of redundant plant equipment and systems and the provision of new supporting systems. There may however be residual radiological, chemical or other hazards which must be addressed during the decommissioning process.

However, other enabling works will also need to be carried out before NI decommissioning can be started. This will include the construction of a facility to process waste during decommissioning for the size reduction and packaging of wastes arising from decommissioning of the NI.

3.2.7.2 Decommissioning of NPP

(a) Decommissioning work Plan

Dismantling plan will be developed in carrying out the buildings and facilities in the NPP. In the dismantling plan, the dismantling work, target facilities and names of the equipment and instruments will be clarified. The dismantling work, for example, the isolation of the facility, equipment and instruments; the reduction of the radiation level; decontamination work; and other dismantling work

will be carried out prior to later works.

In particular, decommissioning work in the contaminated area will be considered depending on the degree of contamination to reduce the total radiation dose of the workforce ALARP.

(b) Process of decommissioning work

During the decommissioning work for the buildings, facilities and equipment, the buildings will be demolished after the removal of facilities and equipment and removal of the controlled area status after decontamination inside the building. Radiation sources of high radiation dose and radioactivity level will be removed as soon as practicable in the decommissioning schedule for the facilities and equipment.

In addition, to prevent the increase of contamination by the transporting radioactive materials, the target facilities and decommissioning process will be planned to prevent the spread of contamination by segregating the contaminated items and non-contaminated items in the facilities.

In the dismantlement of large items, such as the RPV and reactor components, equipment surrounding the large items will be dismantled in advance to improve the workability. In addition, since it is also important to ensure the safety of the facility, utility equipment will be considered regarding the optimal timing of removal.

(c) Decontamination in decommissioning

Decontamination will be performed to the contaminated parts prior to the dismantling as follows:

- ✓ Contaminated wall and/or floor will be removed by a chosen chemical decontamination method or the surface of contaminated part will be removed by a chosen mechanical decontamination method.
- ✓ Contaminated wall and/or floor will be removed by a chosen physical decontamination method.

In this case, radiation measurement technique is important to evaluate the remaining radioactivity in the building after the removal of equipment and after the demolition of the building. Remaining radiation measurement will be performed to confirm the distribution of contamination on the surface of the building after the removal of equipment. And, radioactivity measurement will be performed to the contaminated part to evaluate the penetration depth of the contamination. Then, after the removal of the contaminated part, radioactivity will be measured to confirm the remaining contamination.

(d) Decommissioning method

Appropriate method of decommissioning work will be selected considering the working environment and reduction of exposure dose during the decommissioning work by preventing the generation of radioactive dust as far as practicable. A workable and reliable dismantlement method will be selected suitable for the applied facilities, equipment and instruments. An appropriate decommissioning method will be selected considering the reduction of secondary waste generation and processing required.

It is possible to dismantle non-contaminated or very low level contaminated equipment in a relatively early stage, the decay time of radioactivity of the highly activated and contaminated equipment can be ensured accordingly.

Further, it is important from an environmental point of view to minimise the waste generated during decommissioning and to achieve effective minimisation. In addition, it is essential for the final stage of decommissioning to measure and evaluate the residual radionuclide concentration. Target measurement samples are the building concrete before the cancellation of the controlled area and land soil after the removal of the building. It is essential to conduct the prompt measurement and evaluation.

3.2.7.3 Dismantlement of the reactor core

The dismantling and removal work for the metal structures and equipment will be conducted prior to the dismantlement of the building. Dismantling the reactor core tends to be more difficult due to the thickness of the object in the high radiation environment. Accordingly, in the dismantling of the RPV and core internals, the remote cutting method under water will be employed to reduce the radiation dose. In addition, the combination of the remote operation technique, thermal cutting technologies and the latest mechanical cutting method will be considered.
The dismantling of the following large components will be described in detail below:

(a) Dismantling dryer and separator

Remove the bolts and other parts by remote controlled technique from the RPV, the overhead crane and temporarily placed in the dryer separator pit, and then will be dismantled by the thermal cutting method.

(b) Dismantling other reactor internals

With regard to the reactor internals, such as the top guide, core shroud, core support plate and core spray pipe, those instruments will be roughly cut within the RPV in the water, and after transferring the components to the dryer separator pit by overhead crane detailed cutting will be carried out under the water.

(c) Dismantling of the RPV

Dismantling the RPV will take place after disconnection by cutting the RPV connection pipe, and rough cutting of the container body. Then transferring the RPV to a dryer separator pit using the overhead crane, detailed cutting will be carried out under water.

In the cutting process, the shielding and local ventilation system will be installed to prevent spread of radioactive dust during the cutting process of the equipment, and radiation dose will be monitored by the portable and fixed area dust monitor.

3.2.7.4 Other equipment of NPPs

(a) Dismantling of shielding

The mechanical cutting will be conducted by remote control, and cut pieces will be transported to the operation floor to perform the mechanical cutting to a size that can be stored in the waste container.

(b) Removal of the radioactive equipment

Such radioactive equipment as: reactor cooling system facilities, coolant circulation system, main steam system and Feed Water System (FWS). The equipment will be dismantled by cutting in the air or under water.

(c) Dismantling of the waste disposal and treatment facilities for radioactive liquid and solid waste

Such waste disposal and treatment facilities equipment as: treatment facility and Off-Gas (OG) system for radioactive gaseous waste, treatment facility, Low Conductivity Liquid Waste (LCW) treatment, High Conductivity Liquid Waste (HCW) treatment, washing waste liquid treatment system, storage facility, sludge storage facility, spent resin storage tank and concentrated liquid waste storage. This equipment will be dismantled by cutting in air or under water.

In order to dismantle the contaminated concrete structure, remote operation and performance

classification of the thick concrete waste depending on their radiation level for disposal are required. Therefore, dismantling of the concrete requires advanced technology. On the other hand, most of the concrete structure to be dismantled after the cancellation of controlled area are thick and contain reinforced steels.

3.2.7.5 Dismantling of nuclear power buildings

Dismantling the buildings will be conducted after the completion of the removal of facilities and equipment in the building and cancellation of the controlled area. Concrete wastes generated are categorized as general waste. Floors and walls of each building after the cancellation of the controlled area will be demolished in addition to demolishing method used for general buildings.

3.2.7.6 De-planting and decommissioning of the ILW ISF

On completion of the task to remove all waste packages, the facility will be closed. All operational systems will be made safe and a commensurate radiological survey undertaken. It is assumed that the facility will be contamination free, thus requiring only the safe employment of conventional de-planting and decommissioning methods.
The scope of this work will include:

- ✓ Making safe operational systems;
- ✓ Radiological survey;
- ✓ Removal of hazardous materials;
- ✓ Removal of plant and equipment;
- ✓ Building decommissioning;
- ✓ Recycling of materials for re-use where applicable;
- ✓ Disposal of wastes off-site.

3.2.7.7 Spent Fuel Interim Storage Facility (SF ISF)

It is assumed that SF will be stored after the first SF assembly is transferred from the fuel building into the SF ISF. Once the transfer of the SF from site for disposal has been completed, then the SF ISF will be decommissioned. The scope of work will depend on whether the facility is based on different storage types of SF.

3.2.7.8 Removal of the non-radioactive equipment

These are as follows: the control system facility (measurement equipment), other reactor auxiliary facility, pure water facility, power receiving equipment. This equipment will be dismantled by cutting in air or under water.

3.2.7.9 Removal of ventilation equipment

These are as follows: the supply and exhaust equipment, exhaust tower, duct, blower, exhaust fan, purification equipment and filter for radioactive liquid waste. This equipment will be disassembled and dismantled.

3.2.7.10 Balance of Plant (BoP)

The BoP includes the ancillary buildings, plant, equipment and facilities supporting the operation of each unit, and the common facilities such as workshops, offices, welfare and other miscellaneous buildings and facilities on the site. The aforesaid will have been made safe as part of Site Operation and Plant Preparation. The scope of work for decommissioning the BoP is as follows:

- ✓ Removal of fixtures, fittings, services and temporary structures;
- ✓ Decommissioning of buildings and removal of structures;
- ✓ Backfilling of decommissioning voids with inert, uncontaminated material;
- ✓ Removal of roads, hard standings, pipe and cable trenches;

3.2.8 Review of the Scope of the Overall Decommissioning Plan for the UK ABWR

The contents described in the Sub-section 3.2.1 through the Sub-section 3.2.7 show the whole plan of decommissioning for the UK ABWR, including the decommissioning of the SF and ILW ISF in addition to the nuclear and conventional islands and the BoP.

The scope of the plan includes management of the decommissioning projects as follows:

- ✓ Site management plan;
- ✓ Measures for safety and radiation protection;
- ✓ Management plan for waste based on the concept of waste hierarchy (including the storage facility for waste);

- ✓ Record keeping and documentation;
- ✓ Safety assessment and environment assessment, and associated standards;
- ✓ Surveillance measures in the implementation stage;
- ✓ Specific requirements from regulatory authorities (including ONR and EA) and protective measures if necessary.

This plan will be reconsidered and reviewed periodically before the implementation stage of decommissioning, and the final version of the decommissioning plan will be prepared to submit for the approval and acceptance from the ONR when appropriate [Ref. 6, prg. 5.9, p.14].

3.3 Overview of the Decommissioning Plan and Programme

3.3.1 Overview of the Development of the Decommissioning Plan

Decommissioning plan for the UK ABWR was planned considering the following safety issues:

- ✓ Measures to reduce the radiation exposure of the workforce and public.
- ✓ Dismantling of the facility with the methods of the appropriate maintenance of nuclear facilities necessary for safety in dismantling.
- ✓ Processing, management and disposal of radioactive waste.

The development of the decommissioning plan for the UK ABWR has taken into account the reactor dismantling operations performed in available ABWRs and a number of countries with BWRs, with a view to selecting dismantling techniques and assessment of durations for the decommissioning in accordance with BAT.

3.3.2 Baseline Decommissioning Plan for the Nuclear Island

The baseline decommissioning plan is described in the Section 5 of PCSR on Decommissioning and addresses the following:

- ✓ Description of the Decommissioning Scenario.
- ✓ Shielding and Containment Requirements.
- ✓ Potential Decontamination Strategy.
- ✓ Decontamination Strategy during Post-Operation Clean Out.
- ✓ Reduction of Hazards during Decommissioning.
- ✓ Technology Option (Current or to be Validated).

- ✓ Strategy for Safety Systems.
- ✓ Prevention of Land Contamination.

This section shows the steps of decommissioning; the process of dismantling in an environmentally and safely compatible manner.

The procedure for decommissioning covers the decommissioning scenario (status of the plant, processes, methods, scenario of decommissioning and end state of the plant), and is reflected in the required safety cases, such as reduction of the workforce exposure dose. This section regarding the decommissioning process includes the techniques expected to utilise to the current and future decommissioning projects.

3.3.3 Baseline Decommissioning Plan for the Turbine Island

Baseline decommissioning steps for the T/B will be shown in Section 5 in PCSR on Decommissioning. As part of the decommissioning, after the removal of the equipment inside the T/B, the use of the T/B will be changed to the facility for the treatment of radioactive waste generated during the decommissioning and/or the radiation measurement for the waste. For this reason, demolition of the T/B is carried out in the latter half of the decommissioning process.

After the radioactivity measurement of radioactive waste generated during decommissioning has been completed, demolition of the T/B is carried out. The demolition will be carried out in a safe manner regarding the environment as well as other buildings and facilities. In addition, the requirements relating to the safety and reduction of exposure to workforce during decommissioning are reflected in the demolition plan.

3.3.4 Duration of UK ABWR Decommissioning

The duration of the UK ABWR decommissioning is expected to be a period of about 20 years from permanent shutdown to the SF removal, system decontamination, dismantlement and removal considering the planned duration of decommissioning for Japanese commercial NPP.

In order to clarify the process of work carried out during decommissioning, the flow diagram relating the each dismantling work will be shown. The schedule of decommissioning shown in the flow diagram is described to clarify the implementation period of the following process:

- ✓ Target facilities for dismantling and method of dismantling;
- ✓ Decontamination of the radioactive materials;
- ✓ Dismantling of facilities in the decommissioning and waste treatment and disposal site;
- ✓ Site release.

During the time before the completion of SF removal from the facilities to be decommissioned, decommissioning works will be carried out not to affect the safety function of the NPP.

At the current stage of development of the UK ABWR, this is considered to be appropriate in the aforesaid decommissioning period and it is anticipated that the programme of safety and environmental submissions will be further developed by the operator during the lifecycle of the reactor, taking account of the interdependencies between systems that maintain safety during decommissioning. The decommissioning period for providing safe decommissioning has been considered and will be developed further by the operator during plant operation. Review of the decommissioning duration will be carried out continuously based on the experiences of decommissioning of other ABWR's.

3.3.5 Indicative Summary Programme for Decommissioning of the UK ABWR

The production of a fully detailed schedule for decommissioning is not considered to be necessary at the current stage of development of the lifecycle of the UK ABWR for the GDA and will be the responsibility of the operator.

The information presented in Sub-sections 3.3.2, 3.3.3, 3.3.4 has been used to produce a summary programme for the main elements. The timescale for the decommissioning stage of the UK ABWR is defined relative to the commencement of operation of a UK ABWR plant. The letter of compliance process for the different wastes is provided in accordance with what is presented in the case study for disposability assessment of SF and ILW.

Safety and Environmental applications are part of the plant lifecycle; i.e. at each of the phases (design, construction, commissioning, operation and decommissioning) submissions will be prepared with the most up to date information, to obtain from the regulators the consent to start the new phase.

3.3.6 Review of the UK ABWR Decommissioning in the Context of Government Policy and the Disposability Assessment

This section describes the review of the duration and assumptions considered in the development of the decommissioning plan for the UK ABWR based on the UK policy for the radioactive waste shown in the Section 2 of PCSR on Decommissioning, treatment and disposal for the radioactive waste and SF generated in the operation period (Section 8 of PCSR on Decommissioning).

It is planned that the various radioactive waste, SF and waste generated during decommissioning will be described in Section 8 of PCSR on Decommissioning. The decommissioning plan and the period of decommissioning are developed to match the waste disposal policy and UK government policy for safe and secure storage of SF and medium-level radioactive waste.

4. References

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