OSPAR COMMISSION

Assessment of the 5th Round of Reporting on the Implementation of PARCOM Recommendation 91/4 on Radioactive Discharges

Radioactive Substances Series

2012

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. The Contracting Parties are Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998.
Les Parties contractantes sont l'Allemagne, la Belgique, le Danemark, l'Espagne, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède, la Suisse et l'Union européenne.

Acknowledgement

This report has been prepared by Ms Ingeborg Krol for Germany as lead country.

Contents

Executive Summary

This report confirms that the commitment of all OSPAR Contracting Parties to use 'Best Available Technology' (BAT), for ***'minimizing and, as appropriate, eliminating'*** radioactive pollution from nuclear industries, has been successfully transferred into legal regulations and operational systems. In line with the results of the 4th round of reporting on the implementation of PARCOM Recommendation 91/4 on radioactive discharges, there have been clear indications for a general downward trend in radioactive discharges besides H-3, which suggests that the objective of this commitment clearly works in the right direction.

This report provides a detailed overview of the assessment of the 5th round of reporting on the implementation of PARCOM Recommendation 91/4 on radioactive discharges. The main objective of this report was to review and to document the information provided by the Contracting Parties in their implementation reports in order to

- assess the effectiveness of the implementation of BAT in nuclear facilities by each Contracting Party and overall;
- conclude on Contracting Parties' implementation, including identification of abatement techniques adopted and consideration of whether these constitute BAT;
- assess the effectiveness of measures taken to implement BAT and to make recommendations for the next reporting round.

From all the information provided in the reports, it was possible to conclude that, in general

- BAT is implemented in Contracting Parties' national legislation and regulations,
- operational management systems are in place to prevent, eliminate or reduce liquid waste,
- the abatement techniques applied for liquid discharges are consistent with international reports from e. g. NEA and IAEA on best practice and
- there have been reductions in radioactive discharges and some evidence that these reductions arise from actions taken to reduce discharges rather than from differences in the production of electricity.

Detailed recommendations for the next round of reporting are:

- Further improvement of the reporting Guidelines and associated BAT performance indicators to facilitate their consistent use and encourage information exchange on BAT documentation and decision-making.
- A clear definition of discharges from decommissioning operations considering in particular future procedures.
- A clear definition of the relevance of aerial emissions in general.
- A clear definition which environmental information is relevant for the objectives of OSPAR and has to be reported by the Contracting Parties.

Introduction

Background

In **PARCOM Recommendation 91/4** on radioactive discharges, the Contracting Parties of the OSPAR Convention agreed

"*To respect the relevant Recommendations of international organizations and to apply the Best Available Technology to minimize and, as appropriate, eliminate any pollution caused by radioactive discharge from all nuclear industries, including research reactors and reprocessing plants, into the marine environment*."

Furthermore all Contracting Parties agreed to present ***a statement on progress made in applying such technology every four years***. In accordance to Appendix 1 of the OSPAR Convention, the Best Available Technology for the purposes of OSPAR is defined as follows:

BEST AVAILABLE TECHNOLOGY

1. The use of the Best Available Technology shall emphasise the use of non-waste technology, if available.

2. The term "Best Available Technology" means the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste. In determining whether a set of processes, facilities and methods of operation constitute the best available techniques in general or individual cases, special consideration shall be given to

(a) comparable processes, facilities or methods of operation which have recently been successfully tried out,
(b) technological advances and changes in scientific knowledge and understanding,
(c) the economic feasibility of such techniques,
(d) time limits for installation in both new and existing plants and
(e) the nature and volume of the discharges and emissions concerned.

In addition the **OSPAR Radioactive Substances Strategy**, as amended at the second Ministerial meeting of the OSPAR Commission, provides that:

"*…the objective of the Commission with regard to radioactive substances, including waste, is to prevent pollution of the maritime area from ionizing radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of concentrations in the environment near background levels for naturally occurring radioactive substances and close to zero for artificial radioactive substances. In achieving this objective, the following issues should, inter alia, be taken into account:*

- *Legitimate uses of the sea;*
- *Technical feasibility;*
- *Radiological impacts on man and biota."*

Implementation reports

The OSPAR Commission already published two reports on the "Implementation of PARCOM Recommendation 91/4 on Radioactive Discharges" in the years 2003 and 2008 (accompanied by documents 2003 No. 175 / ISBN 1-904426-21-2 and 2008 No. 351 / ISBN 978-1-905859-90-0). Within this third report the assessment of the 5th round of reporting on the implementation of PARCOM Recommendation 91/4, in accordance with the revised guidelines with the reference number 2004-03, is presented. The reporting periods of the Contracting Party are listed in **table 1** and covers in some cases a time period of more than the required four years. All implementation reports, which are referenced in **ANNEX 2**, include *inter alia* general information regarding national arrangements for the implementation of BAT, site-specific details of radioactive waste management processes, abatement technologies, discharges and environmental monitoring information and data.

Table 1: Contracting Parties Reporting in 5th Round and their Reporting Periods

Contracting Party	Reporting period	Contracting Party	Reporting period
Belgium	1998 - 2009	**Portugal**[1]	
Denmark[1]		**Spain**	2003 - 2009
France	2000 - 2008	**Sweden**	2001 - 2007
Germany	2003 - 2008	**Switzerland**	2003 - 2008
The Netherlands	1998 - 2007	**United Kingdom**	2001 - 2007
Norway	2003 - 2008		

Objectives and Approach

The main objectives and approach for this assessment were primarily based on recommendations developed during the Radioactive Substances Committee Meeting 2008 (RSC 2008, Agenda Item 5). The objectives were to

- assess the effectiveness of the implementation of BAT in nuclear facilities by each Contracting Party and overall (with focus on BAT),
- conclude on Contracting Parties' implementation, including identification of abatement techniques adopted and consideration of whether these constitute BAT and
- assess the effectiveness of measures taken to implement BAT and to make recommendations for the next implementation reporting round.

Information relating to

- national procedures for the implementation of BAT and
- radioactive discharges and waste management processes and abatement techniques used by the individual Contracting Parties has been selected from their implementation reports (see **Annex 2**).

[1] It was agreed that the reports from Denmark and Portugal be included in this assessment, although representatives of these Contracting Parties were not in attendance at the Radioactive Substances Committee meeting to present their reports. Therefore these reports do not currently appear on the OSPAR website.

Structure of this report

Following the introduction, **Section 2** provides information on the Compliance of the reporting requirements and the guidelines by the Contracting Parties. **Section 3** deals with the Effectiveness of Implementation of BAT within the General Information and **Section 4** with the Effectiveness of Implementation of BAT within the Site Specific information. Conclusions and the Recommendations for the next reporting period are provided in **Section 5**.

The annexes of this report are structured as follows:

Annex 1: Guidelines for the Submission of Information about, and Assessment of, the Application of BAT in Nuclear Facilities (2004-03);

Annex 2: List of all National Implementation reports submitted in the 5th round of reporting;

Annex 3: Summary of General Information Implementation of BAT / BEP in national legislation / regulation;

Annex 4: Summary of General Information – Dose constraints / limits for nuclear facilities;

Annex 5: Summary of General Information – Discharge limits;

Annex 6: Summary of General Information – Nature of inspection and surveillance programs;

Annex 7: Summary of Site-Specific Information – Site Characteristics;

Annex 8: Summary of Site-Specific Information – Discharges;

Annex 9: Summary of Site-Specific Information – Environmental Impact;

Annex 10: Summary of Site-Specific Information – Radiation Doses to the Public.

Compliance with Reporting Requirements and Guidelines

The Guidelines

The Guidelines for Submission of Information about, and the Assessment of, the Application of BAT in Nuclear Facilities (2004-03) are documented in **Annex 1**. Some of the key requirements are mentioned below.

General information regarding the implementation of BAT in national legislation or regulation is required, with a focus on new legislation in place since the last round of reporting. In addition, specific information regarding each nuclear facility is also requested including systems in place to reduce, prevent or eliminate discharges of radioactive substances to the marine environment and the nature and efficiency of abatement systems. To support the reporting of the Contracting Parties in an effective way, **Appendix I** of 2004-03 includes a template for the documentation of the management and abatement systems in place. Information on liquid discharges, emissions to air of concern for the marine environment, environmental monitoring programmes and concentrations in water, sediment and fish and dose assessment information are also required.

For the assessment of the effectiveness of the implementation of BAT, especially the following indicators are essential:

- Systems in place to reduce, prevent or eliminate discharges of radioactive substances;
- Decontamination or abatement factors or other measures of the efficiency of abatement systems;
- Downward trends in discharges, environmental concentrations and critical group doses;
- Relevance of the environmental monitoring programme and target values.

Compliance with the Guidelines

Information was generally presented within the overall format of the Guidelines (2004-03). However, in line with the previous rounds of reporting, not all of the Contracting Parties submitted all of the information requested. A brief summary of the content of the national implementation reports, in comparison to key headings in the Guidelines, is given in **Table 2**. More detailed information on the key issues "***Implementation of BAT / BEP in National Regulations and National Arrangements***", "***Discharge Limits***", "***Dose Constraints / Limits for Nuclear Installations***" and "***Nature of Inspection and Surveillance Programs***" are provided in **Section 3**.

Table 2: Summary of Information reported in the Contracting Parties' Implementation Reports related to Guideline Headings

Contracting Party	General Information	Implementation of BAT/BEP	Dose constraints/limits for nuclear facilities	Discharge limits	Monitoring programs of environmental concentrations of radionuclide	Environmental norms and standards	National authority responsible for supervision	Nature of inspection and surveillance programs
Belgium	✓	✓	✓	✓	✓	✓	✓	✓
Denmark								
France	✓	✓	✓	✓	✓	✓	✓	✓
Germany	✓	✓	✓	✓	✓	✓	✓	✓
The Netherlands	✓	✓	✓	✓	✓	✓	✓	✓
Norway	✓	✓	✓	✓	✓	✓	✓	✓
Portugal								
Spain	✓	✓	✓	✓	✓	✓	✓	✓
Sweden	✓	✓	✓	✓	✓	✓	✓	✓
Switzerland	✓	✓	✓	✓	✓	✓	✓	✓
UK	✓	✓	✓	✓	✓	✓	✓	✓

Conclusion

The Radioactive Substances Committee (RSC), outlined in the Summary Records of their meetings, agreed, that with respect to the implementation of PARCOM Recommendation 91/4

- the Contracting Parties had fulfilled the reporting requirements[2],
- the reports were in line with the guidelines (2004-03) and
- the information presented included indications that BAT had been applied in the nuclear installations of the Contracting Parties.

[2] Two Contracting Parties (Denmark and Portugal) did not attend the RSC meetings to present their reports. The RSC was therefore not in a position to make a decision on these reports.

Effectiveness of Implementation of BAT in General Information

As outlined in **Section 2.2**, there are four key elements involved in the assessment of the effectiveness of the implementation of BAT in this report:

- Implementation of BAT/BEP in National Regulations and National Arrangements;
- Discharge Limits;
- Dose Constraints/Limits for Nuclear Installations;
- Nature of Inspection and Surveillance Programs.

Each issue will be considered in detail in the following sections.

National Arrangements for Implementation of BAT

According to the Guidelines (2004-03) all the Contracting Parties has to include general information on the implementation of BAT/BEP in their national legislation and regulation in the national implementation reports. The information of each Contracting Party was reviewed and documented in the **ANNEX 3**. With the exception of Denmark and Portugal all other Contracting Parties provided a clear overview on their regulations and the implementation of BAT/BEP since 2000 or earlier. The processes for establishing and reviewing BAT/BEP seem to work in the right way. All the reports gave a clear indication, that the processes for establishing and reviewing of BAT appear to be well established.

The arrangement cited below was taken over from the 4th round of reporting on the implementation of PARCOM Recommendation 91/4 on radioactive discharges and was complemented with changes cited by the Contracting Parties in the 5th reporting period.

1.1.1 Belgium

The Royal Decree of 20 July 2001 (General Regulations for the Protection of the population, workers and the environment against the dangers of Ionising Radiation – GRPIR) implements European Directives, international conventions and recommendations of ICRP-60 and IAEA, and thus will include the requirement for optimisation of protection.

1.1.2 Denmark

Danish legislation and regulations are based on international principles of radiation protection and derived from EURATOM directives. During the last reporting period no additional information were provided.

1.1.3 France

Since 2006, the Law 2006-686 concerning transparency and nuclear safety, known as the TSN law, caused a comprehensive reform of the organization of nuclear safety and radiation protection regulation in France. The TSN Law creates an integrated system to regulate nuclear installations based on a broadened conception of nuclear safety, covering both the prevention of accidents and the protection of human health and of the environment. It takes into account lessons drawn from an examination of foreign legislation. Furthermore the law 2006-739 was amended concerning a programme for sustainable management and radioactive materials and wastes.

General technical regulations in France include all of the measures of general application concerning nuclear safety. The Best Available Technology was imposed in a Ministerial Order dated 26th of November 1999 establishing the general technical requirements concerning the limits and methods of water collections and discharges. In particular the Ministerial Order requires that the limits of discharges must be established on the basis of the BAT.

1.1.4 Germany

In Germany the Atomic Energy Act includes the general national regulations for protective and preventive measures, radiation protection, and disposal of radioactive waste and irradiated fuel elements. It is the basis for associated ordinances and ensures that the Federal Republic of Germany meets its international obligations in the field of nuclear energy and radiation protection. In addition, the state of scientific and technological advancement, taking into account the BAT, is defined in technical guidelines, such as safety standards, issued by the "Kerntechnischer Ausschuss (KTA)". Additional regulations are issued by the "Deutsches Institut für Normung (DIN)" containing requirements affecting the treatment of radioactive effluents, including retention factors for filter systems. The safety standards issued by the KTA and the DIN are reviewed on a regular basis every five years. Thus, the processes for establishing and reviewing BAT appear to be well established. There have been no relevant changes in legislation since the last implementation report [OSPAR05].

1.1.5 The Netherlands

In the Netherlands, the basic legislation governing nuclear activities is contained in the Nuclear Energy Act. The character and aim of the Nuclear Energy Act is to stimulate the safe application of nuclear energy and nuclear techniques, as well as to give rules for protection against the risks of such applications. The Nuclear Energy Act lays down the basic rules in the nuclear field, makes provision for radiation protection, designates the different competent authorities and outlines their responsibilities. There have no relevant changes in legislation since the previous report [OSPAR05].

1.1.6 Norway

Norwegian policy is based on internationally accepted principles for radiation protection. Authorisation of nuclear installations are issued on the basis of Act No. 36 concerning on radiation protection and the use of radiation. Its purpose is to prevent harmful effects of radiation on human health and contribute to the protection of the environment. Best Available Technology regarding discharges of radioactive substances is implemented in the Radiation Protection Regulation No. 1362. In general Norwegian practice is focussed on BAT, ALARA and precautionary principles. There have been no relevant changes in legislation since the last implementation report [OSPAR05].

1.1.7 Portugal

The single Nuclear and Technological Institute of Portugal has the concern to minimize the releases of radioactive substances to the environment through the appropriate technologies. No detailed information on the national regulations concerning the BAT is given.

1.1.8 Spain

In Spain the basic laws governing nuclear activities are the Nuclear Energy Act (Law 25/1964) and the Law 15/1980 creating the Nuclear Safety Council (CSN) which was reformed by Law 33/2007. The Regulation on Nuclear and Radioactive Facilities (Royal Decrees 1838/1999 and 35/2008) establishes that the licensee must continuously ensure the improvement of the nuclear safety and radiation protection conditions of Spanish facility. The current best techniques and practices must be analysed, in accordance with the requirements that the CSN establishes. The CSN may require at any time the licensee's analysis for the implementation of improvements on nuclear safety and radiation protection. The licensee is also required to develop a Continuous Safety Assessment Programme (CSA) taking into account the evolution of the normative, the progress in technology (BAT), and the operational experience. The CSN instruction IS-26 of 2010 sets the basic nuclear safety requirements applicable to nuclear installations.

1.1.9 Sweden

The primary legislation, the Swedish Radiation Protection Act, includes a requirement that radiation protection shall be in reasonable accordance with technical and methodological development, and shall be improved as technological and methodological development permits (i.e. that BAT shall be applied although the term is not used *per se*). There are no changes in the Act since the third implementation round of reporting related to what is considered as BAT and how BAT is being applied in Sweden. Other relevant codes and regulations explicitly identify BAT as a means for achieving the goal of preventing, eliminating or reducing the impact of human activities on health and the environment, and target levels are established that are considered to relate to BAT.

1.1.10 Switzerland

The Swiss Federal Act and Ordinance on Radiological Protection have been based on the recommendations of the ICRP Publication 60. In 2005 new nuclear energy legislation came into force, which requires the performance of periodic safety reviews by the licensee of nuclear power plants in a time interval of ten years. The periodic safety reviews are evaluated by the Nuclear Safety Inspectorate. In the frame of the periodic safety review the licensee has to assess the liquid and aerial discharges of his plant and at the request of the Inspectorate to benchmark against the corresponding discharges of similar European reactors. If the discharges of a nuclear power plant are higher than the benchmark, the licensee has to analyze the reasons and to make suggestions to reduce the discharges in view of the appropriateness of the means. In this context the BAT/BEP is implemented in the Swiss national legislation according to the terms of the OSPAR Convention There have been no relevant changes in legislation since the last implementation report [OSPAR05].

1.1.11 United Kingdom

Operations at United Kingdoms nuclear installations are governed by various acts, most notably the Radioactive Substances Act. This legislation provides a framework for the standards practices and objectives in the field of radioactive waste management. The United Kingdom has consequently applied the radiological protection principles recommended by ICRP to reduce levels of radioactive discharges and doses of ionizing radiation to humans. A UK Strategy for radioactive discharges 2001 - 2020 was published in 2002 and describes the implementation of the agreements reached at the Ministerial meeting in 1998. This document provides more detail on national and international context for the regulation of radioactive discharges. An updated UK Strategy document was published in 2009.

Two optimisation approaches have been part of the UK pollution Law: The Best Practicable Means (BPM) to minimise discharges and the Best Practicable Environmental Option (BPEO) which is a decision aiding procedure. In its recent consultation document in 2008 on Statutory Guidance to the Environment Agency, DEFRA (Department of Environment, Food and Rural Affairs) recommended that the concept of BAT replaces those of BPM and BPEO in England and Wales. BPM will continue to be used in Scotland and Northern Ireland.

Dose limits

The annual dose limits to the public specified in the implementation reports of the Contracting Parties are in accordance with the recommendations of the International Commission on Radiological Protection (ICRP) and the EU Basic Safety Standards Directive 96/29 EURATOM. The effective dose to members of the public should not exceed 1 mSv per calendar year. Detailed information are given in **ANNEX 4**

Discharge limits

By the majority of the Contracting Parties the discharge limits are directly linked to the dose limits, which lead to the fact that in these cases (e. g. Sweden, Norway) no nuclide specific discharge limits are given. On the other hand the discharge limits are defined in a few countries (e. g. Netherlands, Germany) for each nuclear installation separately. Detailed information to the practice of each Contracting Party is to be taken from the **ANNEX 5**.

Nature of inspection

In the implementation reports of the Contracting Parties the kind of inspections carried out directly and also the inspection performed in the surroundings of the nuclear facilities are presented. Detailed information is given in **ANNEX 6**.

Effectiveness of Implementation of BAT in Site Specific Information

As outlined in **Section 2.1**, for the assessment of the effectiveness of the implementation of BAT, especially the following indicators were considered within this report:

- The systems and abatement technologies in place and the extent to which they may be considered to constitute BAT.
- The effectiveness of these arrangements and techniques in delivering reductions in discharges.

Each issue will be considered in detail in the following sections.

Systems and Abatement Techniques to Reduce Discharge

The Guidelines require site-specific information on systems and abatement techniques in place to reduce, prevent or eliminate discharges of radioactive substances to the marine environment (**2.1**, **2.2** and **Appendix I**, 2004-03). **Appendix I** of the Guidelines includes a list of abatement techniques for liquid discharges and aerial emissions which are taken from the OECD/NEA report on “Effluent Release Options from Nuclear Installations” (OECD Nuclear Energy Agency, 2003). The abatement techniques documented in the OECD/NEA report are also integrated in the **IAEA-TECDOC-1638** report from 2010 (“Setting Authorized Limits for Radioactive Discharges: Practical Issues to Consider”).

<u>Abatement of liquid discharges</u>

- Delay tanks
- Ion exchange
- Ultrafiltration
- Hydro cyclone centrifuging
- Chemical precipitation
- Reverse Osmosis
- Evaporation
- Cross-flow filtration

<u>Abatement of aerial emissions</u>

- Electrostatic precipitation
- Chemical absorption
- Cryogenics
- Decay tanks
- Ultrafiltration
- Cyclone scrubbing
- HEPA filtration

1.1.12 Systems and Abatement Techniques in place in Contracting Parties

A compilation of the site-specific information on systems and abatement techniques, included in the Contracting Parties' implementation reports (**ANNEX 2**), is provided in **ANNEX 8**. An **overall** summary of the abatement techniques used in each Contracting Party is given in **Table 3**. It should be noted, that the identification of BAT, at a site-specific and process level, is a too complex task which is beyond the scope of this assessment. Within this report we can only determine whether the abatement techniques are appropriate and in line with BAT in industry.

Table 3: Systems and Abatement Techniques in Place in Contracting Parties (see Annex 8)

	Fuel Enrichment and Fabrication	Nuclear Power Generation and Decommissioning	Reprocessing	Research, Development and Waste Treatment
Belgium		**discharges:** - evaporation - filtration - ion exchange filtration - solidification **emission:** - storage tanks - HEPA filtration - active carbon cartridges **no decontamination factors** are given		**discharges:** - sedimentation - evaporation - cementation - storage tanks - former bitumisation vitrification **emission:** - filtration **no decontamination factors** are given
Denmark	No information available			
France		**discharges:** - evaporation - filtration - demineralization **emission:** **no decontamination factors** are given	. **discharges:** - storage in pools for about five years - solid waste as far as possible - vitrification - evaporation - distillation - calcinations of residues **emission:** **decontamination factors** are given and documented in **ANNEX 8**	**discharges:** - retention tanks - neutralization - settling - pre-chlorination - filtration through sand - in future: □ settlement □ digestion □ biological treatment □ clarification **emission:** **decontamination factors** are given and documented in **ANNEX 8**

	Fuel Enrichment and Fabrication	Nuclear Power Generation and Decommissioning	Reprocessing	Research, Development and Waste Treatment

Germany		**discharges:**
		- separation and collection of waste water according to the activity concentration and the level of chemical contamination
		- evaporation
		- filtration
		- ion exchange
		- activated carbon cartridges
		- decantation
		- centrifugation
		- floculation
		- degassing
		
		emission:
		- HEPA filtration
		- hold-up loop
		- delay lines for short-lived radioactive noble gases
		- retaining of iodine by activated carbon filters
		
		decontamination factors are only reported for the location of the nuclear facilities in Philippsburg
				discharges:
				- drain tanks
				- higher storage times for short-lived radionuclides
				- filtration
				- ion-exchange
				- sedimentation
				- evaporation
				- neutralization
				- operation of "warm layer"
				- in future:
				  reverse osmosis and/or
				  evaporation
				
				emission:
				- delayed emissions of short-lived radionuclides
				- HEPA filtration
				- off gas scrubber
				- activated charcoal beds
				
				no decontamination factors are given

The Netherlands	**discharges:** - distillation - precipitation or sedimentation of wash water - filtration - deposition - storage and decay of short-lived radionuclides	**discharges:** - distillation - ion exchange - filtration of sludge if necessary - cementation - storage and decay		**discharges:** - collection and storage - sedimentation basins - membrane filtration units - centrifugation of sludge - sludge drying units - cementation - biological purification

	Fuel Enrichment and Fabrication	Nuclear Power Generation and Decommissioning	Reprocessing	Research, Development and Waste Treatment
	emission: **no decontamination factors** are given	**emission:** **no decontamination factors** are given		- electrochemistry - chemical purification based on flocculation **emission:** **decontamination factors** are given and documented in **ANNEX 8**
Norway				**discharges:** - delay tanks - chemical precipitation - centrifuging - hydrocyclone - cross-flow filtration - ion exchange - osmosis - ultrafiltration - evaporation - H-3 trapping in He-3 systems **emission:** - electrostatic precipitation - cyclone scrubbing - chemical adsorption - HEPA filtration - cryogenics - active charcoal filters **decontamination factors** are given and documented in **ANNEX 8**
Portugal				**discharges:** - collecting of liquid discharges in tanks **emission:** **no decontamination factors** are given

	Fuel Enrichment and Fabrication	Nuclear Power Generation and Decommissioning	Reprocessing	Research, Development and Waste Treatment
Spain	**discharges:** - ultra centrifugation - filtration **emission:** - HEPA filters **emission:** **decontamination factors** are given and documented in **ANNEX 8**	**discharges:** - retention tanks - double system of filters - ion exchanger - evaporation - filtration - demineralisation **emission:** - decay tanks - HEPA filters - charcoal beds - catalytic recombination **decontamination factors** are given and documented in **ANNEX 8**		
Sweden		**discharges:** - particulate filtration - ion exchange filtration - cross-flow filtration - large buffer tanks to recycle water - evaporator - good housekeeping **emission:** - delay tanks - HEPA filtration - membrane-filtration in the feed water system - recombiners **decontamination factors** are given and documented in **ANNEX 8**		
Switzerland		**discharges:** - centrifugation; - evaporation; - ion exchange; - chemical precipitation; - cross-flow		**discharges:** - collection - centrifugation; - evaporation; - diffusion through membranes with pressure

	Fuel Enrichment and Fabrication	Nuclear Power Generation and Decommissioning	Reprocessing	Research, Development and Waste Treatment
		nanofiltration since 2007; - residues conditioned with bitumen; - solidification of waste byproducts. **emission:** **decontamination factors** are given and documented in **ANNEX 8**		difference; - solidification of waste by products. **emission:** **decontamination factors** are given and documented in **ANNEX 8**
United Kingdom	**discharges:** - delay tanks - several filtration techniques; - flocculation; - precipitation; - centrifugation; - hydrocyclone; - evaporation; - counter flow system; - dry ice gun; - electrically heated feed cylinders. **emission:** - off-gas scrubbers - HEPA filters **some decontamination factors** are given and documented in **ANNEX 8**	**discharges:** - natural settlement; - fuel integrity; - delay tanks; - ion exchange; - coolant chemistry; - filtration: sand filters facet filters; funda filters; doulton filters; - cross-flow filtration; - submersible Caesium removal unit **emission:** - HEPA filtration; - charcoal absorbers; - sintered metal candle filters on blowdown stack. **some decontamination factors** are given and documented in **ANNEX 8**	**discharges:** - storage tanks - evaporation; - vitrification; - filtration; - ion exchange; - precipitation; - specific treatment for Tc-99; - caustic scrubbers; **emission:** - HEPA filters **decontamination factors** are given and documented in **ANNEX 8**	**discharges:** - settling tanks; - filtration; - ion exchange; - cementation; - chemical flocculation; - precipitation; - pH adjustment; **emission:** **decontamination factors** are given and documented in **ANNEX 8**

1.1.13 Contracting Parties' Systems Abatement Techniques and BAT

As outlined in the NEA Expert Group on Effluent Release Options (OECD, 2003), it is important to note that BAT relates both to the technologies used and the way in which the nuclear facility is designed, built, maintained, operated and decommissioned. The efficiency of plant processes may be optimised during design and construction but, once a facility is built up, there are generally fewer opportunities to change the design of processes so that, for existing plants, the focus for the reduction of discharges is primarily on abatement technology. Nevertheless, operational management systems to prevent, eliminate or reduce liquid waste are an important element of the application of BAT. Contracting Parties generally acknowledged that such systems have to be in place.

As already mentioned in the report of the 4th round of reporting on the implementation of PARCOM Recommendation 91/4 on radioactive discharges also the 5th reporting period shows, that the abatement techniques, identified in the NEA report (OECD, 2003) have been applied by the Contracting Parties individually or in combination. Furthermore, it can be seen from **Table 3** that there is a significant level of similarity among the systems and abatement processes and techniques applied in the nuclear facilities of all Contracting Parties. This level of agreement, together with the national processes in place to implement BAT, provides a strong indication that international best practice technologies are being applied.

Different types of abatement techniques available and used for liquid discharges and emissions, identified in the NEA/OECD report, are presented in **Table 4** and **Table 5**. The individual reports of the Contracting Parties clearly show, that in particular the combination of several chemical or physical processing techniques lead to the fact, that a very high decontamination factor can be achieved. An important step in this regard would be to supplement the techniques mentioned in **Tables 4** and **5** with additional procedures used by the Contracting Parties (see **Table 3**), the identification of efficient combinations of various processes to ensure that the discharges and emissions of nuclear facilities to the OSPAR area can be reduced even more.

Table 4: Examples of Available Abatement Techniques for Liquid Discharges and their Application (OECD, 2003)

Techniques	Application
Chemical precipitation	Removal of dissolved radionuclides in aqueous solution, usually by adding an alkali to increase pH, so that the radionuclides are co-precipitated as insoluble carbonates or hydroxides.
Filtration / Ion exchange resins	The treated liquid effluent is passed through a filter and an ion exchange column to remove e. g. actinides.
Cross-flow filtration	Cross-flow filtration is sometimes used as pre-treatment stage before hydrocycling.
Hydrocyclone centrifugation	Liquid effluents may also contain insoluble radionuclides with different particle sizes. These particles cannot be removed by precipitation or ion-exchange. Hydrocyclone centrifuges remove solid particles by rapidly rotating the liquid effluent in a vortex. Centrifugal forces cause the particles to migrate towards the wall of the hydrocylone separating them from the effluent. The efficiency depends on particle size.
Reverse osmosis, ultra-filtration and evaporation	Used to remove very low levels of contaminants from liquid effluents usually before final discharge to the environment. Reverse osmosis and ultra-filtration rely on passing relatively clean effluents through a sensitive permeable membrane under high pressure. Together with ambient temperature evaporation, the discharges can be very low for the most radionuclides.

Table 5: Examples of Available Abatement Techniques for Aerial Emissions and their Application (OECD, 2003)

Techniques	Application
HEPA filtration	Removal of actinide containing particles.
Wet scrubbers	Removal of soluble fission product particles and some gases such as carbon dioxide. They are used to treat off-gases from nuclear process plants or radioactive waste incinerators.
Carbon filter beds	Volatile iodine fission products and chemically reactive gases from nuclear reactors are abated by carbon filter beds.

The Effectiveness of BAT in reducing Liquid Discharges

An assessment of the liquid radioactive discharges of all nuclear installations in the OSPAR area and their trends in the last 19 years (1990 - 2009) is presented in the OSPAR report "***Liquid discharges from nuclear installations in 2009***". The trends identified in this report for alpha emitting radionuclides, beta- and gamma emitting radionuclides (excluding tritium) and tritium for the time period of 1990 to 2009 are plotted in **Figures 1** to **3**. It turns out that except of H-3, the sum of total alpha activity and sum of total beta activity (excluding tritium) decreased markedly over the past 19 years.

The trends of the discharges of the individual nuclear facilities in the OSPAR area within the last reporting period were taken from the implementation reports of the Contracting Parties and reflect the general trends very well. The information concerning the trends is documented in the **Sections 4.2.1** to **4.2.11**.

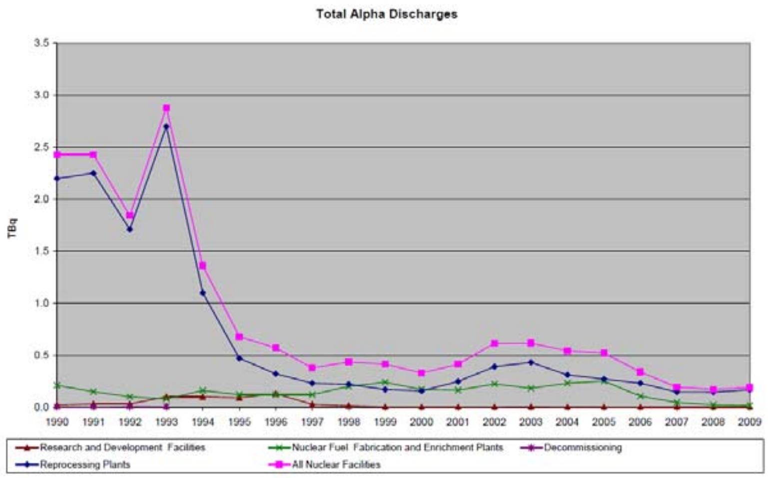

Figure 1: Discharged activity of alpha emitting radionuclides

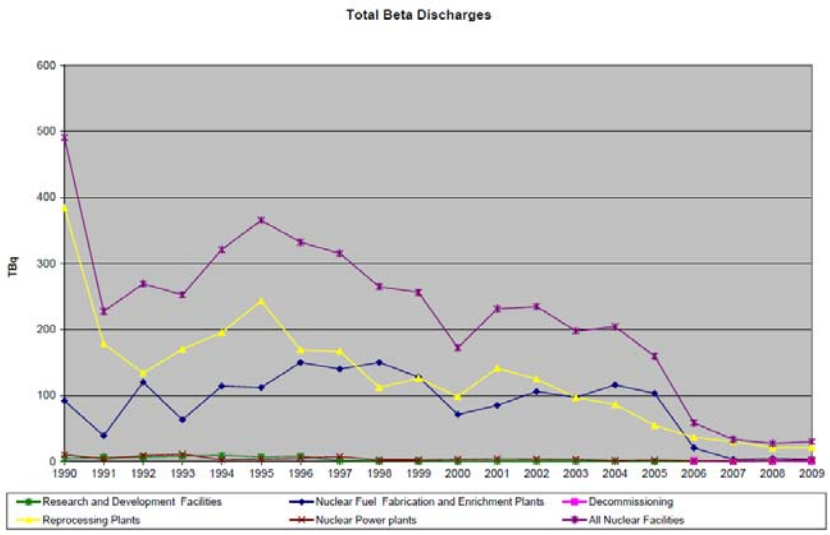

Figure 2: Discharged activity of beta- and gamma emitting radionuclides (excluding tritium)

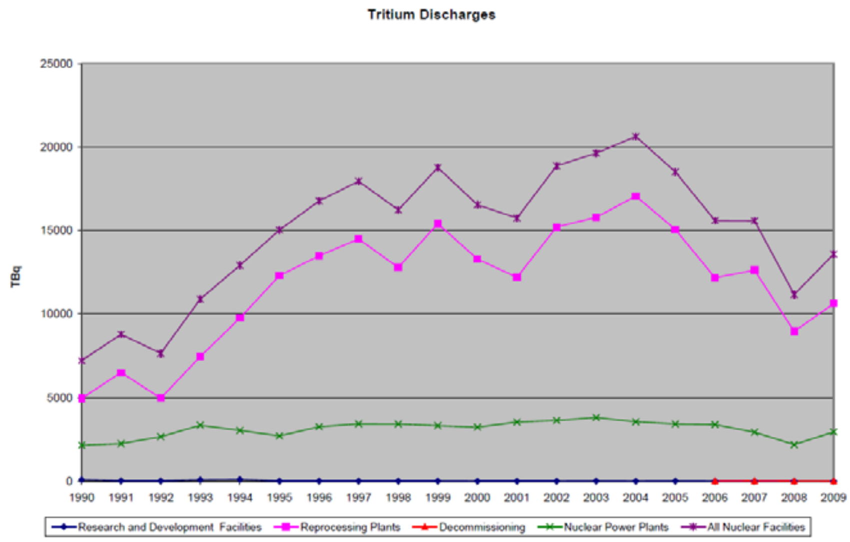

Figure 3: Discharged activity of tritium.

1.1.14 Belgium

Nuclear plant	Trends in liquid discharges
Doel	- no clear downward trend of the average value of normalized H-3 discharges; the normalized discharges are already very low, especially when compared with the UNSCEAR ranges; when taking into account, for example for H-3, the Belgian NPP's are at the bottom limit and sometimes even below implying that although no clear downward trend is present, a absolute minimum is already achieved (according technical feasibility); - clear downward trend of the average value of normalized discharges of beta/gamma emitters excluding H-3 up to 2006;
Tihange	- no clear downward trend of the average value of normalized H-3 because the normalized discharges are already very low; - no clear downward trend of the average value of normalized discharges of beta/gamma emitters excluding H-3 up to 2004; since 2005 a slight downward trend observed;
Fleurus	
Mol-Dessel	- H-3 releases; since 2000 nearly constant; - releases of beta-emitters excluding H-3; exponentially decreased from 2000 to 2009; - releases of alpha-emitters; exponentially decreased from 2001 to 2009;

1.1.15 Denmark

No information available

1.1.16 France

Nuclear plant	Trends in liquid discharges
Nuclear power plants (all)	- downward trend in discharges of beta- and gamma emitters excluding H-3: → decrease from 2000 to 2004; → nearly constant since 2005;
AREVA NC de La Hague	- downward trend in discharges; constant or downwards;
CEA Fontenay aux Roses Centre	- downward trend in discharges; significant for more than 10 years
CEA Saclay Centre	- downward trend in discharges; significant and dependent on the radionuclide

1.1.17 Germany

Nuclear plant	Trends in liquid discharges
Biblis A + B	- no significant downward trend in discharges; - discharges excluding H-3 from operating NPP's are low or very low; - discharges of alpha-emitters from all operating NPP's are below the detection limit;
Brokdorf	
Brunsbüttel	
Emsland	
Grafenrheinfeld	
Grohnde	
Krümmel	
Neckarwestheim 1 + 2	
Philippsburg 1+ 2	
Unterweser	
Mülheim-Kärlich	- decreasing trend in H-3 discharges; - discharges of alpha-emitters below the detection limit;
Obrigheim	
Stade	- decreasing trend in H-3 discharges; - very low discharges of alpha-emitters;
Würgassen	- no significant downward trend in discharges; - very low discharges of alpha-emitters;
URENCO Gronau	- no trends; constantly very low discharges since 1985;
Hanau	- downward trend in discharges to zero 2006
Advanced Nuclear Fuels GmbH	- no trends; discharges of alpha-emitters below the detection limit;
GKSS Geesthacht	The sum of total beta excluding tritium and of tritium discharged from the five research and development facilities are clearly lower (only a few percent) than the discharges from the pressurized nuclear power plants. There is no trend in discharges and emissions from the research and development facilities in Germany in the last period.
Helmholtz-Zentrum Berlin	
Jülich Research Centre	
Institute for Technology of Karlsruhe	
Verein für Kernverfahrenstechnik und Analytik Rossendorf e. V.	

1.1.18 The Netherlands

Nuclear plant	Trends in liquid discharges
Kernenergiecentrale Borssele	
Kerncentrale Dodewaard	- downward trend in discharges to water up to 2004
URENCO	- clear downward trend in total discharges
Petten site	- no downward trend in discharges
Reactor Institute Delft	
COVRA	

1.1.19 Norway

Nuclear plant	Trends in liquid discharges
Institute for Energy Technology Kjeller	- no downward trend in discharges
Institute for Energy Technology Halden	

1.1.20 Portugal

No information available

1.1.21 Spain

Nuclear plant	Trends in liquid discharges
Almaraz	- slight upward trend in discharges of radionuclides excluding H-3 due to application of 2004/2/EURATOM; - small downward trend in H-3 discharges;
José Cabrera	- slight upward trend in discharges of radionuclides excluding H-3 due to decontamination and management of stored operating wastes; - downward trend in H-3 discharges;
Trillo	- stable trend in discharges of radionuclides excluding H-3; - stable trend in H-3 discharges;
Juzbado	- nearly constant trend in discharges of alpha emitters;

1.1.22 Sweden

Nuclear plant	Trends in liquid discharges
Ringhals 1	- constant or downward trend in discharges;
Ringhals 2	
Ringhals 3	
Ringhals 4	

1.1.23 Switzerland

Nuclear plant	Trends in liquid discharges
Beznau Gösgen Leibstadt Mühleberg	- constant trend in H-3discharges; - clear downward trend in discharges of radionuclides excluding H-3;
Waste Treatment and Interim Storage	- clear upward trend in discharges of radionuclides excluding H-3;
Paul Scherrer Institute	- clear downward trend in discharges of radionuclides excluding H-3;

1.1.24 United Kingdom

Nuclear plant	Trends in liquid discharges
Dungeness B	- nearly constant discharges of H-3 and S-35 with the exceptional increase in 2003 due to the increase in electricity generation; - discharges of Co-60 increased from 2004 to 2006 due to engineering operations and decreased in 2007 to the level of 2004;
Hartlepool	- discharges of H-3 and S-35 decreased from 2002 to 2004, stayed at constant level from 2004 to 2006 and increased in 2007 due to increase of electricity generation, but far under the values of 2002; - discharges of Co-60 decreased significantly from 2005 to 2007 due to change in the analytical methods; - discharges of other radionuclides were constant between 2002 and 2004 and fluctuated from 2005 to 2007;
Heysham 1	- discharges of H-3 decreased steadily from 2002 to 2004, increased from 2004 to 2006 and stayed in 2007 at the level of 2004; - discharges of Co-60 increased in 2007 due to an unplanned transfer of ion exchange resin into a sump in the effluent treatment plant; - discharges of all other radionuclides decreased in 2007 due to extended maintenance outage;
Heysham 2	- discharges of Co-60 decreased in 2007 to a third of its 2002 value; - discharges of other radionuclides were relatively steady;
Hinkley Point B	- discharges relatively steady up to 2006; - significant decrease in all radionuclides' discharges in 2007 due to an extended outage for maintenance;
Hunterston B	- no significant variation in discharges from 2002 to 2005 with an exceptional decrease of S-35 from 2002 to 2005; - general decrease in 2007 due to an extended outage for maintenance;
Oldbury	- gradual decrease of discharges from 2002 to 2007; - about 40 % decrease for the group "other radionuclides" during the period;
Sizewell B	- discharges of H-3 decreased slightly since 2003 due to change in the neutron sources; - discharges of radionuclides excluding H-3 decreased steadily from 2002 to 2007;
Torness	- stable trends in discharges;

Nuclear plant	Trends in liquid discharges
Wylfra	- discharges of H-3 with quite variable with differences >30 % from year to year; - discharges of other radionuclides decreased steadily to a value in 2007 being about 16 % of that in 2002;
Berkley	- similar level for discharges of all radionuclides from 2002 to 2004; - increase in the discharges of all radionuclides in 2005; - decrease in 2006 and 2007;
Bradwell	- discharges of Cs-137 and other radionuclides were at similar level from 2002 to 2005 and decreased in 2006 and significantly in 2007 due to the end of defuelling stage; - discharges of H-3 decreased strongly from 2002 to 2003 followed by a small increase from 2003 to 2005, and remained at this level in 2006; significant decrease in 2007;
Hinkley Point A	- discharges of H-3 and Cs-137 decreased from 2002 to 2005 followed by a small increase in 2006 and 2007, but at a level lower than in 2002; - increase of discharges of other radionuclides due to decommissioning of the reactor cooling ponds;
Hunterston A	no significant changes in discharges;
Trawnsfynydd	- decrease of discharges throughout the period; - peaks of the discharges of Sr-90 and other radionuclides in 2004 →;
Chapelcross	- discharges of H-3 decreased since 2003; - discharges of beta- and gamma emitters decreased since 2003; - discharges of alpha emitters decreased since 2002 with a peak in 2003 due to emptying of one of the ponds;
Dungeness A	- discharges of H-3 decreased significantly from 2002 to 2004 and increased since 2005 due to a campaign to dispose of a 2 years backlog of gas processing liquors; - discharges of Cs-137 and other radionuclides decreased steadily since 2002;
Sizewell A	- discharges of H-3 varied strongly with an increase in 2003 and a significant decrease in 2004 and 2005 as well as further increase in 2006 and 2007; - discharges of Cs-137 and other radionuclides were at a constant level between 2002 and 2006 with a significant 50 % decrease in 2007 due to cessation of operation;
Dounreay	- discharges of H-3 fluctuated due to dissolution of alkali metals; - discharges of Sr-90 decreased steadily; - the discharges of other radionuclides remained at or below the minimum detectable activity;
Harwell	- discharges of H-3 decreased substantially in 2003 due to reduced receipts of tritiated water (4 % of the previous value) and remained at that level since then; - discharges of Co-60 decreased by about 80 % of the 2002 value; - discharges of the other radionuclides generally decreased, but not so significantly;
Windscale	see Sellafield
Winfrith	- discharges of H-3 increased as a result of processing work by WMT Ltd; - short-term increase of the discharges of other radionuclides due to decommissioning operations
Calder Hall	see Sellafield

Nuclear plant	Trends in liquid discharges
Sellafield	- general downward trend in all discharges from the main site pipeline; • discharges of alpha emitters decreased around 35 %; • discharges of Tc-99 decreased more than 90 %; • discharges of beta and gamma emitters decreased more than 70 %; • discharges of C-14decreased; - discharges from the factory sewer remained relatively constant;
Capenhurst	- discharges of Tc-99, uranium and Uranium-daughters decreased strongly; - discharges of H-3 decreased strongly; - discharges of alpha emitters containing no uranium increased, primarily because of Np-237 increase
Springfields	- discharges decreased due to cessation of uranium ore concentrate purification in 2006: • discharges of alpha emitters in 2007 valued to 12 % of the discharge in 2002; • discharges of beta and gamma emitters in 2007 were reduced to a value of 97 % in comparison with 2002; • also evident reduction in the discharge of other radionuclides.

Conclusions and Recommendations

The Contracting Parties' implementation reports, which are published on the OSPAR web site, indicate that the arrangements are generally in place for implementation of BAT in the national legislation and regulations related to the nuclear industry[3]. In their national reports, Contracting Parties generally acknowledged that operational management systems are in place to prevent, eliminate or reduce liquid waste. Such systems are an essential element of the application of BAT. In addition, the abatement techniques, identified by international institutions, on available liquid effluent options, have been employed by Contracting Parties individually or in combination to remove particular materials and dissolved nuclides from the liquid effluents. There is a significant level of agreement in the processes being employed, which provides a strong indication that international best practice – especially in the field of the BAT – is being applied. Especially the overall trends in the discharges of alpha emitters, beta- and gamma emitters documented in **Section 4.2** shows that the permanent improvement of BAT, which is clearly linked and initiated by OSPAR, works in the right direction. It is also an important factor that Contracting Parties with individual nuclear facilities not following the general trend have to disclose the reasons, so that transparency is given for all other Contracting Parties and the public. Furthermore the review of the implementation reports has clarified, that the focus of OSPAR on the improvement of the application for processes and technology to reduce the discharge of nuclear facilities has to be continued.

[3] With the exception of Portugal for which no information was available.

Recommendations for next round of reporting

Nearly all information demanded in the Guidelines was stated in the respective implementation reports of the Contracting Parties; however, some reports are not built up according to the thematic sequences indicated in the Guidelines. It seems also to be necessary to give more attention in future to the summaries demanded in the Guidelines after each paragraph. Generally it has to be noted that during the next reporting period, the Contracting Parties should focus their report primarily on respective changes, innovations and further developments, while already existing statements should only be mentioned and cited accordingly. With this approach, the reports could be made more compact which enables a faster and a much more efficient evaluation of new implemented measures.

The extremely extensive tabular listings of the statements from the individual Contracting Parties in the Annexes within this report and the consequent better comparability of their data with data from the other contracting parties shall encourage the Contracting Parties to possible needed revisions in the design of their implementation reports with regard to the 6th round of reporting.

The largest differences in the reports of Contracting Parties, particularly in the extent of the statements, exist in the topic “Environmental program”. While some Contracting Parties represent their measurement programs in detail, other Contracting Parties only refer to their national annual reports which are published by the respective Authorities. To avoid too much data in the implementation reports, we would recommend a reference to the national reports. But, it would be desirable if these national reports are available on the internet in English language.

With regard to aerial emissions there are also significant differences in the way of reporting of the Contracting Parties. Here too, a separate OSPAR report, which deals exclusively with this issue, would make sense. Contracting Parties should nonetheless determine the impact of aerial emissions from their nuclear installations to the North East Atlantic on the basis of quantitative dispersion calculations to define which aerial emissions are relevant and have to be considered.

With respect to the BAT, it is necessary - as already mentioned in the recommendation of the 4th implementation report - to develop closer ties between the experts of the individual Contracting Parties and establish an exchange of experiences in the operational and decommissioning field of work. In addition, more detailed information regarding BAT decisions (including information on unsuccessful trials and the reasons why given techniques were not applied in some situations) would be useful and should be compiled in a report which has to be shared with international organizations.

Finally, as a significant and increasing number of nuclear facilities are undergoing or will shortly undergo decommissioning in many Contracting Parties this aspect will be more and more relevant. Especially in Germany, in the light of the Federal Government decision in 2011 to phase out nuclear energy production, the implementation of BAT with respect to the choice of decontamination and decommissioning techniques will be of utmost importance in the following years.

References

IAEA (2003), Combined Methods for Liquid Radioactive Waste Treatment, Final Report of a Coordinated Research Project 1997-2001, IAEA-TECDOC-1336, IAEA, Vienna, Austria.

IAEA (2004), Management of Waste Containing Tritium and Carbon-14, Technical Reports Series No. 421, IAEA, Vienna, Austria.

OECD Nuclear Energy Agency (2003), Effluent Release Options from Nuclear Installations, Technical Background and Regulatory Aspects, NEA, Radiation Protection Series, Paris, France.

OSPAR (2003a), Implementation of PARCOM Recommendation 91/4 on Radioactive Discharges. ISBN 1-904426-21-2.

OSPAR (2003b), Radioactive Substances Strategy (Agreement no. 2003-21).

OSPAR (2004), Guidelines for Submission of Information about, and the Assessment of, the Application of BAT in Nuclear Facilities (2004-03) (Annex 1).

OSPAR (2006), First Periodic Evaluation of Progress towards the Objective of the OSPAR Radioactive Substances Strategy, Report No. 302/2006

OSPAR (2008), Assessment of the 4th Round of Reporting on the Implementation of PARCOM Recommendation 91/4 on Radioactive Discharges. ISBN 978-1-905859-90-0 Publication Number: 351/2008.

IAEA (2010), Setting Authorized Limits for Radioactive Discharges: Practical Issues to Consider Report for Discussion, IAEA TECDOC Series No. 1638, IAEA, Vienna, Austria.

OSPAR (2011), Liquid discharges from nuclear installations in 2009. ISBN 978-1-907390-84-5 Publication Number: 543/2011.

Annexes

Annex 1: Guidelines for the Submission of Information about, and assessment of, the Application of BAT in Nuclear Facilities (2004 – 03)

Guidelines for the Submission of Information about, and the Assessment of, the Application of BAT in Nuclear Facilities (Reference number: 2004-03)[1]

Replaces agreement 1999-11

GENERAL INFORMATION

INFORMATION TO BE SUBMITTED
Implementation of BAT/BEP in terms of the OSPAR Convention in national legislation/regulation - New legislation since latest implementation round; National regulatory concepts, e.g. what is considered as BAT and how BAT is being applied by each Contracting Party. **Dose constraints/limits for nuclear facilities** Rationale for setting dose constraints/limits **Discharge limits** Rationale for setting discharge limits **Monitoring programmes of environmental concentrations of radionuclides** **Environmental norms and standards (other than dose standards for humans, e.g. standards for drinking water)** **National authority responsible for supervision etc. of discharges** **Nature of inspection and surveillance programmes**

SITE -SPECIFIC INFORMATION – 1. SITE CHARACTERISTICS

INFORMATION TO BE SUBMITTED
1.1 Name of site **1.2 Type of facility** E.g. power plant (PWR, BWR, GCR, AGR), reprocessing plant, fuel fabrication plant, waste treatment plant, etc., or a combination of these (number of units of each type) **1.3 Year for commissioning/licensing/decommissioning** Specified for the main installations within the site **1.4Location** **1.5 Receiving waters and catchment area, including, where relevant, information on water flow of receiving rivers** **1.6 Production** Installed electrical effect and annual electrical output for the last six years (power reactors) Tonnes U processed (reprocessing and fuel fabrication plants) Thermal effect (research reactors) Other relevant data (e.g. for waste treatment plants) **1.7 Other relevant information**

SITE-SPECIFIC INFORMATION – 2. DISCHARGES

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
Discharges to the marine environment, as well as emissions of concern to the marine environment, are limited through application of technical and managerial practices in accordance with Article 2, 3 (b) (i), as well as Appendix 1 on BAT/BEP of the OSPAR Convention	**2.1** System(s) in place to reduce, prevent or eliminate discharges of radioactive substances to the marine environment, as well as emissions of radioactive substances of concern to the marine environment according to the list in Annex 5. In particular, systems taken into operation during the reporting period (or decided to be taken into operation) should be reported as well as changes in management of waste treatment (for example use of other waste streams), or processes that reduce discharges or emissions should be reported.	Relevant systems in place (Annex 1).
	2.2 Efficiency of *abatement* systems in terms of, e.g., retention times and distribution between waste streams destined for discharge and waste streams destined for disposal *according to Annex 5.*	The decontamination (or abatement) factor or other measure of efficiency of abatement systems (Annex 1).
	2.3 Annual liquid discharges: • nuclide specific data as given in the OSPAR Annual Report on Liquid Discharges with possible additional radionuclides from EC reporting requirements • data on beta emitters (excluding tritium), tritium and alpha emitters (normalised data with regard to net electrical output (power reactors) or tonnes U processed (reprocessing plants and fuel fabrication plants). Factors influencing the normalisation should be reported); Data for at least the last six years should be submitted.	Downward trends in absolute and normalised discharges Comparison with values of similar installations world-wide, based on the most recent compilations published by OSPAR, UNSCEAR or EC
	2.4 Emissions to air of concern for the marine environment. Only nuclides with half-life >30 days should be considered, however, as a minimum, information on tritium, C-14 and I-129 should be submitted. Data for at least the last six years.	Downward trends

SITE-SPECIFIC INFORMATION – 2. DISCHARGES *(Continued)*

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
Discharges to the marine environment, as well as emissions of concern to the marine environment, are limited through application of technical and managerial practices in accordance with Article 2, 3 (b) (i), as well as Appendix 1 on BAT/BEP of the OSPAR Convention	**2.5** Systems for quality assurance of: • Performance of retention systems etc. • Data management.	Relevant and reliable systems are in place
	2.6 Site specific target discharge values.	Relevance of target and closeness to target value
	2.7 Any relevant information not covered by the requirements specified above.	
	2.8 Explanations for lack of data or failure to meet BAT/BEP indicators, as well as, when appropriate, a description of on-going or planned activities.	
		SUMMARY EVALUATION: **A BALANCED EVALUATION OF THE CP'S ABILITY TO ACHIEVE THE OBJECTIVE, TAKING INTO ACCOUNT** • The BAT/BEP indicators listed above • Data completeness • Causes for deviations from indicators • Uncertainties • Other information

SITE-SPECIFIC INFORMATION – 3. ENVIRONMENTAL IMPACT

OBJECTIVE	**INFORMATION TO BE SUBMITTED**	**BAT/BEP INDICATOR**
Marine ecosystems shall be protected, in accordance with Article 2, 1 (a), of the OSPAR Convention.	**3.1** *Concentrations of radionuclides of concern in representative samples of water, sediment and fish. Data for at least the last six years.*	Development of environmental quality criteria is a part of the OSPAR Strategy with Regard to Radioactive Substances. Such criteria may be used as a BAT/BEP indicator Downward trends
	3.2 Environmental monitoring programme, frequency of sampling, organisms and or other types of environmental samples considered.	The environmental monitoring programme is relevant, taking sample types, frequencies and the local environment into account
	3.3 Systems for quality assurance of environmental monitoring.	Relevant and reliable systems are in place
	3.4 Any relevant information not covered by the requirements specified above.	
	3.5 Explanations for lack of data or failure to meet BAT/BEP indicators, as well as, when appropriate, a description of on-going or planned activities.	
		SUMMARY EVALUATION: **A BALANCED EVALUATION OF THE CP'S ABILITY TO ACHIEVE THE OBJECTIVE, TAKING INTO ACCOUNT** • The BAT/BEP indicators listed above • Data completeness • Causes for deviations from indicators • *Uncertainties* • Other information

SITE-SPECIFIC INFORMATION – 4. RADIATION DOSES TO THE PUBLIC

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
Human health shall be protected, in accordance with Article 2.1 (a) of the OSPAR Convention.	**4.1** Average annual effective dose to individuals within the critical group(s) via the marine exposure pathway(s), and caused by current discharges. Data should be submitted for the last six years.	Downward trend
	4.2 Total exposures (i.e. including those from emissions and historic discharges/emissions).	The exposure is well within the constraint (or similar), provided the constraint gives reasonable allowance for other practices so that the annual effective dose from all practices is kept below 1 mSv
	4.3 The definition of the critical group(s), including information on age distribution, size and other relevant information, and on whether the critical group is real (identified) or hypothetical. **4.4** Information on exposure pathway(s) considered, and whether these are treated individually or collectively.	The critical group is relevant, taking local conditions and habits, as well as the exposure situation, into account
	4.5 Basis for methodology to estimate doses (models, actual measurements, and verification of data, as appropriate).[4] **4.6** Site-specific factors for significant nuclides, used to estimate the dose to critical group members from discharge values.	The dose estimates are reliable and sufficiently realistic
	4.7 Site specific target annual effective dose.	Relevance of target and closeness to target value
	4.8 Systems for quality assurance of processes involved in dose estimates.	Relevant and reliable system is in place
	4.9 Any relevant information not covered by the requirements specified above.	
	4.10 Explanations for lack of data or failure to meet BAT/BEP indicators, as well as, when appropriate, a description of on-going or planned activities.	

[4]If this information is general for the nuclear sector and/or part of a statutory programme, this information may be entered under GENERAL INFORMATION

OBJECTIVE	INFORMATION TO BE SUBMITTED	BAT/BEP INDICATOR
		SUMMARY EVALUATION: **A BALANCED EVALUATION OF THE CP'S ABILITY TO ACHIEVE THE OBJECTIVE, TAKING INTO ACCOUNT** • The BAT/BEP indicators listed above • Data completeness • Causes for deviations from indicators • *Uncertainties* • Other information

Appendix 1

System(s) in place to reduce, prevent or eliminate discharges and their efficiency

Abatement systems[5] and management (according to 2.1 and 2.2).

Abatement system/ Management	**Into operation (Year)**		**Efficiency of abatement system**		**Comments**
	Existing	**Planned**	**Decontamination Factor**	**Other measure of efficiency**	
Discharges:					
delay tank(s)					
chemical precipitation					
centrifuging					
hydrocyclone					
cross-flow filtration					
ion exchange					
osmosis					
ultrafiltration					
..other….					
..other….					
Emissions:					
electrostatic precipitation					
cyclone scrubbing					
chemical adsorption					
HEPA filtration					
cryogenics					
..other….					
..other….					
Changes in management or processes*:*					
……					
……					

5 The examples on abatement techniques are taken from the recently published OECD/NEA report "Effluent release options from nuclear installations".

Annex 2: National Implementation Reports

The Implementation reports listed below are available on the OSPAR website[6]:

Publication No. ***391/2009***: Implementation of PARCOM Recommendation 91/4 on liquid discharges, Report from the ***Netherlands***, OSPAR Commission 2009.

Publication No. ***392/2009***: Implementation of PARCOM Recommendation 91/4 on liquid discharges, Report from ***Sweden***, OSPAR Commission 2009.

Publication No. ***393/2009***: Implementation of PARCOM Recommendation 91/4 on liquid discharges, Report from ***United Kingdom*** – Part I + II, OSPAR Commission 2009.

Publication No. ***503/2010***: Implementation of PARCOM Recommendation 91/4 on liquid discharges, Report from ***France***, OSPAR Commission 2010.

Publication No. ***506/2010***: Implementation of PARCOM Recommendation 91/4 on radioactive discharges for 2010, Report from ***Switzerland***, OSPAR Commission 2010.

Publication No. ***505/2010***: Implementation of PARCOM Recommendation 91/4 on radioactive discharges for 2010, Report from ***Norway***, OSPAR Commission 2010.

Publication No. ***529/2011***: Implementation Report of PARCOM Recommendation 91/4, Report from ***Spain***, OSPAR Commission 2011.

Publication No. ***530/2011***: Implementation Report of PARCOM Recommendation 91/4, Report from ***Belgium***, OSPAR Commission 2011.

Publication No. ***531/2011***: Implementation Report of PARCOM Recommendation 91/4, Report from ***Germany***, OSPAR Commission 2011.

RSC 11/5/2-E: Portuguese report on the implementation of PARCOM recommendation 91/4 on radioactive discharges, Presented by ***Portugal***[xxx]

Denmark – no report submitted.

Annex 3: Summary of Site-Specific Information on http://www.ospar.org in the Publications section (as part of the Radioactive Substances Series)

Annex 3: Summary of General Information – Implementation of BAT/BEP in national legislation / regulation

GENERAL INFORMATION
Implementation of BAT/BEP in national legislation / regulation

BELGIUM	DENMARK	FRANCE
- **law** concerning protection of the population from ionizing radiation **from 1958** (modified several times by different Royal decrees); - **new legislation by Royal Decree in 2001** to harmonize the legislation with the European Directives • "General Regulations for the Protection of the population, workers and the environment against the dangers of Ionising Radiation – (**GRPIR**)" • FANC (Federal Agency for Nuclear Control) has to survey the objectives of this legislation: → propose, apply and improve law and regulations; → control human (and not human) activities responsible for exposure of man to radioactivity; → ensure the surveillance or radioactivity on the territory (TELERAD automatic network); → co-operation to nuclear emergency plans; → distribute neutral and objective information; - **law of 2006** gives right to the public to access information with regard to the environment; - **major principles of all the Belgian regulations** are based on EC Directives, international conventions and recommendations of ICRP and IAEA: • justification of exposure → exposure to radiation only allowed if the advantage is larger than the possible risk and damage of the exposure; • optimisation → known as the ALARA-principle → the exposure has to be as low as possible taking social and economic factors into account; • dose limits → exposure of individuals as result of combination of different exposures has to be subject to limits to prevent unacceptable risks;	- information not available	- **Laws:** in 2006 two laws were approved by Parliament: • *Law No. 2006-686* → concerning transparency and nuclear safety (**TSN law**); • *Law No. 2006-739* → concerning a programme for sustainable management of radioactive materials and wastes; - **Environmental Code:** • defines the principles and general rules applicable to environmental protection; • three major principles: → precautionary *principle* → do all steps to prevent serious and irreversible environmental damages at an economically acceptable cost; → *polluter-pays principle* → polluter carries all costs resulting from measures to prevent or reduce pollution and to combat it; → *participatory principle* → everyone has access to information and the public is involved in the process of developing projects; - **TSN law**: • establishes a new system to regulate nuclear installations; • introduces new provisions regarding information; • supplemented by various implementing regulations; - **General technical regulations**: • include all of the measures of general application concerning nuclear safety; • Ministerial Order (1999-11-26) establishes the general technical requirements concerning limits and methods of water takings and discharges; • limits of discharges must be established on the basis of BAT; • BAT understood in the sense of Directive No. 96/61/CE of 9/24/96 concerning the combined prevention and reduction of pollution.

Implementation of BAT/BEP in national legislation / regulation

GERMANY	NETHERLANDS	NORWAY
- **Atomic Energy Act** (last amended in 2002): • includes general national regulations for protective and preventive measures, radiation protection, disposal of radioactive waste and irradiated fuel elements; • basis for associated ordinances; • licence required: → for the construction, operation or any holding of a stationary installation for the production, treatment, processing or fission of nuclear fuel; → for materially altering such an installation or its operation; • licensing prerequisites must be fulfilled; • purposes of the Act: → to cease the use of nuclear energy for the commercial production of electricity in a structured manner and to ensure ongoing operation until the date of discontinuation; → to protect life, health and property against the hazards of nuclear energy and the detrimental effects of ionising radiation; → to provide for the compensation for any damage and injuries incurred - **Radiation Protection Ordinance (StrlSchV)** regulates the principles of: • radiation protection; • dose limits; • requirements for the organisation of radiation protection; • personal and environmental monitoring; • accident management; • design against incidents; • accident planning values;	- Basic legislation – **Nuclear Energy Act** • stimulation of the safe application of nuclear energy and radioactive techniques; • giving rules for protection against risks of such applications; • basic rules in nuclear fields; • provisions for radiation protection: → justification; → optimisation (ALARA, but not explicitly BAT/BEP); → dose limits.	- legal basis for nuclear installations: • **Act No.36** on Radiation Protection and Use of Radiation of 12.05.2000; • **Regulation No.1362** on Radiation Protection and Use of Radiation of 21.11.2003; • **Act No. 28** concerning Nuclear Energy Activities of 12.05.1972, revised 17.06.2005; - purpose of Radiation Protection Act: • to prevent harmful effects of radiation on human health; • to contribute to the protection of the environment; - Norwegian practice focus on: • Best Available Techniques (BAT) → regarding discharges of radioactive substances implemented in the Radiation Protection Regulation → reference to OSPAR definition; • ALARA principles; • precautionary principles;

GENERAL INFORMATION
Implementation of BAT/BEP in national legislation / regulation

PORTUGAL	SPAIN	SWEDEN
- information not available	- **Basic laws**: • Nuclear Energy Act (Law 25/1964); • Law 15/1980 → creating the Nuclear Safety Council (CSN); • reforms by Law 33/2007. - **Regulation on Nuclear and Radioactive Facilities** (Royal Decrees 1838/1999 and 35/2008) • continuously improvement of the nuclear safety and radiation protection conditions of the facility; • current best techniques and practices must be analysed and implemented according to the requirements of CSN; • development of a Continuous Safety Assessment Programme (CSA) by the licensee; • annual report on the results of the CSA submitted to CSN; - **Regulation on the Protection of Health against Ionising Radiations** (Royal Decree 783/2001): • requirements on the system applied to limit emissions and discharges – system of limitation, surveillance and control of radioactive effluents; • radioactive waste provided with adequate treatment and removal systems in order to ensure that doses due to releases are lower than the established limits in the licences; • specific limits, surveillance requirements and conditions for the releases are given for every facility; • in normal operating conditions the doses to members of the public are in accordance with ALARA principle. - **Regulations on the Evaluation of the Environmental Impact** (Royal Legislative Decree 1/2008): • involves a wide range of activities including the generation of nuclear energy; • submission of a “Declaration of Environmental Impact” report in the licensing process. - **The Nuclear Safety Council’s Instruction IS-26** (16th June 2010): • Periodic Safety Review programme (PSR) performed on a ten years basis following the recommendations of the CSN Safety Guide 1.10 → overall assessment of the behaviour of the installation during the considered period;	- **Radiation Protection Act:** • protection of man and environment against harmful effects of radiation; • radiation protection shall be in reasonable accordance with technical and methodological development and shall be improved; - **Radiation Protection Ordinance**: • details according to the authorisation in Radiation protection act; • authorises the Swedish Radiation Safety Authority (SSM) to act as the central administrative authority in the area of radiation protection. - **Environmental Code:** • covered a wide range of environmental issues, including provisions on environmental impact assessments, licensing procedures etc.; • applicable to activities generating ionising radiation in the environment; • identifies the BAT as a means for achieving the goal of prevention, eliminating of reducing the impact of health and the environment of human activities. - **Regulations issued by SSM:** • “Regulations on the Protection of Human Health and the Environment from the releases of Radioactive Substances from certain Nuclear Facilities” • applicable to nuclear power reactor, research or material testing reactor, facility for fabrication of uranium pellets and nuclear fuel bundles, facility for storage or other handling of spent nuclear fuel, facility for storage, handling and final deposal of nuclear material or nuclear waste; • not applicable to shallow land burials of low-level nuclear waste, to the transport of nuclear material/waste outside the facility, to the dismantling of a nuclear facility, after the closure of such a waste facility; • identify BAT as a means for limitation of releases; • BAT defined as “ the most effective measure available to limit the release of radioactive substances and the harmful effects of the releases on human health and the environment, which does not entail unreasonable costs”

PORTUGAL	SPAIN	SWEDEN
	• release of radioactive effluents into the environment must comply with established limits; • design of nuclear installations must ensure that radiological consequences in future generations are not greater than those of current generation. - **Reference Levels** (RL): • established by CSN for liquid and gaseous effluents; • regularly reviewed;	

SWITZERLAND	UNITED KINGDOM	
- **Swiss Federal Act** and **Ordinance on Radiological Protection** based on recommendations of ICRP Publication 60 since 1994; - new dose factors in compliance with IAEA Safety Series No. 115 since 2000; - fundamental concepts of justification, optimization, radiation dose limitation and the 10 µSv-per-year-concept adopted by Swiss legislation and by Swiss Federal Nuclear Safety Inspectorate in its regulatory guidelines. - **Ordinance** for ratification of international resolution and recommendations since 2000 → PARCOM recommendation 91/4 has to be considered by the execution of environmental protection regulations; - **New nuclear energy legislation in 2005** → requiring of periodic safety reviews: • performed by the licensee of NPPs in a time interval of 10 years; • evaluated by the Nuclear Safety Inspectorate; • assessment of liquid and gaseous discharges of the NPP and, if requested , compared to corresponding discharges of similar European reactors; • discharges of the NPP higher than the benchmark → analysis of	- formal basis – the **Radioactive Substance Act 1993** (RSA 93) as amended by the: • Environmental Act (1995); • Basic Safety Standards Directive (BSS). - **other relevant legislation**: • Environmental Protection Act (1990); • Nuclear Installation Act (1965, as amended); • Pollution Prevention and Control Act (2000); • Control of Major Accident and Hazards Act (1999); • Water Industry Act (1991); - **appliance of radiological protection principles** → recommended by ICRP to reduce levels of radioactive discharges and doses of ionizing radiation to humans; - **UK Strategy for Radioactive Discharges 2001-2020** published in 2002 describes the implementation of the agreements reached at the 1998 Ministerial meeting → reviewed in 2008 and published in 2009: • adaptation of targets and profiles to current assumptions about future activities; • change of assumption due to implementation of a programme of	

GENERAL INFORMATION
Implementation of BAT/BEP in national legislation / regulation

SWITZERLAND	UNITED KINGDOM	
the reasons by the licensee and make suggestions in reducing the discharges. - BAT/BEP implemented in the Swiss national legislation according to the terms of the OSPAR convention.	new-build nuclear power stations in England and Wales; • potential discharges of the new build programme not accurately quantified and not included in current discharge profiles; • intention to review the strategy about every five years; • additional controls: → justification of practices by the Government; → optimization of protection; → application of limits and conditions to control discharges → protection against unacceptable radiation risks; • based on following principles: → sustainable developments; → precautionary principle; → polluter-pays-principle; → use of "concentrate and contain" over "dilute and disperse". - two optimisation approaches are part of UK pollution law: • **Best Practicable Means** (BPM) → minimization of radioactive waste arising as well as discharges and disposals of radioactive waste → ALARA principle; • **Best Practicable Environmental Options** (BPEO) → decision aiding procedure; • replacement of BPM and BPEO by BAT-concept in England and Wales; • further use of BPM in Scotland and North Ireland; • development of a database of national and international waste minimization techniques by the Environmental Agencies Requirement Working Group to support BAT, BPM or BPEO;	

Annex 4: Summary of General Information – Dose constraints / limits for nuclear facilities

Dose constraints / limits for nuclear facilities

BELGIUM	DENMARK	FRANCE
- dose limits are given by GRIPR: • effective dose: → public → 1 mSv/a; → workers → 20 mSv/a; → apprentices and students ≥ 18 years → 20 mSv/a → apprentices and students 16 ≤ < 18 years → 6 mSv/a; • dose equivalent for any individual organ or tissue: → public → – mSv/a; → workers → 500 mSv/a; → apprentices and students ≥ 18 years → 500 mSv/a → apprentices and students 16 ≤ < 18 years → – mSv/a; • dose equivalent for lens of the eye: → public → 15 mSv/a; → workers → 150 mSv/a; → apprentices and students ≥ 18 years → 150 mSv/a → apprentices and students 16 ≤ < 18 years → 50 mSv/a; • dose equivalent for skin: → public → 50 mSv/a; → workers → 500 mSv/a; → apprentices and students ≥ 18 years → 500 mSv/a → apprentices and students 16 ≤ < 18 years → 150 mSv/a; • dose equivalent for hands, arms, feet and ankles: → public → – mSv/a; → workers → 500 mSv/a; → apprentices and students ≥ 18 years → 500 mSv/a → apprentices and students 16 ≤ 18 years → 150 mSv/a; - nuclear installations apply for their workers a dose constraint of 10 mSv/a.		- **acceptable annual dose limit for a member of the public → 1 mSv/a** - radiological impact of nuclear activities → operators' task: • reduction of the radiological impact to values as low as reasonably possible; • evaluation of the dosimetric impact caused by its activity → Article L1333-8 of Public Health Code or regulations concerning discharges from INBs depending on the case; - evaluation contents: • discharges from identified outlets → stack and discharge outfalls into the fluvial and marine environment; • diffuse emissions and sources or radiological exposure to ionizing radiation present in the facility; - impact estimated for identified reference groups: • homogeneous groups of persons receiving the highest average dose among the entire population exposed at a given facility under realistic scenarios; • enables comparison between the total dose and the acceptable annual dose limit for a member of the public (< 1 mSv/a) → Article R1333-8 of the Public Health Code; - liquid radioactive discharges produced by the nuclear industry → very little radiological impact.

GENERAL INFORMATION
Dose constraints / limits for nuclear facilities

GERMANY	NETHERLANDS	NORWAY
- dose limits in accordance with recommendations of the ICRP and Directive 96/29/EURATOM; - **limit for the effective dose to members of the public** from practices (§ 46 StrlSchV) → < 1 mSv/a; - dose limits for the exposures resulting from discharges and emissions of nuclear installations General Administrative Provision (AVV) to § 47 StrlSchV): • effective dose → < 0,3 mSv/a; • organ dose for gonads, uterus, bone marrow (red) → < 0,3 mSv/a; • organ dose for colon, lungs, stomach, bladder, breast, liver, oeso-phagus, thyroid, other organs or tissues unless specified → < 0,9 mSv/a; • organ dose for bone surface and skin → < 1,8 mSv/a; - assumptions for calculation of the dose to members of the public for six age groups: • permanent stay at the most unfavourable location; • exclusive consumption of foodstuffs produced at another most un-favourable location; - General Administrative Provision (AVV) to § 47 StrlSchV describes: • transfer parameters quantifying the transport of radionuclides into foodstuffs, including human milk and sediment; • procedures for calculation of activity concentrations of radionuclides in air, soil, freshwater, foodstuffs including human milk and sediment; • consumption rates for the six age groups for all relevant categories of foodstuffs including drinking water and human milk; • dose coefficients and dose rate coefficients for internal and external exposure for organs and effective dose; • exposure pathways; - dose coefficients for internal exposure taken from relevant ICRP pub-lications and the Directive 96/29/EURATOM; - calculation of the annual radiation exposure of members of the general public for all nuclear facilities carried out by the Federal Office for Radiation Protection (BfS) → based on: • discharge and emission data measured by the operators; • actual meteorological conditions; • application of AVV to § 47 StrlSchV;	- **dose limit for members of the public: < 1 mSv/a** - assumption: a member of public will be exposed to 10 sources at most; - a location limit for individual sources: < 0,1 mSv/a, also a nuclear power plant due to normal operation.	- **dose limit for the most exposed members** of the general population from liquid discharges → < 1 µSv/a; - dose limit for emissions to air → 100 µSv/a, where iodine isotopes shall not contribute >10 µSv/a.

Dose constraints / limits for nuclear facilities

PORTUGAL	SPAIN	SWEDEN
-	- dose limits for members of the public: • **effective dose** → 1 mSv/a; • equivalent dose to the skin → 50 mSv/a; • equivalent dose to lens → 15 mSv/a. - dose constraint set as an effective dose of 0,3 mSv/a for NPPs and other fuel cycle installations (since 1993).	- dose limit for individuals of the general public, resulting from all practices → 1 mSv/a; - **effective dose < 0.1 mSv/a** to an individual in the critical group, from one year of releases of radioactive substances to air and water from all facilities located in the same geographically delimited area; - integration of the effective dose (dose from external radiation and the committed effective dose from internal exposure) over a period of 50 years; - calculating dose to individuals in the critical group both children and adults; - dose coefficients for intake and inhalation specified in Council Directive 96/29/EURATOM, Appendix III; - calculated dose ≥ 0.1 mSv/a → realistic calculations of radiation dose based on measured dispersion data and conditions within the most affected area have to be conducted for the most affected area.

SWITZERLAND	UNITED KINGDOM	
- **dose limit for members of the public** according to the Ordinance of Radiological Protection → **< 1 mSv of annual effective dose**; - dose guide values according to the Inspectorate's Guideline R-11: • source-related dose guide value for nuclear installations → < 0.3 mSv/a and person → sum of the doses due to radioactive emissions into atmosphere, discharges into water and direct radiation; • dose guide value for direct radiation → < 0.1 mSv/a and person; - design of a nuclear facility may not exceed the dose guide values as a result of: • radioactive releases caused by incidents with an occurrence greater than 0.01 per year; • dose limit for members of the public not exceeded by incidents with an occurrence greater than 0.0001 per year.	- **dose limit for members of the public** since 1993 → **< 1 mSv/a**; - in 2000 implementation of elements of the BSS Directive in England and Wales requires to ensure that: • all public radiation exposures from radioactive waste disposal are kept ALARA; • the sum of such exposures → dose limit < 1 mSv/a; • the dose received from any single site → < 0,5 mSv/a; • the dose received from any new source → < 0,3 mSv/a; - separate direction in Scotland with equivalent recommendations; - limits, source and site constraints already in use since 1995 → CM 2919 "Review of Radioactive Waste Management Policy" → includes a lower bound/threshold to optimization of 20 µSv/a below which operators are not required to secure further reductions in exposures if BPM is applied to limit discharges; - in the draft of UK Discharge Strategy was proposed → no further reduction of discharge limits when doses are less than 10 µSv/a; - this value of 10 µSv/a is not included in the relevant Scottish Statutory Guidance	

Annex 5: Summary of General Information – Discharge limits

Discharge limits

BELGIUM	DENMARK	FRANCE
- annual limits for discharges and emissions specified for a nuclear facility in such a way that the resulting doses to the population shall not exceed 1 mSv/a for all pathways combined; - discharge limits have to be based on a fraction of the public annual limit of 1 mSv → dose constraints are set for each nuclear site; - model used for estimation of the radiation exposure of the critical group based on the Nuclear Regulatory Guide with the following conservative adaptations: • dose factors based on the ICRP72; • 6 classes of age; • eventual adaptation of some parameters (consumption habit etc.); - dose is calculated at the most unfavourable receiving points taking into account the relevant exposure pathways and living habits.	-	- "INB procedures" Decree No. 2007/1557: • adopted in application of Article 36 of TSN Law; • repeals Decree No. 95-540; • concerns nuclear installations and the regulation of the transport of radioactive substances; • defines new framework for procedures concerning the full life cycle of an INB → from construction license to final shutdown and dismantling; • relationship between the ministers responsible for nuclear safety and the ASN; • authorizing decrees now include the authorization of discharges from the INB → supplemented by individual stipulations based on ASN decisions → specific stipulations setting the limits for discharges from the INB into the environment need the approval of the ministers responsible for nuclear safety; • safety review of installations every 10 years; - limit values for discharges: • regulatory limits in the past not representative of actual discharges → optimization efforts → substantial reduction in discharges; • ASN will revise discharge limits such that they are close to actual discharge figures → keeping up operators' efforts to reduce and control their discharges; • updating of requirements time-consuming → at present 70 % of French facilities' regulations based on Decree No. 95-540 or TSN Law; • permits of water intakes and non-radioactive discharges by prefectorial orders for a specific period → generally 15 to 18 years; • permits for liquid and gaseous radioactive discharges by interministerial orders of unlimited duration → reviewable at any time; - control of radioactive discharges: • implementation of provisions by the operators; • monitoring of the discharges → operator's responsibility; • monitoring of the environment; • measurements of related parameters → especially meteorology; • record of the data obtained in registers → sent to ASN monthly for checking; • a certain number of samples collected from the discharges must be sent to an independent laboratory for analysis → results of these "cross" analyses must be sent to ASN; • unscheduled inspections of ASN → inspectors assisted by technicians from an independent laboratory → about 10 to 20 inspections with

GENERAL INFORMATION
Discharge limits

BELGIUM	DENMARK	FRANCE
		sampling per year; - changes in the accounting rules for radioactive discharges in 2002 by ASN → progressively applied to almost all of the French nuclear facilities in OSPAR area due to renewal of their discharge permits: • for each of the regulated categories of radionuclides → specific analysis of radionuclides and not overall measurements; • detection limits defined for each type of measurement; • for each INB and for each type of effluent a “reference spectrum” is defined → if the activity is less than the decision threshold, this threshold figure is used in the accounting; • other radionuclides not systematically accounted are included of their activity concentrations are higher than the decision threshold; - Tritium discharges: • low radiotoxicity; • not concentrated in food chains in the form of tritiated water; • investigations about the influence of tritium necessary → ASN decided to establish two independent discussion groups: • “tritium impact” group → establishing an inventory of the scientific knowledge concerning tritium’s impact on health; • “defence in depth” group → investigating the state of the art regarding the technical possibilities for treating tritium and establishing an inventory of knowledge concerning the environmental impact; • information of the public: • consulting during the permitting procedures → public inquiry; • recommendation of ASN to the operators → establishment of a procedure for consulting the public in certain cases (experiment); • annual report to ASN concerning the impact of the facility on the environment → full information on discharges of effluents for the preceding year; - changing in annual liquid discharge limits for: • two 900-MWe units: → Tritium → new → 40000 to 80000 GBq (high burnup fraction fuel); old → 55000 GBq; → Iodines → new → 0,3 GBq; old → 750 GBq (including other radionuclides except H-3, K-40 and Ra); → other radionuclides except H-3, K-40 and Ra → new → 30 GBq; old → 750 GBq (including iodines); → C-14 → new → 130 GBq; old → unregulated;

GENERAL INFORMATION
Discharge limits

BELGIUM	DENMARK	FRANCE
		• two 1300-MWe units: → Tritium → new → 80000 to 90000 GBq (high burnup fraction fuel); old → 80000 GBq; → Iodines → new → 0,1 GBq; old → 222 GBq (including other radionuclides except H-3, K-40 and Ra); → other radionuclides except H-3, K-40 and Ra → new → 5 GBq; old → 222 GBq (including iodines); → C-14 → new → 190 GBq; old → unregulated; • two 1450-MWe units: → Tritium → new → 80000 to 110000 GBq (high burnup fraction fuel); old → 80000 GBq; → Iodines → new → 0,1 GBq; old → 1100 GBq (including other radionuclides except H-3, K-40 and Ra); → other radionuclides except H-3, K-40 and Ra → new → 25 GBq; old → 1100 GBq (including iodines); → C-14 → new → 190 GBq; old → unregulated;

GENERAL INFORMATION
Discharge limits

GERMANY	NETHERLANDS	NORWAY
- annual limits for discharges and emissions of a nuclear facility → the dose limits of § 47 StrlSchV mustn't be exceeded during normal operation and decommissioning; - limits for discharges and emission laid down in the licence of every nuclear facility; - Guideline on Emission and Environmental Monitoring (REI): • specifies requirements for discharge and emission monitoring; • contains mandatory measurement programmes; - Monitoring of radioactive discharges and emissions: • carried out by the operators themselves → results are submitted to the national authority; • described in the Appendices of REI; • refers to corresponding KTA Safety Standards of the KTA 1500 series - KTA 1500 series gives instructions concerning: • type of sampling; • sample treatment; • time periods of sampling; • radionuclides considered; • detection limits; • reporting; - important guidelines of the KTA 1500 series: • KTA 1503.1 → monitoring of emissions in normal operations of nuclear power plants; • KTA 1503.2 → monitoring of emissions in case of design basis accidents in nuclear power plants; • KTA 1504 → monitoring of discharges with water in nuclear power plants; • KTA 1507 → monitoring of discharges and emissions from research reactors; - further important KTA Safety Standards Series → KTA 3600 series → requirements for technical standards in "Activity Control and Activity Management", e. g.: • KTA 3603 "Facilities for the treatment of radioactively contaminated water in nuclear power plants"; • KTA 3605 "Treatment of radioactively contaminated gases in nuclear power stations with light water reactors"; - application of national standards of the German Institute for Standardisation (DIN) and international standards ISO and IEC in the design and operation of all technical installations;	- a limited amount of radionuclides, which differs per installation, can be disposed; - for surface water limits can be given per group of nuclides: • beta/gamma emitters (excluding tritium); • alpha emitters; • tritium (given only for NNPs and NWTPs); - research facilities → Re_{ing} (radiotoxicity equivalent for ingestion) → defined by the Ministry of Housing, Spatial Planning and the Environment as the radioactivity that, if completely ingested at the discharge source, would cause an effective dose of 1 Sv to reference man;	- radionuclide specific discharge limits not defined by NRPA; - restrictions of discharges implemented through dose limit to the most exposed members of the general population; - nuclide specific notification levels: • in addition to the discharge limits; • informing of NRPA at excess of notification level → reason for the discharge must be explained;

Discharge limits

PORTUGAL	SPAIN	SWEDEN
-	- effective dose value for nuclear facilities during operation and decommissioning → 0,1 mSv/a; - discharge limits formulated in terms of dose and distributed between liquid and gaseous effluents for every NPP; - no specific discharge limit distribution for effluents released by the fuel fabrication plant; - system of limitation, surveillance and control of radioactive effluents included in the operation permits → part of Technical Specifications - Technical Specifications content: • discharge limits; • sampling programmes; • analysis programmes; - procedural details for these Radiological Technical Specifications developed in the official document "Off Site Dose Calculation Manual" (ODCM); - ODCM includes also: • methodology; • parameters for estimating offsite doses due to radioactive emissions and discharges; • parameters for calculating the monitoring alarm/trip set points; - monthly estimation of cumulated doses in the last 12 consecutive months by the operators: • source term: all radionuclides detected by mean of the effluent sampling and analysis programmes; • estimation according to the procedures specified in ODCM;	- no radionuclide specific discharge limit defined; - limitation of releases implemented through the restriction of dose to the critical group members; - specific release-to-dose factors in mSv/Bq: • calculated for each nuclear facility and for each radionuclide that may be released; • calculated for 97 radionuclides that may be discharged to the marine environment and 159 radionuclides that may be emitted to air; • based on considerations of local dispersion conditions in air and in the environment, local settlements, local production of food-stuffs as well as on moderately conservative assumptions on diet and contribution of locally produced food-stuff to the diet; • the sum of dose contribution from all monitored radionuclides released → < 0.1 mSv/a. - monitoring of all released radionuclides → since 2002 monitoring of the emission of C-14 and H-3. - Discharge control through measurements of representing samples for each release pathway: • nuclide-specific measurements of gamma and alpha-emitting radionuclides; • where relevant → measurements of Sr-90 and H-3;

GENERAL INFORMATION
Discharge limits

SWITZERLAND	UNITED KINGDOM	
- fixed in the licence for operation of each facility; - observation of the source-related dose guide value of 0.3 mSv per year and person; - dose calculation model for a person of the critical group defined in the Inspectorate's Guideline G-14; - annual discharge limits for liquid discharges given for H-3 and other nuclides; - released nuclides without H-3 normalized with a reference exemption limit (LE) of 200 Bq/kg; - supplementary a limit is set for the concentration of radioactivity in the discharged water → concentration < 100 → calculated according to the summation rule for nuclide specific exemption limits given as specific activity LE in the Radiological Protection Ordinance	- annual limits for discharges and emissions; - in addition quarterly notification levels, which are not limits, but allow to investigate whether BPM has been applied in the control of relevant discharges; - BPM not adopted → breach of authorisation;	

Annex 6: Summary of General Information – Nature of inspection and surveillance programs

GENERAL INFORMATION

Nature of inspection and surveillance programs

BELGIUM	DENMARK	FRANCE
- inspection of nuclear installations several times each year by FANC or authorized inspection and controlling bodies; - environmental monitoring program undertaken by special authorized laboratories under the co-ordination and responsibility of FANC; - analyses in accordance with internal Quality Control procedures also involving calibration of detectors and yearly comparison exercises; - **TELERAD network**: • automatic remote radioactivity measuring network; • modernized in 2010 with modern data communication links; • 218 stations measure constantly the radioactivity of the ambient air and river waters; • stations distributed: → throughout the entire country for nationwide monitoring; → in rings around the nuclear sites to monitor the installations; → in the urban areas close to the nuclear sites; • equipment of the stations: → around the nuclear sites gamma spectrometry; → existing river stations also modified with gamma spectrometry; → new automatic gamma spectrometry probes up- and down-stream of the Doel NPP on the Scheldt river; → automatic gamma spectrometry probes placed at the outlet of the release channels of the NPPs; • in-situ controlling of the radioactivity of waters from selected sewage purification plants with automatic gamma spectrometry probes; • all stations linked to a centralized system with a full redundant set-up at a disaster recovery site; - reporting: • monthly and annual reports of results of discharge measurements by operators to FANC → since 2011 new note concerning the periodical reporting of radioactive releases transposing the requirements of recommendation 2004/2/EURATOM; • annual report of results of the radiological surveillance program of the territory on the FANC website; • annual report of discharge data from nuclear installations to EURATOM and to OSPAR; • hourly report of the dose rate data from the TELERAD network to the European Commission;	- no information available	- national network for environmental radioactivity measurement: • implementation of Euratom 96/29 directive and 2003/4/CE directive; • information of the public concerning the nuclear industry's impact on health throughout France; • development of an internet portal in order to enable access to radioactivity measurements and their interpretation in terms of radiologic impact → development and validation completed in 2009 → opened to public in 2010; • publication of mandatory and non-mandatory environmental measurements carried out by various actors. - quality of environmental measurements: • introduction of a system for approving laboratories; • approvals cover all of the environmental matrices → water, soils, sediments, biologic matrices (fauna, flora, milk), aerosols and atmospheric gases; • measurements include artificial and natural radionuclides and ambient gamma dosimetry; • inter-laboratory comparison trials organized by IRSN over a five-year cycle; • new approval procedures since 2008 → approved laboratories published in ASN's Official Gazette; • Approval Committee is the authority within the National Network for the Measurement of Environmental Radioactivity → responsible to ASN. - approved laboratories have to: • establish an organization that meets the stipulations of Standard EN ISO/CEI 17025; • take part in inter-laboratory trials; • 60 approved laboratories in the beginning of 2010;

GENERAL INFORMATION
Nature of inspection and surveillance programs

GERMANY	NETHERLANDS	NORWAY
- inspection of the nuclear installations several times a year by the licensing authority for: • verification of the compliance with the emission surveillance program; • taking of random double samples for measurements in laboratories of their own - Guideline "**Verification of the Licensee's Monitoring of Radioactive Effluents from Nuclear Power Plants**" : • list of measurements performed by independent experts, preferably by an official institution → BfS; • three major parts: → routine measurement program → in line with the measurements according to KTA 1503.1 and KTA 1504; → intercomparison measurements during the operation starting phase; → quality control by round-robin tests; - independent and remote monitoring for emissions by the supervisory authority via Remote Monitoring System for Nuclear Power Plants (KFÜ) data network → continuous surveillance of actual plant parameters and transmission of the parameters to the competent supervisory authority: • operational aspects; • monitoring of emissions; • monitoring of environmental concentrations of radionuclides • meteorology; - surveillance of the measurements of water and air samples of the operators by an independent organisation → the amount of the control measurements is defined in the REI. - reporting to the competent authority by the operators: • discharges: → monthly – gamma-emitters; → quaterly – H-3, Sr-89, Sr-90, total-alpha; → annually – Fe-55, Ni-63; • emissions: → quarterly – radioactive noble gases, iodine, particulates, alpha-emitters, Sr-89, Sr-90, H-3, C-14; - annual reporting: • national report "Environmental Radioactivity and Radiation Exposure" published by the Ministry of Environment, Nature Conservation and Nuclear Safety (BMU); • international reporting of the discharges and emissions to EURATOM and OSPAR;	- inspection of nuclear installations for quality control of measurements: • ad hoc several times per year by the Nuclear Safety Service (KFD); • once per year by the KFD and RIVM (National Institute of Public Health and the Environment)	- regular inspection by the Norwegian Radiation Protection Authority (NRPA) regarding: • nuclear safety; • radiation protection; • environmental protection; - assessment of the annual reports from the operators on environmental monitoring and control measurements of discharges.

Nature of inspection and surveillance programs

PORTUGAL	SPAIN	SWEDEN
- information not available	- Integrated Plant Supervision System (SISC) implemented 2007 for: • systematic evaluation of the NPPS; • control of the NPPs' safety; - focus of SISC to three strategic performance areas: • nuclear safety; • radiological protection; • security; - detached into 7 cornerstones → two of them are: • occupational radiological protection; • public radiological protection concerning the measurement of procedures and systems designed to minimize the radioactive releases from NPPs in normal operation and keeping the releases within the authorized limits; - CSN procedure PG.IV.07 describes SISC and establishes the methodology to evaluate the results; - calculation and verification of SISC operating indicators according to CSN procedure PA.IV.202; - inspections by qualified CSN experts are carried out according to CSN procedure PT.IV.251 and PT.IV.252; - tasks of the inspections regarding radioactive effluents: • compliance with the authorization procedure (sampling, measurement, analysis) → possibility to collect and analyze samples due to the operator's methods → in addition independent sampling and analyzing by CSN as quality control; • applicable actions required by the Technical Specifications when monitors have not been operable; • actions carried out when alarm set points have been exceeded; • operability of the radioactive effluent treatment systems; • operability of the radiological surveillance instrumentation; • supervision of corrective actions implemented after incidents; • problem identification by licensees through self-assessments, audits and monitoring results, their inclusion into the Corrective Action Program, and their solution; - exact radioactive effluent sampling and analysis; - 2004/2/EURATOM Recommendation is applied since 2008;	- inspections at nuclear facilities by SSM to assess systems for collecting data on releases and environmental radioactivity: • online measurements; • filter systems; • waste water sampling; • measurements; • quality assurance; • reporting; - checks of the measurements performed by the operator: • stabilised pooled annual samples from each monitored waste water stream shall be sent to SSM within three months after the end of the discharges year; • analyse of randomly chosen monthly samples of waste water by SSM; • measurements of annual samples concerning gamma emitters and tritium by SSM; • comparison of the results with the operators' data; • control measurements of alpha emitters and Sr-90 in single cases by independent external laboratories; • gammaspectrometric control measurements of aerosol filters by SSM on request → normally once a year; - check of the environmental measurements: • annual analysis of up to 50 sub-samples of the analysed material by the operators; • normally gammaspectrometric measurements, but also alphaspectrometric analysis and Sr-90-analysis, - intercomparisons: • intercomparison organised by SSM → operators analyse liquid, filter or environmental samples of unknown activity; • SSM itself participates in international intercomparisons organised by IAEA or WHO. - safekeeping period: • monitoring data of NPPs preserved and transferred to national archives after decommissioning; • stabilised pooled annual samples of waste water are stored at the facility for at least 10 years; • similar regulations apply also to aerosol filters and environmental samples; • iodine filter samples stored for three months.

Nature of inspection and surveillance programs

PORTUGAL	SPAIN	SWEDEN
	- C-14-measurements: • always measured by Trillo NPP; • since 2007 by the other NPPs; - tasks of inspections regarding the environmental monitoring programs: • existence of adequate equipment for sampling, its operability and the calibration and maintenance process carried out in the course of the period; • implementation of quality control program according to the program approved by CSN; • correct use of procedures in the sampling of previously selected samples by CSN; • correct application of the procedures to the phases of treatment, conservation, identification and transport of samples; • traceability of the information throughout all the process; • program of audit carried out by the operator → internal audit about the monitoring program development, external audits to the analytical laboratories involved; - annual inter-laboratory exercises organized by CSN in cooperation with CIEMAT → participation of all laboratories analyzing environ-mental samples → see Table 10; - Technical documentation of laboratories participating in the sampling stations network (REM) has to content: • description of sampling, detection and measurement equipment; • sampling, analysis and measurement procedures used by the laboratory; • quality assurance program for the measurements made; • results of participation in analytical intercomparison exercises organized by CSN; - periodically audits about quailty systems of the laboratories involved in REM by CSN;	

GENERAL INFORMATION
Nature of inspection and surveillance programs

SWITZERLAND	UNITED KINGDOM	
- controlling of emissions and discharges by the nuclear facility itself according to the Inspectorate's "Regulation on radioactive dis-charges, monitoring of radioactivity and direct radiation in the vicinity of the nuclear facility"; - cross-check of samples and measurements between the Inspectorate, BAG (XX) and the nuclear facility at least 4x per year; - inspection of the abatement systems and environmental surveillance by the Inspectorate including all aspects of: • sampling; • measurement (laboratories and equipment); • data records; • quality assurance; • reporting; - regulations define and establish: • surveillance programs; • the location, frequency and methods of sampling and mea-surement; • responsibility for conducting the tests; operating of a remote dose rate monitoring system as part of the environment surveillance program by the Inspectorate itself.	- review of each authorization periodically by environment agencies → if required, major review or reauthorization process; - authorization review process includes: • all relevant activities conducted or foreseen; • any modifications; • processing → also legacy wastes; • decommissioning; - a number of authorizations have been reviewed and revised during the last reporting period; - forms of regulation and surveillance to ensure that the operator is complying with the conditions, including discharge and emission limits, set out in the RSA 93 authorization: • site inspections; • scrutiny of waste disposal returns (including discharge and emission); • independent sampling; • environmental monitoring; - frequency of inspections: • depending on the nature of the site; • generally not less than monthly; • considerably more often for major and complex sites; • major in-depth multi-inspectorate inspections occasionally with a duration of at least one week; - operator has to: • take duplicate samples; • provide them to the regulator as required; - analysis of the duplicated samples by the regulator's independent analyst → control of the measurements of discharges performed by the operator.	

Annex 7: Summary of Site Specific Information – Site Characteristics

SITE SPECIFIC INFORMATION
Site Characteristics

	BELGIUM			
	Doel	**Tihange**	**Fleurus**	**Mol-Dessel**
Type of facility	4 nuclear power plants (PWR)	3 nuclear power plants (PWR)	- National Institute of Radioelements (IRE); - MDS-Nordion;	- waste treatment and storage centre: • Belgoprocess site 1; • Belgoprocess site 2; - nuclear research centre SCK-CEN; - Belgonucléaire; - Franco-Belge de Fabrication de Com-bustibles International (FBFC International); - Institute for Reference Materials and Measurements (IRMM);
Year for commissioning / licensing / decommissioning	- commissioning: → 1975 – 1975 – 1982 – 1985; - shut-down: →2015 – 2015 – 2022 – 2025;	- commissioning: → 1975 – 1982 – 1985; - shut-down: →2015 – 2022 – 2025;		- shut down of Belgonucléaire: → August 2006; - dismantling of Belgonucléaire: → started in 2009;
Location	Doel	Tihange	Fleurus, Wallonia	Mol-Dessel, Flanders
Receiving waters and catchment area	river Scheldt	river Meuse	liquid discharges sent to Belgoprocess site 1 for treatment	river Molse-Nete
Production	installed capacity → increasing from 2776 MW(e) in 1998 to 2878 MW(e) in 2009;	installed capacity → increasing from 2973 MW(e) in 1998 to 3024 MW(e) in 2009;		

SITE SPECIFIC INFORMATION
Site Characteristics

	FRANCE				
	Belleville-sur-Loire	Le Blayais	Cattenom	Chinon	Chooz
Type of facility	2 nuclear power plants (PWRs)	4 nuclear power plants (PWRs)	4 nuclear power plants (PWRs)	4 nuclear power plants (PWRs)	2 nuclear power plants (PWRs)
Year for commissioning / licensing / decommissioning	first critically → 1987	first critically → 1981	first critically → 1986	first critically → 1982	first critically → 1996
Location	Belleville-sur-Loire	Le Blayais	Cattenom	Chinon	Chooz
Receiving waters and catchment area	Loire	Gironde Estuary	Moselle	Loire	Meuse
Production	installed electrical capacity → 2600 MWe;	installed electrical capacity → 3600 MWe;	installed electrical capacity → 5200 MWe;	installed electrical capacity → 3600 MWe;	installed electrical capacity → 2900 MWe;

	FRANCE				
	Civaux	Dampierre-en-Burly	Fessenheim	Flamanville	Golfech
Type of facility	2 nuclear power plants (PWRs)	4 nuclear power plants (PWRs)	2 nuclear power plants (PWRs)	2 nuclear power plants (PWRs)	2 nuclear power plants (PWRs)
Year for commissioning / licensing / decommissioning	first critically → 1997	first critically → 1980	first critically → 1977	first critically → 1985	first critically → 1990
Location	Civaux	Dampierre-en-Burly	Fessenheim	Flamanville	Golfech
Receiving waters and catchment area	Vienne	Loire	Rhine	Channel → North Sea	Garonne
Production	installed electrical capacity → 2900 MWe;	installed electrical capacity → 3600 MWe;	installed electrical capacity → 1800 MWe;	installed electrical capacity → 2600 MWe;	installed electrical capacity → 2600 MWe;

SITE SPECIFIC INFORMATION
Site Characteristics

	FRANCE				
	Gravelines	**Nogent-sur-Seine**	**Paluel**	**Penly**	**Saint Laurent des Eaux**
Type of facility	6 nuclear power plants (PWRs)	2 nuclear power plants (PWRs)	4 nuclear power plants (PWRs)	2 nuclear power plants (PWRs)	2 nuclear power plants (PWRs)
Year for commissioning / licensing / decommissioning	first critically → 1980	first critically → 1987	first critically → 1984	first critically → 1990	first critically → 1981
Location	Gravelines	Nogent-sur-Seine	Paluel	Penly	Saint Laurent des Eaux
Receiving waters and catchment area	North Sea	Loire	Gironde Estuary	Moselle	Loire
Production	installed electrical capacity → 5400 MWe;	installed electrical capacity → 2600 MWe;	installed electrical capacity → 3600 MWe;	installed electrical capacity → 5200 MWe;	installed electrical capacity → 1800 MWe;

SITE SPECIFIC INFORMATION
Site Characteristics

	FRANCE		
	CEA Fontenay aux Roses Centre	**CEA Saclay Centre**	**AREVA NC de La Hague** former: Établissement COGEMA
Type of facility	- research laboratories - 2 basic nuclear installations (INBs): • INB 165 → process-INB; • INB 166 → support-INB;	- research centre with 8 IBNs: • 2 open pool-type research reactors (OSIRIS and ORPHEE); • 1 teaching Argonaut-type reactor (ULYSSE); • 2 high-level activity laboratories (LHA and LECI); • 2 reprocessing facilities for radioactive liquid effluent (INB 35) and solid radioactive waste (INB 72); • 1 irradiation facility (POSEIDON); - National Institute for Nuclear Science and Technology (INSTN)	spent nuclear fuel reprocessing facility with several units
Year for commissioning / licensing / decommissioning	- INBs → cleanup and dismantling phase; - until 2006 4 INBs;	- first criticality/commissioning: • OSIRIS → 1966; • ORPHEE → 1980; • ULYSSE → 1961; • LHA → gradually from 1954 to 1960; • LECI → 1959 (first part) – 1970 (second part) – 2005 (third part); • INB 35 → since 1958, new improvements 2010; • IBN 72 → authorised 1971; • PSEIDON → authorised 1972; - shutdown: • ULYSSE → 2007, - decommissioning: • LHA → 2008;	- commissioning: • unit UP2 in 1966; • unit UP2-HAO in 1976 modificated to unit UP2-800 in 1994; • unit UP3-A in 1990; • unit R4 in 2002; • unit ACC in 2002;
Location	district of Fontenay-aux-Roses	Saclay, about 20 km SW of Paris;	La Hague, northwest Tipp of the Cotentin peninsula
Receiving waters and catchment area	communal and departmental sewerage system → purification plant in Achères → river Seine	- industrial waste water after treatment sent to → Saclay ponds → rue de Vauhallan → Bièvre → Seine → English Channel - dilution factor at the mouth of the Seine → around 50000;	- the Channel → North Sea; - discharges carried out during a relatively short time, beginning at a precise moment before the high tide, to ensure the best dilution;

SITE SPECIFIC INFORMATION
Site Characteristics

	FRANCE		
	CEA Fontenay aux Roses Centre	**CEA Saclay Centre**	**AREVA NC de La Hague** former: Établissement COGEMA
Production	–	- installed electrical capacity: • OSIRIS → 70 MW(th); • ORPHEE → 14 MW(th);	- production capacity: • unit UP2 → 600 t U/a; • unit UP2-HAO → 400 t U/a increased to 800 t U/a (unit UP2-800); • unit UP3-A → 800 t U/a; - changes in production capacity in 1999: • production limit of each unit UP2-800 and UP3-A set to 1000 t U/a; • production limit of the site set to 1700 t U/a; - indicator "equivalent electrical energy": • more relevant than the mere tonnage or uranium treated; • represents the service rendered by the reprocessed fuel → reference for the normalisation of the data; • practically proportional to the fission products content of the spent fuel → contains the most part of the radioactivity → represents the radioactive input to the process;

SITE SPECIFIC INFORMATION
Site Characteristics

	GERMANY				
	Biblis A	**Biblis B**	**Brokdorf**	**Brunsbüttel**	**Emsland**
Type of facility	nuclear power plant (PWR)	nuclear power plant (PWR)	nuclear power plant (PWR)	nuclear power plant (BWR)	nuclear power plant (PWR)
Year for commissioning / licensing / decommissioning	commissioning → 1974	commissioning → 1976	commissioning → 1986	commissioning → 1976	commissioning → 1988
Location	Biblis, Hessen		Brokdorf, Schleswig-Holstein	Brunsbüttel, Schleswig-Holstein	Lingen, Niedersachsen
Receiving waters and catchment area	Rhine		Elbe		Ems
Production	installed electrical generation capacity → 1225 MW(e);	installed electrical generation capacity → 1300 MW(e);	installed electrical generation capacity: - 1440 MW(e) up to 2007; - 1480 MW(e) since 2008;	installed electrical generation capacity → 806 MW(e);	installed electrical generation capacity → 1400 MW(e);

SITE SPECIFIC INFORMATION
Site Characteristics

	GERMANY				
	Grafenrheinfeld	**Grohnde**	**Krümmel**	**Mülheim-Kärlich**	**Neckarwestheim 1**
Type of facility	nuclear power plant (PWR)	nuclear power plant (PWR)	nuclear power plant (BWR)	nuclear power plant (PWR)	nuclear power plant (PWR)
Year for commissioning / licensing / decommissioning	commissioning → 1981	commissioning → 1984	commissioning → 1983	- commissioning → 1986 - shut down → 1988 - decommissioning → 2004	commissioning → 1976
Location	Grafenrheinfeld, Bayern	Grohnde, Niedersachsen	Brunsbüttel, Schleswig-Holstein	Mülheim-Kärlich, Nordrhein-Westfalen	Neckarwestheim, Baden-Württemberg
Receiving waters and catchment area	Main	Weser	Elbe	Rhine	Neckar
Production	installed electrical generation capacity → 1345 MW(e);	installed electrical generation capacity → 1430 MW(e);	installed electrical generation capacity: - 1316 MW(e) up to 2005; - 1402 MW(e) since 2006;	installed electrical generation capacity → 1302 MW(e);	installed electrical generation capacity → 840 MW(e);

SITE SPECIFIC INFORMATION
Site Characteristics

	GERMANY				
	Neckarwestheim 2	**Obrigheim**	**Philippsburg 1**	**Philippsburg 2**	**Stade**
Type of facility	nuclear power plant (PWR)	nuclear power plant (PWR)	nuclear power plant (BWR)	nuclear power plant (PWR)	nuclear power plant (PWR)
Year for commissioning / licensing / decommissioning	commissioning → 1976	- commissioning → 1968 - shut down → 2005 - decommissioning → 2008	commissioning → 1979	commissioning → 1984	- commissioning → 1972 - shut down → 2003 - decommissioning → 2005
Location	Neckarwestheim, Baden-Württemberg	Obrigheim, Baden-Württemberg	Philippsburg, Baden-Württemberg		Stade, Niedersachsen
Receiving waters and catchment area	Neckar		Rhine		Elbe
Production	installed electrical generation capacity: - 1365 MW(e) up to 2005; - 1395 MW(e) since 2006; - 1400 MW(e) since 2007;	installed electrical generation capacity → 357 MW(e);	installed electrical generation capacity → 926 MW(e);	installed electrical generation capacity → 1458 MW(e);	installed electrical generation capacity → 573 MW(e);

SITE SPECIFIC INFORMATION
Site Characteristics

	GERMANY				
	Unterweser	**Würgassen**	**URENCO Gronau**	**Hanau**	**Advanced Nuclear Fuels GmbH**
Type of facility	nuclear power plant (PWR)	nuclear power plant (BWR)	nuclear fuel fabrication (uranium enrichment)	different facilities for nuclear fuel fabrication (PWR, MOX)	nuclear fuel fabrication (LWR)
Year for commissioning / licensing / decommissioning	commissioning → 1978	- commissioning → 1971 - shut down → 1995 - decommissioning → 1997	commissioning → 1985	- commissioning → 1969; - decommissioning → 1996; - decommissioned → 2006;	commissioning → 1979
Location	Stadland, Niedersachsen	Beverungen, Nordrhein-Westfalen	Gronau, Nordrhein-Westfalen	Hanau, Hessen	Lingen, Niedersachsen
Receiving waters and catchment area	Weser		Vechte → Ijsselmeer	Main	Ems
Production	installed electrical generation capacity → 1410 MW(e);	installed electrical generation capacity → 670 MW(e);	capacity of uranium → 1800 t/a	capacity of uranium → 1350 t/a	capacity of uranium → 400 t/a

SITE SPECIFIC INFORMATION
Site Characteristics

	GERMANY				
	GKSS Geesthacht	**Helmholtz-Zentrum Berlin** former: Hahn-Meitner-Institut	**Jülich Research Centre**	**Institute for Technology of Karlsruhe**	**Verein für Kernverfahrens-technik und Analytik Rossendorf e. V.** former: nuclear research centre
Type of facility	different research and development facilities including two reactors;	different research and development facilities including one reactor (BER II);	different research and development facilities including three reactors;	- different research and deve-lopment facilities including three reactors; - pilot reprocessing plant;	research reactor
Year for commissioning / licensing / decommissioning	- commissioning: • reactor 1 → 1958; • reactor 2 → 1963; - decommissioning: • reactor 2 → 1993;	commissioning → 1973	- commissioning: • reactor 1 → 1962; • reactor 2 → 1966; • reactor 3 → 1962; - decommissioning: • reactor 1 → 1985; • reactor 2 → 1988; • reactor 3 → 2006; - decommissioned: • reactor 1 → 2007	- commissioning: • reactor 1 → 1961; • reactor 2 → 1965 • reactor 3 → 1971; - decommissioning: • reactor 1 → 1981; • reactor 2 → 1984; • reactor 3 → 1991; - pilot reprocessing plant → 1990;	- commissioning → 1957; - decommissioning → 1991
Location	Geesthacht, Schleswig-Holstein	Berlin	Jülich, Nordrhein-Westfalen	Karlsruhe, Baden-Württemberg	Rossendorf, Sachsen
Receiving waters and catchment area	Elbe	Havel	Rur	Rhine	Elbe
Production	reactor capacity: - reactor 1 → 5 MW; - reactor 2 → 15 MW;	reactor capacity → 10 MW;	reactor capacity: - reactor 1 → 10 MW; - reactor 2 → 15 MW; - reactor 3 → 23 MW;	reactor capacity: - reactor 1 → 44 MW; - reactor 2 → 58 MW; - reactor 3 → 20 MW;	–

SITE SPECIFIC INFORMATION
Site Characteristics

	NETHERLANDS		
	Kernenergiecentrale Borssele	**Kerncentrale Dodewaard**	**URENCO**
Type of facility	nuclear power plant (PWR)	nuclear power plant (BWR)	fuel enrichment plant
Year for commissioning / licensing / decommissioning	- commissioned → 1973 - licensed → 1973 - license modified → Sept. 2004 • use of max. 4,4 %wt enriched U-235 • burn-up of nuclear fuel elements to max. 68 MWd/kgU (pin average)	- commissioned →1968 - licensed → 1968 - shut down → 1997 - safe enclosure → since 01.07.2005;	commissioning → 1985
Location	Borssele, Province Zeeland	Dodewaard, Province Gelderland	Almelo, Province Overijssel
Receiving waters and catchment area	river Scheldt - cooling water from the estuary of the river Scheldt; - radioactive liquid effluents discharged into the river Scheldt;	river Waal - cooling water from the estuary of the river Waal; - catchment area → river Waal;	river IJssel - no use of surface water or ground water for cooling purposes (closed-circuit type); - waste water treated in the municipal sewage treatment plant;
Production	- steady thermal power capacity → 1366 MW(th) - electrical power capacity → 485 MW(e) - Net output increased by 35 MW(e) by a turbine upgrade at the end of 2006;	- steady thermal power capacity → 183 MW(th); - electrical power capacity → 58 MW(e);	licensed production capacity increased: - from 2800 tSW/a to 3500 tSW/a in 2005; - to 3700 tSW/a in 2006; - to 4500 tSW/a in 2007; [tSW – tonnes of Separative Work]

SITE SPECIFIC INFORMATION
Site Characteristics

	NETHERLANDS		
	Onderzoeks Locatie Petten or Petten site	**Reactor Institute Delft (RID) (part of the Applied Sciences faculty of the Delft University of Technology)**	**COVRA (Centrale Organisatie Voor Radioactief Afval)**
Type of facility	- two research reactors: • Hoge Flux Reactor (HFR) → swimming pool reactor; • Lage Flux Reactor (LFR) → argonaut low flux reactor; - research laboratories; - auxiliary industry (Tyco-Mallinckrodt); - Covidien company specialized in the production of radio-nuclides for nuclear pharmaceuticals; - Mo-99-production facility.	research reactor (HOR) → swimming pool reactor	waste treatment plant
Year for commissioning / licensing / decommissioning	commissioned → 1960 (research reactors)	commissioned → 1963	- commissioned in 1989 - licensed in 1989
Location	Petten, Province Noord-Holland	Delft, Province Zuid-Holland	Vlissingen, Province Zeeland
Receiving waters and catchment area	North Sea - catchment are might be defined as the dunes	North Sea - liquid waste discharged into the municipal sewage system and treated in the sewage treatment plant in Den Haag - not captured radionuclides proceed to the North Sea	river Scheldt - use of in basin collected rainwater as cooling water ; - cooling water eventually released via the basin to the inland harbour Kaloothaven, which runs into the river Scheldt;
Production	installed capacity: • 50 MW(th) for the HFR; • 30 kW(th) for the LFR;	installed capacity: 2 MW(th)	information about production in a standardised way very difficult

SITE SPECIFIC INFORMATION
Site Characteristics

	NORWAY	
	Institute for Energy Technology Kjeller	**Institute for Energy Technology Halden**
Type of facility	- research reactor JEEP II → heavy water cooled and moderated; - metallurgic laboratory I and II, inclusive hot cells; - storage areas for spent fuel and un-irradiated fuel; - radioactive waste treatment plant for LL- and IL-waste; - medical radioactive isotope facility,	research reactor (HBWR) → heavy water cooled and moderated with three main systems: - primary system (heavy water); - secondary system (two light water heat removal systems – closed loop system)
Year for commissioning / licensing / decommissioning	- commissioned → 1967; - current licence period for JEEP II, metallurgic laboratory, storage areas and radioactive waste treatment plant → 01.01.2009 – 31.12.2018; - licence for operation of the medical radioactive isotope facility not required according to Act No. 28,	- commissioned → 1959 - current licence period → expiry date 31.12.2014,
Location	Institute for Energy Technology Kjeller, about 20 km NE Oslo	Halden, south-eastern part of Norway [containment with the reactor and the primary system located in a mountain hall]
Receiving waters and catchment area	- liquid effluents pumped to the radioactive waste treatment plant; - discharges of the radioactive waste treatment plant to the river Nitelva, further to lake Øyern/river Glomma/ Oslo Fjord;	liquid discharges to the river Tista, further to Iddefjord and to Skagerrak;
Production	- thermal effect of the JEEP II → 2 MW(th); - annual management of solid waste by the radioactive treatment waste plant is about 160 drums (210 litres) - transport of the drums to the combined storage and disposal facility in Hirndalen; - liquid radioactive waste stored for decay at the production site or in the radioactive treatment waste plant	- max. heat removal capacity → 25 MW; - heat is transferred from the tertiary system to an adjacent paper factory as steam; - water temperature in the primary system 235 °C corresponding to an operating pressure of 33.4 bar;

SITE SPECIFIC INFORMATION
Site Characteristics

	PORTUGAL **Campus de Sacavém**
Type of facility	research and development facility with four units: - reactors and nuclear safety unit (URSN) including the Portuguese research reactor RPI; - radiological protection and safety unit (UPSR); - physics and accelerators unit (UFA); - chemical and radiopharmaceutical sciences unit (UCQR);
Year for commissioning / licensing / decommissioning	
Location	
Receiving waters and catchment area	river Tagus
Production	

SITE SPECIFIC INFORMATION
Site Characteristics

	SPAIN			
	Almaraz	**José Cabrera**	**Trillo**	**Juzbado**
Type of facility	2 nuclear power plants (PWR): - Almaraz I; - Almaraz II;	nuclear power plant (PWR)	nuclear power plant (PWR)	fuel fabrication plant for light water reactors
Year for commissioning / licensing / decommissioning	- critically → 1981 – 1983; - commercial operation → 1983 – 1984;	- critically → 1968; - commercial operation → 1969; - shut-down → 2006; - dismantling → since 2010;	- critically → 1988; - commercial operation → 1988;	commissioned → 1985
Location	Almaraz, province of Cáceres	Almonacid de Zorita, province of Guadalajara	Trillo, province of Guadalajara	Juzbado, province of Salamanca
Receiving waters and catchment area	- cooled by water from the Arrocampo reservoir on the Tajo river; - discharges into the Arrocampo reservoir;	- cooled by water from the Zorita reservoir on the Tajo river; - discharges into the Zorita and Almoguera reservoirs;	- cooled by water from the Tajo river; - discharges into the Tajo river;	Tormes river → tributary to the Duero river;
Production	installed electrical capacity: - Alamaraz I → 1050 MW(e) since 2008; - Alamaraz II → 980 MW(e);	installed electrical capacity → 160 MW(e);	installed electrical capacity → 1066 MW(e);	annual capacity: - 400 t until 2010; - 500 t since 2010;

SITE SPECIFIC INFORMATION
Site Characteristics

	SWEDEN			
	Ringhals 1	**Ringhals 2**	**Ringhals 3**	**Ringhals 4**
Type of facility	nuclear power plant (BWR)	nuclear power plant (PWR)	nuclear power plant (PWR)	nuclear power plant (PWR)
Year for commissioning / licensing / decommissioning	- criticality → 1973 - commercial operation → 1976	- criticality → 1974 - commercial operation → 1975	- criticality → 1980 - commercial operation → 1981	- criticality → 1982 - commercial operation → 1983
Location	Ringhals, Swedish West Coast (approx. 50 km S Göteborg, 15 km N Varberg)			
Receiving waters and catchment area	Kattegat			
Production	- gross power → 860 MWe - net power → 830 MWe	- gross power → 917 MWe - net power → 875 MWe	- gross power → power uprate from 960 MWe to 1050 MWe in 2008 - net power → power uprate from 960 MWe to 1000 MWe in 2008	- gross power → 960 MWe - net power → 915 MWe

SITE SPECIFIC INFORMATION
Site Characteristics

	SWITZERLAND					
	Beznau	**Gösgen**	**Leibstadt**	**Mühleberg**	**Waste Treatment and Interim Storage (ZWILAG)**	**Paul Scherrer Institute (PSI)**
Type of facility	2 nuclear power plants (PWR): - KKB 1; - KKB 2;	nuclear power plant (PWR)	nuclear power plant (BWR)	nuclear power plant (BWR)	waste treatment and interim storage facility	research facility with: - various laboratories; - waste treatment plants; - federal interim storage facility BZL; - 3 research reactors: • PROTEUS; • DIORIT; • SAPHIR;
Year for commissioning / licensing / decommissioning	- site licence: • KKB 1 → 1964; • KKB 2 → 1967; - construction licence: • KKB 1 →1964; • KKB 2 →1967; - commercial operation: • KKB 1 →1969; • KKB 2 →1971;	- site licence →1972; - construction licence →1973; - commercial operation →1979;	- site licence →1969; - construction licence →1975; - commercial operation →1984;	- site licence →1965; - construction licence →1967; - commercial operation →1972;	- interim storage facility → in operation since 2001; - incineration and melting plant → in 2004;	- two research reactors DIORIT and SAPHIR under decommissioning; - incineration plant out of operation since 2002 → decommissioning analysed;
Location	Döttingen, Kanton Aargau	Däniken, Kanton Solothurn	Leibstadt, Kanton Aargau	Mühleberg, Kanton Bern	Würenlingen, Kanton Aargau	between Villigen and Würenlingen, Kanton Aargau

SITE SPECIFIC INFORMATION
Site Characteristics

	SWITZERLAND					
	Beznau	**Gösgen**	**Leibstadt**	**Mühleberg**	**Waste Treatment and Interim Storage (ZWILAG)**	**Paul Scherrer Institute (PSI)**
Receiving waters and catchment area	- river Aare; - catchment area of the Rhine;		river Rhine	- river Aare; - catchment area of the Rhine;		
Production	- licensed thermal power: • KKB 1 → 1130 MW(th); • KKB 2 → 1130 MW(th); - nominal net electrical power: • KKB 1 → 365 MW(e); • KKB 2 → 365 MW(e);	- licensed thermal power → 3002 MW(th); - nominal net electrical power → 970 MW(e);	- licensed thermal power → 3600 MW(th); - nominal net electrical power → 1165 MW(e);	- licensed thermal power → 1097 MW(th); - nominal net electrical power → 390 MW(e);	–	maximal thermal power of research reactor PROTEUS → 1 kW(th);

SITE SPECIFIC INFORMATION
Site Characteristics

	UNITED KINGDOM					
	Dungeness B	**Hartlepool**	**Heysham 1**	**Heysham 2**	**Hinkley Point B**	**Hunterston B**
Type of facility	2 nuclear power plants (AGR)	2 nuclear power plants (AGR)	2 nuclear power plants (AGR)	2 nuclear power plants (AGR)	2 nuclear power plants (AGR)	nuclear power plant (AGR)
Year for commissioning / licensing / decommissioning	commissioning → 1983	commissioning → 1984	commissioning → 1984	commissioning → 1988	commissioning → 1976	commissioning → 1976
Location	Kent	Cleveland	Lancashire		Somerset	Near West Kilbride, Ayrshire
Receiving waters and catchment area	English Channel	North Sea	Morecambe Bay → Irish Sea		Bristol Channel	Firth of Clyde
Production	installed electrical capacity → 1110 MW(e);	installed electrical capacity → 1210 MW(e);	installed electrical capacity → 1150 MW(e);	installed electrical capacity → 1250 MW(e);	installed electrical capacity → 1220 MW(e);	installed electrical capacity → 1190 MW(e);

	UNITED KINGDOM				
	Oldbury	**Sizewell B**	**Torness**	**Wylfa**	**Berkeley**
Type of facility	generating station (Magnox)	nuclear power plant (PWR)	nuclear power plant (AGR)	generating station (Magnox)	decommissioning station (Magnox)
Year for commissioning / licensing / decommissioning	commissioning → 1967	commissioning → 1995	commissioning → 1988	commissioning → 1971	- commissioning → 1962; - ceased generation / commenced decommissioning → 1989;
Location	Gloucestershire	Suffolk	East Lothian	Anglesey	Gloucestershire
Receiving waters and catchment area	Severn Estuary	North Sea		Irish Sea	River Severn
Production	installed electrical capacity → 1188 MW(e);	installed electrical capacity → 1188 MW(e);	installed electrical capacity → 1250 MW(e);	installed electrical capacity → 980 MW(e);	–

SITE SPECIFIC INFORMATION
Site Characteristics

	UNITED KINGDOM				
	Bradwell	**Hinkley Point A**	**Hunterston A**	**Trawsfynydd**	**Chapelcross**
Type of facility	defuelling station (Magnox)	defuelling station (Magnox)	decommissioning station	decommissioning station (Magnox)	defuelling station (Magnox)
Year for commissioning / licensing / decommissioning	- commissioning → 1962; - ceased generation / commenced decommissioning → 2002;	- commissioning → 1964; - ceased generation / commenced decommissioning → 2000;	- commissioning → 1964; - ceased generation / commenced decommissioning → 1990;	- commissioning → 1965; - ceased generation / commenced decommissioning → 1993;	- commissioning → 1959; - ceased generation / commenced decommissioning → 2004;
Location	Essex	Somerset	Near West Kilbride, Ayrshire	Gwynedd	Dumfriesshire
Receiving waters and catchment area	Blackwater Estuary	Bristol Channel	Firth of Clyde	Lake Trawsfynydd → no impact to OSPAR waters	Solway Firth
Production	installed electrical capacity → 246 MW(e);	installed electrical capacity → 470 MW(e);	–	–	installed electrical capacity → 196 MW(e);

SITE SPECIFIC INFORMATION
Site Characteristics

	UNITED KINGDOM				
	Dungeness A	**Sizewell A**	**Capenhurst**	**Springfields**	**Dounreay**
Type of facility	generating station	generating station	- uranium enrichment by centrifuge; - split in two companies in 1993: • Urenco Capenhurst Limited (UCL); • BNFL Capenhurst by Sellafield Ltd (SL);	uranium purification and fuel manu-facture plant (uranium metal and oxide fuel)	fast reactor research and develop-ment
Year for commissioning / licensing / decommissioning	- commissioning → 1965; - ceased generation / commenced decommissioning → 2006;	- commissioning → 1965; - ceased generation / commenced decommissioning → 2006;	commissioning → 1976;	commissioning → from 1949;	- commissioning → 1955; - ceased generation / commenced decommissioning; • Dounreay fast reactor (DFR) → 1977; • prototype fast reactor (PFR) → 1994; • reprocessing facilities → 1996;
Location	Kent	Suffolk	Cheshire, England	Salwick, Preston, Lancs	Caithness, north coast of Scotland
Receiving waters and catchment area	English Channel	North Sea	Rivacre Brook → Mersey Estuary	River Ribble	North Atlantic Ocean
Production	installed electrical capacity → 450 MW(e);	installed electrical capacity → 420 MW(e);	tonnes U processed in: - 2004 → 362 tU/a; - 2005 → 481 tU/a; - 2006 → 523 tU/a; - 2007 → 587 tU/a;	tonnes U processed → ~ 5000 tU/a	- not applicable since 1994; - U processing is planned for the fu-ture as part of the decommis-sioning programme;

SITE SPECIFIC INFORMATION
Site Characteristics

	UNITED KINGDOM				
	Harwell	**Windscale**	**Winfrith**	**Calder Hall**	**Sellafield**
Type of facility	nuclear power research and development site	research and development site with: - Pile 1; - Pile 2; - Windscale's Advanced Gas-cooled Reactor (WAGR)	nuclear research centre → all reactors closed, also Steam Generating Heavy Water Reactor (SGHWR)	decommissioning Calder Hall NPS (Magnox)	- reprocessing Magnox and Oxide fuels; - manufacture of Mixed Oxide fuels; - management of stored wastes and clean-up of historical facilities;
Year for commissioning / licensing / decommissioning	- commissioning → 1947; - ceased generation / commenced decommissioning → 1990;	- commissioning: • Pile 1 → criticality 1950; • Pile 2 → criticality 1951; • WAGR → 1962 - shutdown: • Pile 1 → 1957; • Pile 2 → 1957; • WAGR→ 1981; - ceased generation / commenced decommissioning: • Pile 1 → 1993; • WAGR→ 1981;	- commissioning • site → 1957; • SGHWR → 1967 - ceased generation / commenced decommissioning • SGHWR → 1990;	- commissioning → 1956; - ceased generation / commenced decommissioning → 2003;	- commissioning: • windscale Piles to B205 Magnox reprocessing → 1951 to 1964; • THORP → 1991; • MOX → 2001; - ceased generation / commenced decommissioning: • B205 Magnox reprocessing → in operation; • THORP → in operation; • MOX → in operation;
Location	Oxfordshire	Cumbria	Dorset		Cumbria
Receiving waters and catchment area	River Thames → Thames Estuary	(transfer of wastes to Sellafield)	English Channel	-	Irish Sea
Production	–	–	- installed electrical capacity → 100 MW(e); - installed thermal capacity → 300 MW(th);		

Annex 8: Summary of Site Specific Information – Discharges

SITE SPECIFIC INFORMATION
Discharges

<table>
<tr><th rowspan="2"></th><th colspan="4">BELGIUM</th></tr>
<tr><th>Doel</th><th>Tihange</th><th>Fleurus</th><th>Mol-Dessel</th></tr>
<tr><td>System to reduce discharges</td><td colspan="2">- discharges from controlled areas:
• ion exchange filtration;
• filtration;
• evaporation;
• solidification of concentrate phase → after treatment dilution of water and released in the receiving waters;
- emissions:
• storage tanks (gas from hydrogenous circuits);
• filtration → by-passed through HEPA-filters if “action” levels are exceeded;
• active carbon cartridges (trapping iodine);</td><td></td><td>- liquid waste from:
• SCK-CEN and Belgoprocess;
• NPPs, Belgonucléaire, FBFC, IRE, IRMM, hospitals and research centres;
- division of liquid effluents:
• low activity effluents:
→ suspicious:
β/γ-activity < 400 kBq/m^3 ;
α-activity < 40 kBq/m^3;
→ contaminated:
β/γ-activity < 400 MBq/m^3;
α-activity < 800 kBq/m^3;
→ higher:
β/γ-activity < 40 GBq/m^3;
α-activity < 80 MBq/m^3;
• medium activity effluents:
→ β/γ-activity < 40 TBq/m^3;
- discharge treatment:
• sedimentation in decantation tanks:
→ particulate phase sent in storage tanks;
→ liquid phase evaporated depending on the radioactivity level;
• cementation of residues and solid phases (until 2004 bitumisation);
• p to 1992 vitrification of high solid wastes.
- emissions → filtration → continuously monitoring and sampling;</td></tr>
<tr><td>Efficiency of abatement systems</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Annual liquid dis-charges</td><td></td><td></td><td></td><td></td></tr>
</table>

SITE SPECIFIC INFORMATION
Discharges

	BELGIUM			
	Doel	Tihange	Fleurus	Mol-Dessel
Trend analysis of liquid discharges	- average value of normalized tritium discharges → 14.9 TBq/GWa → no clear downward trend in liquid discharges of H-3; - average value of normalized discharges of beta/gamma emitters excluding H-3→ 6.0 GBq/GWa → clear downward trend up to 2006; - Comparison with UNSCEAR range: • Tritium discharges near the lower end limit of range; • Non-tritium discharges below the level of range;	- average value of normalized tritium discharges → 15.5 TBq/GWa → no clear downward trend in liquid discharges of H-3; - average value of normalized discharges of beta/gamma emitters excluding H-3 → 13.1 GBq/GWa: • no clear downward trend up to 2004; • since 2005 a slight downward trend observed; - Comparison with UNSCEAR range: • Tritium discharges near the lower end limit of range; • Non-tritium discharges near the lower end limit up to 2006; • Non-tritium discharges below the level of range since 2006;		- liquid discharges fairly constant; - since 2000 the H-3-releases are nearly constant around 2 TBq and 3 TBq per year; - releases of alpha-emitters excluding H-3 exponentially decreased from 2000 to 2009 (from 2.4 GBq to 0.2 GBq); - releases of □alpha-emitters exponentially decreased from 2001 to 2009 (from 98.7 MBq to 16 MBq);
Emissions to air	C-14 estimated to 5.55E+02 GBq/a according to literature			

	FRANCE			
	Belleville-sur-Loire	**Le Blayais**	**Cattenom**	**Chinon**
System to reduce discharges	- liquid radioactive discharges divided in two major groups: • effluents from the reactor coolant system → fission gases, fission products, activation products, chemical substances (boric acid, lithium); • effluents from the auxiliary circuits; - kinds of effluents: • radioactively and chemically clean; • radioactively and chemically loaded • weakly radioactive → drain waters from floors and wastewaters from showers, laundry, washbasins; - arrangements in reducing the production of effluents at the source: • inspection of main sumps to detect any significant flow of effluents; • plexiglas installation on the inlet manifolds of some of the sumps to see the origin of the effluents; • implementation of procedures for tracing leaks; - spent liquid effluents collected under four categories: • drain waters from floors; • service drain effluents • chemical effluents; • residual drain waters; - treatment with processes due to the characteristics of the effluents: • filtration; • evaporation; • demineralization; - management of effluents designed to • prevent pollution; • provide for full control of effluent discharges: → check of quality and quantity of radioactive effluents; → control of the activity released; • active involvement of all the personnel concerned → awareness-raising and training; - implementation of BAT/BEP for reduction of the activity: • better identification of effluents at the source → use of appropriate treatment; • increase in the treatment by evaporation; • improvements in treatment processes at certain sites → in particular flocculation of aluminium sulphate to improve the efficiency of the demineralizer processing of Ag-110m; - optimized recycling of the effluents; - exceptions for C-14 and H-3: • C-14 activity directly linked to the power produced; • no industrial method for trapping H-3 exists;			

SITE SPECIFIC INFORMATION
Discharges

	FRANCE			
	Belleville-sur-Loire	**Le Blayais**	**Cattenom**	**Chinon**
System to reduce discharges continued	- implementation of a H-3-management policy: • reduction of atmospheric releases of H-3 to a minimum; • discharge of H-3 preferentially as a liquid; • reduction of the concentrations of H-3 in the reactor coolant system in the event of primary/secondary leaks → limit of the transfer to the secondary cooling system; • avoidance of disseminating H-3 into the tanks/pools during the shutdown of an unit by diluting the reactor coolant system before shut downs for refuelling; • feasibility studies on the storage of liquid tritium for decay → neither technically nor economically viable;			
Efficiency of abatement systems				
Annual liquid dis-charges	- accounting rules: • based on radionuclide-by radionuclide analysis; • increase of liquid and gaseous discharges due to the uncertainty of measurement when below half of the detection limit; • rely on the definition of a reference spectrum → consists of a list of radionuclides that must be identified by appropriate measurement ; • mandatory declaration of the activity released by the radionuclides belonging to the reference spectrum; • radionuclides whose measured activity is less than the half of the detection limit of the apparatus are systematically recorded at a value equal to half of the detection limit; • objective → overestimation of the discharged activity by introducing the uncertainty of measurement; - average releases of liquid H-3 per net power produced: • for 900-MWe-series → 15,1 TBq/GWe; • for 1300-MWe-series → 25,8 TBq/GWe; • for 1450-MWe-series → 16,6 TBq/GWe;			
Trend analysis of liquid discharges				
Emissions to air				

	FRANCE			
	Chooz	Civaux	Dampierre-en-Burly	Fessenheim
System to reduce discharges	- liquid radioactive discharges divided in two major groups: • effluents from the reactor coolant system → fission gases, fission products, activation products, chemical substances (boric acid, lithium); • effluents from the auxiliary circuits; - kinds of effluents: • radioactively and chemically clean; • radioactively and chemically loaded • weakly radioactive → drain waters from floors and wastewaters from showers, laundry, washbasins; - arrangements in reducing the production of effluents at the source: • inspection of main sumps to detect any significant flow of effluents; • plexiglas installation on the inlet manifolds of some of the sumps to see the origin of the effluents; • implementation of procedures for tracing leaks; - spent liquid effluents collected under four categories: • drain waters from floors; • service drain effluents • chemical effluents; • residual drain waters; - treatment with processes due to the characteristics of the effluents: • filtration; • evaporation; • demineralization; - management of effluents designed to • prevent pollution; • provide for full control of effluent discharges: → check of quality and quantity of radioactive effluents; → control of the activity released; • active involvement of all the personnel concerned → awareness-raising and training; - implementation of BAT/BEP for reduction of the activity: • better identification of effluents at the source → use of appropriate treatment; • increase in the treatment by evaporation; • improvements in treatment processes at certain sites → in particular flocculation of aluminium sulphate to improve the efficiency of the demineralizer processing of Ag-110m; • optimized recycling of the effluents; - exceptions for C-14 and H-3: • C-14 activity directly linked to the power produced; - no industrial method for trapping H-3 exists;			

SITE SPECIFIC INFORMATION
Discharges

	FRANCE			
	Chooz	Civaux	Dampierre-en-Burly	Fessenheim
System to reduce discharges continued	- implementation of a H-3-management policy: • reduction of atmospheric releases of H-3 to a minimum; • discharge of H-3 preferentially as a liquid; • reduction of the concentrations of H-3 in the reactor coolant system in the event of primary/secondary leaks → limit of the transfer to the secondary cooling system; • avoidance of disseminating H-3 into the tanks/pools during the shutdown of an unit by diluting the reactor coolant system before shut downs for refuelling; • feasibility studies on the storage of liquid tritium for decay → neither technically nor economically viable;			
Efficiency of abatement systems				
Annual liquid discharges	- accounting rules: • based on radionuclide-by radionuclide analysis; • increase of liquid and gaseous discharges due to the uncertainty of measurement when below half of the detection limit; • rely on the definition of a reference spectrum → consists of a list of radionuclides that must be identified by appropriate measurement ; • mandatory declaration of the activity released by the radionuclides belonging to the reference spectrum; • radionuclides whose measured activity is less than the half of the detection limit of the apparatus are systematically recorded at a value equal to half of the detection limit; • objective → overestimation of the discharged activity by introducing the uncertainty of measurement; - average releases of liquid H-3 per net power produced: • for 900-MWe-series → 15,1 TBq/GWe; • for 1300-MWe-series → 25,8 TBq/GWe; • for 1450-MWe-series → 16,6 TBq/GWe;			
Trend analysis of liquid discharges				
Emissions to air				

SITE SPECIFIC INFORMATION
Discharges

	FRANCE			
	Flamanville	Golfech	Gravelines	Nogent-sur-Seine
System to reduce discharges	- liquid radioactive discharges divided in two major groups: • effluents from the reactor coolant system → fission gases, fission products, activation products, chemical substances (boric acid, lithium); • effluents from the auxiliary circuits; - kinds of effluents: • radioactively and chemically clean; • radioactively and chemically loaded • weakly radioactive → drain waters from floors and wastewaters from showers, laundry, washbasins; - arrangements in reducing the production of effluents at the source: • inspection of main sumps to detect any significant flow of effluents; • plexiglas installation on the inlet manifolds of some of the sumps to see the origin of the effluents; • implementation of procedures for tracing leaks; - spent liquid effluents collected under four categories: • drain waters from floors; • service drain effluents • chemical effluents; • residual drain waters; - treatment with processes due to the characteristics of the effluents: • filtration; • evaporation; • demineralization; - management of effluents designed to • prevent pollution; • provide for full control of effluent discharges: → check of quality and quantity of radioactive effluents; → control of the activity released; • active involvement of all the personnel concerned → awareness-raising and training; - implementation of BAT/BEP for reduction of the activity: • better identification of effluents at the source → use of appropriate treatment; • increase in the treatment by evaporation; • improvements in treatment processes at certain sites → in particular flocculation of aluminium sulphate to improve the efficiency of the demineralizer processing of Ag-110m; • optimized recycling of the effluents; - exceptions for C-14 and H-3: • C-14 activity directly linked to the power produced; - no industrial method for trapping H-3 exists;			

	FRANCE			
	Flamanville	**Golfech**	**Gravelines**	**Nogent-sur-Seine**
System to reduce discharges continued	- implementation of a H-3-management policy: • reduction of atmospheric releases of H-3 to a minimum; • discharge of H-3 preferentially as a liquid; • reduction of the concentrations of H-3 in the reactor coolant system in the event of primary/secondary leaks → limit of the transfer to the secondary cooling system; • avoidance of disseminating H-3 into the tanks/pools during the shutdown of an unit by diluting the reactor coolant system before shut downs for refuelling; • feasibility studies on the storage of liquid tritium for decay → neither technically nor economically viable;			
Efficiency of abatement systems				
Annual liquid discharges	- accounting rules: • based on radionuclide-by radionuclide analysis; • increase of liquid and gaseous discharges due to the uncertainty of measurement when below half of the detection limit; • rely on the definition of a reference spectrum → consists of a list of radionuclides that must be identified by appropriate measurement ; • mandatory declaration of the activity released by the radionuclides belonging to the reference spectrum; • radionuclides whose measured activity is less than the half of the detection limit of the apparatus are systematically recorded at a value equal to half of the detection limit; • objective → overestimation of the discharged activity by introducing the uncertainty of measurement; - average releases of liquid H-3 per net power produced: • for 900-MWe-series → 15,1 TBq/GWe; • for 1300-MWe-series → 25,8 TBq/GWe; • for 1450-MWe-series → 16,6 TBq/GWe;			
Trend analysis of liquid discharges				
Emissions to air				

	FRANCE		
	Paluel	Penly	Saint Laurent des Eaux
System to reduce discharges	- liquid radioactive discharges divided in two major groups: • effluents from the reactor coolant system → fission gases, fission products, activation products, chemical substances (boric acid, lithium); • effluents from the auxiliary circuits; - kinds of effluents: • radioactively and chemically clean; • radioactively and chemically loaded • weakly radioactive → drain waters from floors and wastewaters from showers, laundry, washbasins; - arrangements in reducing the production of effluents at the source: • inspection of main sumps to detect any significant flow of effluents; • plexiglas installation on the inlet manifolds of some of the sumps to see the origin of the effluents; • implementation of procedures for tracing leaks; - spent liquid effluents collected under four categories: • drain waters from floors; • service drain effluents • chemical effluents; • residual drain waters; - treatment with processes due to the characteristics of the effluents: • filtration; • evaporation; • demineralization; - management of effluents designed to • prevent pollution; • provide for full control of effluent discharges: → check of quality and quantity of radioactive effluents; → control of the activity released; • active involvement of all the personnel concerned → awareness-raising and training; - implementation of BAT/BEP for reduction of the activity: • better identification of effluents at the source → use of appropriate treatment; • increase in the treatment by evaporation; • improvements in treatment processes at certain sites → in particular flocculation of aluminium sulphate to improve the efficiency of the demineralizer processing of Ag-110m; • optimized recycling of the effluents; - exceptions for C-14 and H-3: • C-14 activity directly linked to the power produced; - no industrial method for trapping H-3 exists;		

SITE SPECIFIC INFORMATION
Discharges

	FRANCE		
	Paluel	**Penly**	**Saint Laurent des Eaux**
System to reduce discharges continued	- implementation of a H-3-management policy: • reduction of atmospheric releases of H-3 to a minimum; • discharge of H-3 preferentially as a liquid; • reduction of the concentrations of H-3 in the reactor coolant system in the event of primary/secondary leaks → limit of the transfer to the secondary cooling system; • avoidance of disseminating H-3 into the tanks/pools during the shutdown of an unit by diluting the reactor coolant system before shut downs for refuelling; • feasibility studies on the storage of liquid tritium for decay → neither technically nor economically viable;		
Efficiency of abatement systems			
Annual liquid dis-charges	- accounting rules: • based on radionuclide-by radionuclide analysis; • increase of liquid and gaseous discharges due to the uncertainty of measurement when below half of the detection limit; • rely on the definition of a reference spectrum → consists of a list of radionuclides that must be identified by appropriate measurement ; • mandatory declaration of the activity released by the radionuclides belonging to the reference spectrum; • radionuclides whose measured activity is less than the half of the detection limit of the apparatus are systematically recorded at a value equal to half of the detection limit; • objective → overestimation of the discharged activity by introducing the uncertainty of measurement; - average releases of liquid H-3 per net power produced: • for 900-MWe-series → 15,1 TBq/GWe; • for 1300-MWe-series → 25,8 TBq/GWe; • for 1450-MWe-series → 16,6 TBq/GWe;		
Trend analysis of liquid discharges			
Emissions to air			

SITE SPECIFIC INFORMATION
Discharges

<table>
<tr><th></th><th colspan="3">FRANCE</th></tr>
<tr><th></th><th>CEA Fontenay aux Roses Centre</th><th>CEA Saclay Centre</th><th>AREVA NC de La Hague
former: Établissement COGEMA</th></tr>
<tr><td>System to reduce discharges</td>
<td>- treatment of liquid discharges
• stored in laboratory's tanks;
• inspected before authorisation for discharge in accordance with:
→ decree of 199-03-30 relating to discharges from the centre;
→ the authorisation of liquid and gaseous effluent discharges by the nuclear industry research centre;
- reduction of liquid discharges:
• SABINE station (Station for cleansing of slurry resulting from the cleaning of sewers) → slurry effluents collected by hydro-cleaning → treated by settling filtration → dehydrated slurries and clarified effluents directed towards the appropriate waste management processes;
• retention tanks to recover any water used for extinguishing a fire;</td>
<td>- installations for treatment of liquid effluents beside STELLA:
- a station in order to recycle water for cooling circuits:
• neutralisation;
• settling;
• pre-chlorination;
• filtration through sand;
• neutralisation by sodium hydroxide;
• post chlorination;
- an effluent cleaning treatment station (replaced in 2012 by a new one of probably membrane type):
• settlement;
• digestion;
• biological treatment;
• clarification;</td>
<td>- general principles:
• very stringent system of containment to prevent losses;
• natural radioactive decay especially for short half-life radionuclides → storage in pools for about 5 years before reprocessing;
• optimisation of the destination of by-products → recycling as much as possible;
• non-recyclable by-products → solid waste as far as possible → preference for vitrification;
• exposure of workers and risks for population/workers taken into account to balance the options → consistency with ICRP principles;
- recyclable wastes for vitrification:
• collection of effluents
• treatment to recover all reagents;
• recycling, concentrating and purifying by evaporation or distillation under vacuum in order to remove fission products, uranium and plutonium;
• calcination of residue;
- non-recyclable solutions:
• liquid effluent management based on an activity level sorting out;
• all high activity effluents including the residue of the evaporation of medium and low activity effluents → vitrification;
• medium and low activity effluents collected and evaporated separately as:
→ acid effluents;
→ alkaline effluents;
• very low activity effluents ("V"-effluents) including distillates of the evaporation of medium and low activity effluents → collected in batches → checked for the activity → below the limits filtered and discharged to the sea;
- analytical laboratory analysis effluents:
• both alpha emitters and the other emitters significant after volume reduction → mostly non-recyclable;
• implementation of plasma torch spectrography → very small samples and avoidance of unusual reagents;
• since 2001 new plutonium recovery management → significant reduction of alpha activity;</td></tr>
</table>

SITE SPECIFIC INFORMATION
Discharges

	FRANCE		
	CEA Fontenay aux Roses Centre	**CEA Saclay Centre**	**AREVA NC de La Hague** former: Établissement COGEMA
Efficiency of abatement systems	- annual waste production: • on average 5 m³ of very low level activity waste by SABINE station → dehydrated slurries; • around 180 m³ of liquid effluents discharged into the urban server after inspection;	- decontamination factor for radioactive liquid effluent except H-3 and C-14→ DF ~104; - tritiated and/or carbon effluents → separately collected → can be added to the cement after distillation;	- implementation of a new effluent management system → substantial reduction of the quantity and the activity of the effluents; - lesser volume of solid waste by vitrification → accepting much higher activity concentrations; - replacement of UP2-400 units by more sophisticated facilities (e. g. R4) → significant reduction in beta emitters discharges to the sea → factor 2 between 1999 and 2004; - dramatic reduction of radionuclides with particular interest: • echnetium-99 → major part sent to vitrification since 1996 → discharges decrease about a factor of 10 between 1989 and 2004; • Caesium-137 → discharges reduce more than a decade within 10 years; • Plutonium-(239+240) → discharges reduced by a factor of 10 between 1989 and 2004 → further decreasing trend by a factor of 2; - efficiency of the system measured by a transfer function Fn (the reverse is the Decontamination Factor DF); - transfer functions for the marine pathway and the radionuclides of interest: • Fn(Cs-137) → 10-7; • Fn(Tc-99) → 10-4; • Fn(Pu-239+Pu-240) → <10-7; • Fn(total alpha) → estimated about 10-7; - no global transfer factor for total beta determined → abatement techniques with not the same efficiency;

SITE SPECIFIC INFORMATION
Discharges

	FRANCE			
	CEA Fontenay aux Roses Centre	**CEA Saclay Centre**	**AREVA NC de La Hague** former: Établissement COGEMA	
Annual liquid discharges	annual liquid discharges for alpha-emitters, beta-emitters and H-3 reported	- annual liquid discharges for gamma- and alpha-emitters, pure beta-emitters (except H-3) and H-3 reported - pure beta-emitters → essentially consist of C-14;	- discharge of the effluents complied with the discharge limits → if not → appropriate treatment equipment; • determining the parameters of the discharges; • types of monitoring: → continuous monitoring of the flow and the radioactivity at the pipe level before any mixing with other categories of effluents; → monitoring of radioactivity at the discharge point for categories of the most significant radionuclides; - differentiation between routine operational and exceptional liquid discharges → "exceptional" are those that the ministerial order of 08.01.2003 attributes to final cessation of operation and dismantling and reconditioning of legacy waste; - monitored discharges reported annually to OSPAR → but no difference between routine and exceptional discharges; - status of the annual discharges can be found since 2004 in the annual report of environment monitoring; - routine discharge data normalised against the equivalent energy produced by the reprocessed fuel elements;	
Trend analysis of liquid discharges	- downward trend in discharges → significant for more than 10 years (no more IBNs in operation); - comparison with values recorded by similar facilities → not applicable;	- downward trend in discharges → significant, depending on the radionuclide → reductions by a factor of between 10 and 100 over 30 years and between 5 and 30 since 1990; - comparison with values recorded by similar facilities → not applicable;	- normalised data show a global downward trend; - downward trend in discharges → constant or downwards; - downward trend in normalised discharges → mainly downwards; - comparison with UNSCEAR → no available comparative UNSCEAR data;	
Emissions to air				

SITE SPECIFIC INFORMATION
Discharges

	GERMANY			
	Biblis A	**Biblis B**	**Brokdorf**	**Brunsbüttel**
System to reduce discharges	- origin of waste → primary coolant system; - waste treatment • filtration; • ion exchange procedures; - applied procedure: • quality and design of fuel elements; • permanent monitoring of primary coolant; • operation mode and coolant chemistry to avoid damage of fuel elements; • reduction of mobilization of corrosion and activation products by means of coolant chemistry; - improvements → filtration and evaporation of waste waters;		- origin of waste → primary coolant cycle and attached system; - waste treatment: • filtration; • ion exchange procedures; • evaporation; • combustion; • collection; - applied procedure: • quality and design of fuel elements; • operation mode to avoid damage of fuel elements; • special operation mode in case of damaged fuel elements; - improvements: • permanent monitoring of operations; • emissions and discharges kept as low as possible due to adherence to the minimization obligation;	- origin of waste → reactor core with water and steam cycles; - waste water treatment: • centrifugation; • ion exchange procedures; • evaporation; • cross-flow filtration only for wash water; - exhaust air treatment: • HEPA filtration; • delay lines with retention of short-lived radioactive noble gases; • filtration and hold-up loop; - applied procedure: • quality and design of fuel elements; • operation mode to avoid damage of fuel elements; - improvements: • permanent monitoring of operations; • emissions and discharges kept as low as possible due to adherence to the minimization obligation;
Efficiency of abatement systems				
Annual liquid discharges	annual liquid discharges reported			

SITE SPECIFIC INFORMATION
Discharges

	GERMANY			
	Biblis A	Biblis B	Brokdorf	Brunsbüttel
Trend analysis of liquid discharges	- trends in liquid discharges • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of UNSCEAR;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of UNSCEAR;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges far below UNSCEAR ranges • H-3 discharges below the mean value of UNSCEAR;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of UNSCEAR;
Emissions to air	annual emissions to air for H-3 and C-14 reported			

SITE SPECIFIC INFORMATION
Discharges

	GERMANY			
	Emsland	**Grafenrheinfeld**	**Grohnde**	**Krümmel**
System to reduce discharges	- origin of waste → reactor core with water and steam cycles; - waste water treatment: • ion exchange procedures; • evaporation for waste water; - exhaust air treatment: • HEPA filtration; • hold-up loop; - applied procedure: • quality and design of fuel elements; • operation mode to avoid damage of fuel elements; - improvements: • permanent monitoring of operations; • emissions and discharges kept as low as possible due to adherence to the minimi-zation obligation;	- origin of waste → primary coolant system; - waste treatment: • ion exchange; • evaporation; • aerosol filtration; • activated carbon filters; - applied procedure: • deployment of high quality fuel elements; • implementation of an operation mode geared toward maintaining fuel element integrity; • regular checks of fuel elements and fuel rods to monitor the quality and the state of the elements; - improvements: • ~10 % of the primary cooling contents permanently routed through ion exchangers; • evaporation systems → waste water from the controlled area almost completely freed from radioactive components; • exhaust air from controlled areas passed through aerosol filters and activated carbon filters → change of activated carbon filters if loading is 1 % or 10 %; • clean-up and hold-up procedures → best available state of the art technology; • internal operating guidelines: → training of the staff; → differentiated preparatory work; → discharges as low as possible;	- origin of waste → primary coolant system; - waste treatment: • filtration; • ion exchange procedures with mixed-bed filters; • evaporation; • decantation; • centrifugation; - applied procedure: • administrative requirements; • protection of the equipment against leaking; • preventive maintenance; • monitoring of leakages; • separator/decanter for contaminated laundry drains and sludges;	- origin of waste → reactor core with water and steam cycles; - waste water treatment: • ion exchange procedures; • evaporation; - exhaust air treatment: • HEPA filtration; • delay lines for short-lived radioactive noble gases; • retaining of iodine available by activated carbon filters; - applied procedure to minimize waste production: • quality and design of fuel elements; • operation mode to avoid damage of fuel elements; - improvements: • permanent monitoring of operations; • emissions and discharges kept as low as possible due to adherence to the minimi-zation obligation;
Efficiency of abatement systems				
Annual liquid dis-charges	annual liquid discharges reported			

SITE SPECIFIC INFORMATION
Discharges

	GERMANY			
	Emsland	**Grafenrheinfeld**	**Grohnde**	**Krümmel**
Trend analysis of liquid discharges	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges far below UNSCEAR ranges; • H-3 discharges in general in the lower part of published ranges;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;
Emissions to air	annual emissions to air for H-3 and C-14 reported			

SITE SPECIFIC INFORMATION
Discharges

	GERMANY			
	Mülheim-Kärlich	**Neckarwestheim 1**	**Neckarwestheim 2**	**Obrigheim**
System to reduce discharges	- origin of waste → primary cooling system; - waste water treatment → shut down due to decommissioning: • silting filtration; • ion exchange procedures; • floc precipitation; - waste water treatment actually → two evaporator installations for all nuclear waste water; - exhaust air treatment → shut down due to decommissioning: • filters for aerosols and iodine; • hold-up line for retention of noble gases; - applied procedure → emissions and discharges kept as low as possible due to adherence to the minimization obligation;	- origin of waste → primary cooling system; - waste water treatment: • ion exchange procedures; • evaporation; - applied procedure: • leak tightness of fuel elements; • cleaning of the primary cooling system; • waste processing; - improvements → evaporation with a high degree of decontamination;		- origin of waste → primary coolant system; - waste water treatment: • filtration; • ion exchange procedures; • evaporation; - applied procedure: • leak tightness of fuel elements until 2005; • specialized operation modes for fuel elements up to 2005; • cleaning of the primary cooling system until 2005; • full system decontamination in 2007; • ozone laundry system for contaminated clothing since 2008; • waste processing;
Efficiency of abatement systems				
Annual liquid discharges	annual liquid discharges reported			
Trend analysis of liquid discharges	- trends in liquid discharges: • decreasing trends for H-3; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges very low; • H-3 discharges very low;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;	- trends in liquid discharges: • decreasing trend of H-3 discharges • discharges of alpha-emitters very low; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;
Emissions to air	annual emissions to air for H-3 and C-14 reported			

SITE SPECIFIC INFORMATION
Discharges

	GERMANY			
	Philippsburg 1	**Philippsburg 2**	**Stade**	**Unterweser**
System to reduce discharges	- origin of waste → primary coolant cycle and attached system; - waste water treatment: • separation and collection of waste water according to the activity concentration and the level of chemical contamination; • highly contaminated water → evaporation; • in case of low chemical contamination/low degree of conductivity → ion exchange procedures; • hardly contaminated, but strongly chemically polluted water → centrifugal systems consisting of a decanter and a separator; • cross-flow filtration for wash water; - exhaust air treatment: • activated carbon filters; • delay over time: → retention of Xe-isotopes; → retention of Kr-isotopes, but not Kr-85; - applied procedure: • quality assurance measure for design, construction and production of fuel elements at the manufacturers' site and monitoring by the contractor and the regulatory authority; • handling of fuel elements according to detailed manual constructions → avoidance of damaging fuel elements; • automatic electronic control mechanisms → monitoring that fuel elements are not overloaded; • special operation mode for fuel elements; • regular inspection of fuel element; • regular monitoring of activity concentration in the primary coolant → early identification of damaged elements; • pilot installation of hollow-fibre micro filtration at experimental stage → replacement of the cross-flow filtration;		- origin of waste → primary coolant cycle and attached system; - waste water treatment: • filtration; • ion exchange procedures; • decantation; • evaporation; - applied procedure: • quality and design of fuel elements; • chemical set-up of the major coolant; • smooth operation modes to avoid damage of fuel elements or to minimize the impact of damaged fuel elements; - improvements: • permanent monitoring of operations; • emissions and discharges kept as low as possible due to adherence to the minimization obligation;	- origin of waste → primary coolant cycle and attached system; - waste water treatment in the primary coolant cycle: • filtration; • ion exchange procedures; • degassing; • evaporation; - waste water treatment in the controlled areas: • collection; • silting filtration; • evaporation; - applied procedure: • quality and design of fuel elements; • operation mode to avoid damage of fuel elements; • special programmes in case of damage of fuel elements; - improvements: • continuous monitoring of operations; • emissions and discharges kept as low as possible due to adherence to the minimization obligation;
Efficiency of abatement systems				
Annual liquid discharges	annual liquid discharges reported			

SITE SPECIFIC INFORMATION
Discharges

	GERMANY			
	Philippsburg 1	Philippsburg 2	Stade	Unterweser
Trend analysis of liquid discharges	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;	- trends in liquid discharges: • decreasing trend in H-3 discharges; • discharges of alpha-emitters very low; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters below the detection limit; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges below UNSCEAR ranges; • H-3 discharges below the mean value of the ranges;
Emissions to air	annual emissions to air for H-3 and C-14 reported			

SITE SPECIFIC INFORMATION
Discharges

	GERMANY		
	Würgassen	**URENCO Gronau**	**Hanau**
System to reduce discharges	- origin of waste → primary coolant cycle and old contaminations; - waste water treatment: • filtration; • ion exchange procedures (no more in use); • distillation; - improvements: • permanent monitoring of operations; • emissions and discharges kept as low as possible due to adherence to the minimization obligation;	- origin of waste: • decontamination of UF_6-components; • cleaning of UF_6-containers; • media from traps for UF_6/HF; - waste treatment: • filtration; • evaporation; - applied procedure: • protection of UF_6-system against leaking; • utilization of vacuum systems; • recycling of residual waste → minimization of radioactive discharges; • recovery/reuse of cleaned auxiliary substances; • utilization of maintenance free gas centrifuges; - improvements → no further measures planned;	- origin of waste → no waste arising anymore;
System to reduce discharges (continued)			
Efficiency of abatement systems			
Annual liquid discharges	annual liquid discharges reported	annual liquid discharges (only total alpha) reported → highest value of 0,015 MBq in 2003	annual liquid discharges (only total alpha) up to 2005 reported
Trend analysis of liquid discharges	- trends in liquid discharges: • no significant trends identifiable; • discharges of alpha-emitters very low; - comparison of normalized data with UNSCEAR ranges: • Non-Tritium discharges very low; • H-3 discharges very low;	trends in liquid discharges → constantly low releases since 1985;	trends in liquid discharges → constantly low releases up to 2005;
Emissions to air	annual aerial emissions for H-3 and C-14 reported	annual aerial emissions (only total alpha) reported	annual aerial emissions (only total alpha) up to 2005 reported

	GERMANY		
	Advanced Nuclear Fuels GmbH	**GKSS Geesthacht**	**Helmholtz-Zentrum Berlin** former: Hahn-Meitner-Institut
System to reduce discharges	- origin of waste: • no waste water outside the plant; • exhaust air containing uranium compounds from the production process and building ventilation system; - exhaust air treatment: • from production processes → dust separators and two filtration steps for aerosols; • building ventilation system → open uranium available → two filtration steps; - applied procedure: • air pressure in working areas and in areas in which open uranium is processed or handled is lower than in other working areas and the environment; • exhaust air fans and supply air fans sealed against each other → exhaust air fan must be in operation before supply air fan can be started → avoidance of increase in pressure in the production area; • in case of an outage of the power supply network → exhaust air fan is supplied by an independent stand-by system; • distributors attached at a higher level ensure that internal air is routed to the floor and air from more clean areas is routed to potentially less cleaner areas; • difference in pressure regularly controlled at each aerosol filter; • guarantee of functionality of the air ventilation and exhaust air system → major components are subject to in service inspections with scope to: → absence of uranium in exhaust airducts for exhaust air from processing; → factors for retaining at the second step of filtration; → potential leaking in filter seals; → direction of air-flows inside the building; → functionality of the power supply stand-by system; → air sampling systems at exhaust air stacks;	- origin of waste → primary coolant cycle; - waste water treatment: • filtration; • ion exchange procedures; - applied procedure → tightness of fuel elements by corrosion resistant cladding (AlMg-alloy) and special surface treatment; - improvements: • sedimentation, neutralization and evaporation of waste water; • future in-process measures → concentration of waste water by reverse osmosis and/or evaporation;	- origin of waste → releases from all facilities including BER II; - waste water treatment: • central collection of all contaminated waste water in transfer tanks → discharges into the municipal sewerage system; • low contaminated waste water from BER II released via the State Collecting Facility for radioactive waste; • reactor's primary coolant water continuously cleaned by ion exchange resins; • reactor's secondary coolant cycle and the coolant tower cycle monitored → free of activity; • State Collecting Facility → arising from research, Industry and medicine with different chemical and physical properties; - applied procedure: • fuel elements used in BER II → MTR elements with a low U-235 enrichment of 20 % (LEU); • fuel plates tightly enclosed on all sides by cladding material → surface checked for freedom from contamination after the manufacturing process; • transfer of fission products from the fuel into the basin water minimal → continuous monitoring of the dose rate at the basin surface and regular sampling of basin water; • at the State Collecting Facility → evaporation and enclosing in cement after sorting; • recycling of sources containing H-3; - improvements → operation of a "warm layer" → heated layer of purified water applied to the surface of the basin water → clear reduction of the transfer of fission and activation products from the surface of the basin water into the hall atmosphere → no effect on tritium emission, but reduction in dose;

SITE SPECIFIC INFORMATION
Discharges

	GERMANY		
	Advanced Nuclear Fuels GmbH	**GKSS Geesthacht**	**Helmholtz-Zentrum Berlin** former: Hahn-Meitner-Institut
System to reduce discharges continued	- origin of waste: • permanent control of radioactivity in exhaust air by the operator and simultaneously by an independent measuring organization → monitoring of emissions; • continuous monitoring for uranium deposition in the environment → monitoring of immissions; • operation, maintenance, checks and measurements based on approved and controlled procedures;		
Efficiency of abatement systems			
Annual liquid discharges	annual liquid discharges (only total alpha) → not detected;	annual liquid discharges reported	
Trend analysis of liquid discharges	trends in liquid discharges → alpha discharges below the detection limit;		
Emissions to air	annual aerial emissions (only total alpha) → not detected;	annual aerial emissions reported	

	GERMANY		
	Jülich Research Centre	**Institute for Technology of Karlsruhe**	**Verein für Kernverfahrenstechnik und Analytik Rossendorf e. V.** former: nuclear research centre
System to reduce discharges	- origin of waste: • waste water → collected in 25 drain tanks → their content then centrally collected; • exhaust air → from 17 different facilities; - waste water treatment: • higher storage times for short-lived nuclides; • evaporation in case of higher concentration; - exhaust air treatment: • delayed emissions of short-lived nuclides; • aerosol filters (level H12); • activated carbon filters;	- origin of waste: • handling of open radioactive materials; • decommissioning of research reactors and pilot reprocessing plant; - waste water treatment: • radioactive waste water collected in tanks at 16 collecting stations → measurement of activity concentrations → in case of higher concentration → transfer into the decontamination plant → evaporation; • chemical waste water → mixed with effluents from collecting tanks and decontamination plant → clarified in a multistage process in the clarification plant; • final collection in three end basins before discharge; • single batches transferred to a biological sewage plant for further treatment; - exhaust air treatment: • release through 27 exhaust air vents and stacks; • HEPA filters; • off gas scrubber in: → solid waste incineration plant; → reprocessing plant for vessel off-gas; • activated charcoal beds → reduction of radioactive iodine emissions;	- origin of waste: • waste water collected in 6 drain tanks and 5 small tanks; • radioactive emissions through 11 exhaust air vents and stacks; - waste water treatment: • higher storage times for short-lived nuclides; • ion exchange in case of higher concentrations; • cleaning effluents by precipitation and filtration; - exhaust air treatment: • delayed emissions of short-lived nuclides; • aerosol filters (level H12); • activated carbon filters;
Efficiency of abatement systems			
Annual liquid dis-charges	annual liquid discharges reported		
Trend analysis of liquid discharges			
Emissions to air	annual emissions to air for H-3 and C-14 reported		

Discharges

	NETHERLANDS		
	Kernenergiecentrale Borssele	**Kerncentrale Dodewaard**	**URENCO**
System to reduce discharges	- ion exchange techniques → saturated resin to solid waste system; - distillation → extract to solid waste system; - filtration of sludge if necessary → residue to solid waste system; - immobilization by cementation of distillation extract; - storage and decay if possible; - addition of chemicals preventing corrosion in the primary cooling system; - monitoring/surveillance of leakage of fuel pins;	- ion exchange techniques → saturated resin to solid waste system; - evaporation → extract to solid waste system; - filtration of sludge → residue to solid waste system; - sedimentation → sediment to solid waste system; - immobilization by cementation of evaporation extract; - storage and decay if possible; - addition of chemicals preventing corrosion in the primary cooling system;	- distillation → extract to solid waste system; - precipitation/sedimentation of wash water → natriumdiuranate is filtrated and deposited into special vessels; the recovered uranium can be reused in another nuclear fuel fabrication plant; - storage and decay of short lived nuclides;
Efficiency of abatement systems	- efficiency of distillation step is about a factor 104 (except tritium); - tritium discharges are not reduced by distillation. - No information about the efficiency of the other reduce systems	No information on the efficiency of the waste water treatment systems	No information on the efficiency of the waste water treatment systems
Annual liquid discharges	annual liquid discharges reported	no liquid discharges since June 2005	annual liquid discharges reported
Trend analysis of liquid discharges	- no downward trend for H-3 and C-14 emissions → remain relatively constant; - Comparison with UNSCEAR values → discharges of H-3 are equal or lower than the average UNSCEAR value of 19 TBq/Gwa except for 2006 (change of turbine)	- downward trend for the discharges to water and emissions to air up to 2004; - since 2005 discharges are zero. - Comparison with UNSCEAR values not possible due to decommissioning phase;	clear downward trend in total discharges
Emissions to air	- annual emissions to air of H-3 and C-14 reported; - No measurements of iodine-129;	no emissions to air since 2003, when the last fuel elements were transported to a reprocessing plant	- not relevant to the marine compartment due to the involatile nature of uranium; - plant is not located in the direct neighbourhood of a sea or lake;

SITE SPECIFIC INFORMATION
Discharges

	NETHERLANDS		
	Onderzoeks Locatie Petten or Petten site	**Reactor Institute Delft (RID) (part of the Applied Sciences faculty of the Delft University of Technology)**	**COVRA (Centrale Organisatie Voor Radioactief Afval)**
System to reduce discharges	- installations for water treatment: • sedimentation basins • membrane filtration-units; • centrifugation of sludge; • sludge drying units. - processes for waste water treatment: • collection and storage of samples before discharge to sea; • addition of flocculation chemicals and chemicals for pH adjustment; • separation of radioactive particles by sedimentation, centrifugation and membrane filtration; • removing and drying sediments and sludge; • transportation of dried sediments and sludge to the decontamination building; • preparation for transportation to COVRA.	- batchwise collection of all waste water; - minimize dilution of waste water; - batchwise distillation of waste water; - ion exchange techniques → saturated resin to solid waste system; - storage and decay if possible; - monitoring/surveillance of leakage of fuel pellets. - additional → waste water treatment in a municipal sewage treatment plant	- biological purification; - electrochemistry; - chemical purification based on flocculation; - centrifugal separation; - filtration; - drying of sediments.
Efficiency of abatement systems	efficiency of the ceramic membrane filters for removal radionuclides lies between 10 and 100	No information on the efficiency of the waste water treatment systems	- efficiency of the waste water treatment system is given for several radionuclides; - the activity concentration of a radionuclide after the treatment is divided by the activity concentration before → "slip-through" factor [factor 0.3 means cleaning efficiency of 70 %]
Annual liquid discharges	- the actual annual liquid discharges of the HFR and LFR will be overestimated because the discharges refer to the Petten site - information on C-14 and I-129 not available;	the actual annual liquid discharges of the HOR will be overestimated because the discharges are part of the total discharges of the RID Complex	annual liquid discharges reported
Trend analysis of liquid discharges	no downward trend in discharges observed		
Emissions to air	- annual emissions to air reported only for H-3; - information on C-14 and I-129 not available;	no information available on emissions to air relevant to the marine compartment	annual emissions to air reported

SITE SPECIFIC INFORMATION
Discharges

	NORWAY	
	Institute for Energy Technology Kjeller	**Institute for Energy Technology Halden**
System to reduce discharges	- discharges: • delay tanks; • chemical precipitation; • centrifuging; • hydrocyclone; • cross-flow filtration; • ion exchange; • osmosis; • ultrafiltration; • evaporator; • etc. - emissions: • electrostatic precipitation; • cyclone scrubbing; • chemical adsorption; • HEPA-filtration; • cryogenics; • active charcoal filters. - no new systems taken into operation during the reported period;	- discharges: • sedimentation in delay tanks; • filtration and ion exchange from delay tanks; • ion exchange; • evaporation; • H-3 trapping in He-3-system since 2006. - emissions: • HEPA-filtration and active charcoal filtration; - changes in management or process: • new discharge line in 2006;
	further efforts to reduce or eliminate discharges: - continuous evaluation of equipment, methods and routines for potential discharge reducing measures; - measures to enhanced worker awareness of the issue; - reducing of discharges seen in view of resulting doses to the public and the economic investment → current discharge level and resulting dose to the public is very low → major new installations are not justified by marginal reductions in discharges; - better modest changes to existing equipment or procedures and an increased worker awareness.	

SITE SPECIFIC INFORMATION
Discharges

	NORWAY	
	Institute for Energy Technology Kjeller	**Institute for Energy Technology Halden**
Efficiency of abatement systems	- discharges: • delay tanks → DF 3 or 67 %; • ion exchange → DF 33 or 97 %, except H-3; • evaporator → DF 20 or 95 %, except H-3. - emissions: • HEPA-filtration → DF 50 or 98 %; • active charcoal filters → DF >20 or >95 %.	- discharges: • sedimentation in delay tanks → DF 1.02 – 1.25 or 2 % – 20 % (sedimentation dependent of the nuclide – transition metals 10 % to 20 %, alkali elements 2 %, lanthanides 4 %); • filtration and ion exchange from delay tanks → DF 33 or 97 %; • ion exchange → DF 100 or 99 %; • evaporation → DF 20 or 95 %; • H-3 trapping in He-3-system since 2006 → DF 10 or 90 %. - emissions: • HEPA-filtration and active charcoal filtration → DF 100 or 99 % (filter replacement at reduced efficiency);
Annual liquid discharges	- annual liquid discharges reported - higher discharges through treatment of ion-exchange resins: • in 2006 46.6 % of the limit caused by H-3 and Cs-137; • in 2008 30.4 % of the limit caused by H-3, Co-60 and Cs-137;	annual liquid discharges reported
Trend analysis of liquid discharges	no downward trend in liquid discharges	
Emissions to air	annual emissions to air reported for H-3, I-125 and Cs-137	- annual emission reported only for H-3; - emission of I-129 estimated to 0.2 Bq/a; - emission of C-14 not estimated;

SITE SPECIFIC INFORMATION
Discharges

	PORTUGAL Campus de Sacavém
System to reduce discharges	- radioactive liquid effluents treated in the radioactive liquids effluents discharge control facility (ECoDELiR); - ECoDELiR divided in two groups which can operate independently; - treatment of liquid discharges: • collecting of the liquid discharges in tanks; • analysis of samples by gamma-spectroscopy with NaI(Tl)-detectors to determine the artificial radionuclides; • values < 740 Bq/l → discharging to the municipal residual water treatment plant (ETAR); • values > 740 Bq/l → wait for decay or dilution with water;
Efficiency of abatement systems	
Annual liquid dis-charges	total activity of liquid discharges between 4,1 MBq and 499 MBq;
Trend analysis of liquid discharges	
Emissions to air	

SITE SPECIFIC INFORMATION
Discharges

	SPAIN			
	Almaraz	**José Cabrera**	**Trillo**	**Juzbado**
System to reduce discharges	- liquid waste of both units treated in a liquid radwaste treatment plant → no independent data can be reported; - two types of liquid waste: • quality reactor waste → primary system waste processed by boric acid recovery system and coolant water clean-up system → liquids often reused, but also discharged; • non-quality reactor waste → laundry, shower, floor drains → main contribution of the liquid effluents discharged by the plant; - treatment of quality reactor waste: • retention tanks; • double system of filters; • ion exchanger; • evaporation → slurries treated in the solid waste plant → condensed effluents sent to decay tank; - treatment of non-quality reactor waste: • clarification; • filtration; • demineralisation; - treatment of emissions: • decay tanks; • filtration → coarse filters, HEPA-filters and charcoal bed;	- treatment of liquid discharges: • ion exchange; • evaporation; • storage tanks; - treatment of emissions: • decay tanks until 2006; • coarse and HEPA filters for retention of particles; • charcoal bed for adsorption of iodine;	- treatment of water from pressurized primary circuit: • chemical and volume control system (CVCS) → remove of gases; • ion exchange → remove of fission products; • evaporator → recovering of boric acid; • condensate reused as coolant or sent to the radioactive liquid treatment for discharging; - treatment of liquid waste: • determination of chemical and radioactive characteristics; • evaporation; • demineralisation, if further decreasing of the radioactive level is required - treatment of emissions: • catalytic recombination of H_2 to H_2O; • charcoal beds; • filtration → coarse filters, HEPA-filters;	- treatment of water: • ultra centrifugation; • filtration; • analyze and discharge; - treatment of emissions: • filtration with HEPA filters;

SITE SPECIFIC INFORMATION
Discharges

	SPAIN			
	Almaraz	**José Cabrera**	**Trillo**	**Juzbado**
Efficiency of abatement systems	- efficiency for liquid discharges: • filters → DF 98 % for 2 µm, 5 µm and 25 µm particles; for corrosion products DF 1; • mixed ion exchangers → for anions DF 100-0-1 for Cs and Rb DF 10-2 for other elements DF 1000-100-10 (DF depending on the used ion exchanger); • evaporator → enrichment of boron concentration to 21000 ppm; - efficiency for emissions: • coarse filter → DF ≥ 80 % for particles; • HEPA filter → DF ≥ 99,9 %; • charcoal bed → DF ≥ 90-99 %;	- efficiency for liquid discharges: • mixed ion exchangers → for noble gases, Cs, Y and Mo DF 1-10, for other nuclides DF 10 (DF depending on the used ion exchanger); • evaporator → decontamination coefficient 106 for liquids (except I and B), 103 for gases, 105 for I and B; - efficiency for emissions: • coarse filter → DF 50 %; • HEPA filter → DF 99,95 %; • charcoal bed → DF 99,5 %;	- efficiency for liquid discharges: • filters → DF 98 % for 5 µm and 25 µm particles; • mixed ion exchangers → DF 1000-100 ; for iodine DF > 15; for Na-24 DF > 25 (DF depending on the used ion exchanger); • evaporator → Decontamination coefficient from 100 to 1E+06; • degasification system → degasification factor 4,6E+04; - efficiency for emissions: • coarse filter → DF ≥ 50-85 % for particles; • HEPA filter → DIN 24184; • charcoal bed → DF ≥ 99 %;	- efficiency for liquid discharges: • ultra centrifugation → DF 95 %; • filters → DF 10 %; - efficiency for emissions: • coarse filter → DF > 99,95 % for 0,3 µm particles; • HEPA filter → DF > 99,97 % for 0,3 µm particles;
Annual liquid discharges	annual liquid discharges reported			- annual liquid discharges reported; - annual alpha activity in discharges;
Trend analysis of liquid discharges	- absolute total activity excluding tritium → slight global upward trend due to application of 2004/2/EURATOM; - absolute total activity of H-3 → small global downward trend; - Comparison with UNSCEAR range: • Non-tritium discharges below the UNSCEAR range; • Tritium discharges slightly higher than the UNSCEAR range;	- absolute total activity excluding tritium → slight upward trend because of decontamination and management of stored operating wastes; - absolute total activity of H-3 → downward trend; - Comparison with UNSCEAR range: • Non-tritium discharges below the UNSCEAR range; • Tritium discharges above the UNSCEAR range;	- absolute total activity excluding tritium → stable trend ; - absolute total activity of H-3 → stable trend; - Comparison with UNSCEAR range: • Non-tritium discharges well below the UNSCEAR range; • Tritium discharges similar the UNSCEAR range;	- total alpha activity → reasonably constant → range from 1,74E-2 GBq/a to 3,70E-2 GBq/a; - normalized data not calculated due to missing reference data;
Emissions to air	annual emissions to air reported			- annual emissions to air reported; - annual alpha activity in emissions;

	SWEDEN			
	Ringhals 1	**Ringhals 2**	**Ringhals 3**	**Ringhals 4**
System to reduce discharges	- discharges: • particulate filtration; • ion exchange filtration; • large buffer tanks to recycle water from the reactor pool; • evaporator; • good housekeeping; - emissions: • delay tanks; • recombiners;	- discharges: • particulate filtration; • ion exchange filtration; • cross-flow filtration in combination with different absorbers and resins; - emissions: • delay tanks; • HEPA-filtration;	- discharges: • particulate filtration; • ion exchange filtration; - emissions: • delay tanks; • HEPA-filtration;	- discharges: • particulate filtration; • ion exchange filtration; - emissions: • delay tanks; • HEPA-filtration; • membrane-filtration in the feed water system;
	- changes in management or process: - non fuel-leakage operations policy; - control-rod policy; - minimising air leakage into turbine systems; - separation of waste streams for improved treatments (some highly contaminated waters are transferred to Ringhals 1 waste treatment plant);			
Efficiency of abatement systems	- discharges: • particulate filtration → DF 2-4; • ion exchange filtration → DF 10-50; • large buffer tanks to recycle water from the reactor pool → DF 10 [reduces the water volume that has to be processed at peak and will indirectly improve decontamination] • evaporator → DF 10; • good housekeeping → DF 10; - emissions: • delay tanks → delay time 6-12 hours with recombiners in operation; • recombiners → volume reduction by a factor 5-10.	- discharges: • particulate filtration → DF 2-4; • ion exchange filtration → DF 5-10; • cross-flow filtration in combination with different absorbers and resins → DF >100; - emissions: • decay tanks → normally all nuclides except Kr-85 have decayed • HEPA-filtration → 100 %;	- discharges: • particulate filtration → DF 2-4; • ion exchange filtration → DF 10-50; - emissions: • decay tanks → normally all nuclides except Kr-85 have decayed; • HEPA-filtration → 100 %; - changes in management or process → separation of waste streams for improved treatments → some highly contaminated waters are transferred to Ringhals 1 waste treatment plant → DF >10	- discharges: • particulate filtration → DF 2-4; • ion exchange filtration → DF 10-50; - emissions: • decay tanks → normally all nuclides except Kr-85 have decayed; • HEPA-filtration → 100 %; • membrane-filtration in the feed water system → 50 % - 90 % of Ar-41. - changes in management or process → separation of waste streams for improved treatments → some highly contaminated waters are transferred to Ringhals 1 waste treatment plant → DF >10
Annual liquid discharges	annual liquid discharges reported			

SITE SPECIFIC INFORMATION
Discharges

	SWEDEN			
	Ringhals 1	Ringhals 2	Ringhals 3	Ringhals 4
Trend analysis of liquid discharges	- trends in liquid discharges → constant or downwards; - comparison with UNSCEAR → within or below the range of UNSCEAR;			
Emissions to air	- since 2002 measurement of C-14 and H-3 → before 2002 estimation of the C-14 emissions to air based on international experience; - measurements of I-129 not requested by SSM;			

SITE SPECIFIC INFORMATION
Discharges

<table>
<tr><th rowspan="2"></th><th colspan="4">SWITZERLAND</th></tr>
<tr><th>Beznau</th><th>Gösgen</th><th>Leibstadt</th><th>Mühleberg</th></tr>
<tr><td rowspan="2">System to reduce discharges</td>
<td>- waste water is collected and treated in batches;
- abatement system:
• centrifugation;
• chemical precipitation, if necessary;
• cross-flow nanofiltration since 2007;
• solidification of waste by-products;</td>
<td>- waste water is collected and treated in batches;
- abatement system:
• evaporation;
• residues conditioned with bitumen;</td>
<td>- waste water is collected and treated in batches;
- abatement system:
• centrifugation;
• evaporation;</td>
<td>- waste water is collected and treated in batches;
- abatement system:
• centrifugation;
• ion exchange;
• solidification of waste byproducts;</td></tr>
<tr><td colspan="4">monitoring:
- measurements during the abatement → concentration criterions fulfilled → discharge;
- monitoring of the activity concentration during the discharge by total gamma counters → concentration limits exceeded → discharge automatically stopped;</td></tr>
<tr><td rowspan="2">Efficiency of abatement systems</td>
<td>decontamination factors (DF):
• chemical precipitation system
→ DF up to 1000;
• cross flow nanofiltration system
→ additionally DF up to 100;</td>
<td>evaporation →DF from 100 up to 10000;</td>
<td>evaporation → DF from 1000 up to 10000;</td>
<td>centrifugation and ion exchange system → DF 100;</td></tr>
<tr><td colspan="4">no reduction of tritium discharges by the abatement systems</td></tr>
<tr><td>Annual liquid dis-charges</td><td colspan="4">annual liquid discharges reported</td></tr>
<tr><td>Trend analysis of liquid discharges</td>
<td>- reduction of the liquid discharges < 1GBq/a due to nanofiltation since 2007;
- clear downward trend for liquid discharges without H-3 observed in the last 5 years;
- no up or downward trend for the liquid discharges of H-3 observed;</td>
<td>- discharges of radioactive substances without H-3 the lowest among the European PWRs;
- further reduction of the discharges by a factor of 5 from 1994 up to now;
- no up or downward trend for the liquid discharges of H-3 observed;</td>
<td>- low discharges of radioactive substances without H-3;
- downward trend for liquid discharges without H-3 observed due to optimization of waste water management;
- no up or downward trend for the liquid discharges of H-3 observed;</td>
<td>- downward trend for liquid discharges without H-3 observed due to optimization of waste water management;
- no up or downward trend for the liquid dis-charges of H-3 observed;</td></tr>
<tr><td>Emissions to air</td>
<td colspan="2">- annual H-3- and C-14-emissions to air reported;
- since 2004 measurements of C-14 → before 2004 estimation based on measurements done over a period of several months in the 1980s;
- measurements of I-129 activity not requested;</td>
<td>- annual H-3- and C-14-emissions to air reported;
- measurements of I-129 activity not requested;</td>
<td>- annual H-3- and C-14-emissions to air reported;
- since 2004 measurements of C-14 → before 2004 estimation based on measurements done over a period of several months in the 1980s;
- measurements of I-129 activity not requested;</td></tr>
</table>

SITE SPECIFIC INFORMATION
Discharges

	SWITZERLAND	
	Waste Treatment and Interim Storage (ZWILAG)	**Paul Scherrer Institute (PSI)**
System to reduce discharges	- waste water is collected and treated in batches; - installed abatement systems: • evaporation, in addition an ion exchanger to process the distillate; • centrifugation; • solidification of waste by-products; - evaporation and centrifugation systems not used on a large scale until now;	- waste water is collected and treated continuously; - abatement systems: • diffusion through membranes due to the pressure difference; • solidification of waste by-products;
	monitoring: - measurements during the abatement → concentration criterions fulfilled → discharge; - monitoring of the activity concentration during the discharge by total gamma counters → concentration limits exceeded → discharge automatically stopped;	
Efficiency of abatement systems	evaporation → DF up to 10000;	decontamination factor (DF) of the system at least a factor of 1000;
Annual liquid dis-charges	annual liquid discharges reported	
Trend analysis of liquid discharges	clear upward trend for liquid discharges without H-3 observed;	downward trend for liquid discharges without H-3 of one order of magnitude observed → value now < 101 GBq/a;
Emissions to air	- annual H-3- and C-14-emissions to air reported; - measurements of I-129 activity not requested;	- annual H-3 emissions to air reported; - radioisotopes with short half lives (C-11, N-13, O-15) produced by the accelerators monitored;

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM			
	Dungeness B	**Hartlepool**	**Heysham 1**	**Heysham 2**
System to reduce discharges	- main sources of radioactive liquid effluents: • reactor gas dryers → remove water from the gas coolant to tritiated water storage tanks; • pond water treatment plants → radionuclides from corrosion of cladding material, leaching of graphite sleeves etc. • drainage from radiation controlled areas; • activity from storage tanks → soluble steel activation and fission products; - Active Effluent Treatment Plant (AETP) or equivalent system: • separation of oils, particulate and treated liquids → at last final monitoring and delay tanks; • almost totally duplicated; • removal of particulates by filtration; • reduction of dissolved activity by non-regenerable ion exchange units → only in cases of significant increase in the level of radionuclides; - Pond Management: • pond water → most radioactive contributor to effluents transferred to AETP; • defective or leaking fuel elements → first in dry buffer storage → then separate water-tight container for decay → at last fuel cooling ponds → minimization of releases to fuel storage ponds; • closed pond water treatment system → discharges to sea only for small quantities of liquid following treatment; • pond water continuously recirculated through deep bed sand filters and ion exchange filter beds; • control of chloride ion concentration → reduction of the chance of fuel corrosion in the pond; • monitoring of pond radiochemical factors → sampling and analysis; • addition of boron to prevent critical events in the pond → increase of boron level in discharges; - liquid effluent treatment: • a number of particulate filters → for instance sand pressure filters and back-up filters; • ion exchange resins to remove soluble radioactivity from the cooling ponds optimized by pre-filtration; • active effluent treatment system → liquid effluents treated and filtered for final disposal → sludge directed to long-term storage for subsequent specialist disposal; • tritiated water storage tanks → retention of organic compounds floating on water surface → reduction of organically bound tritium; - liquid abatement techniques: • fuel integrity; • delay tanks; • ion exchange; • coolant chemistry; - aerial abatement techniques: • HEPA filters;			
Efficiency of abatement systems	- ion exchange and chemical adsorption → radionuclide dependant; - HEPA filtration → 99,98 %;			
Annual liquid dis-charges	annual liquid discharges reported			

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM			
	Dungeness B	**Hartlepool**	**Heysham 1**	**Heysham 2**
Trend analysis of liquid discharges	- H-3 and S-35 → relatively constant → only increase in 2003 due to increase of electricity generation; - increase of Co-60 by 100 % from 2004 to 2005 → remained at that level at 2006 due to engineering operations → in 2007 decrease to the level of 2004;	- H-3 and S-35 → decrease from 2002 to 2004 → similar level from 2004 to 2006 → increase in 2007 due to increase of electricity generation, but far under the values of 2002; - Co-60 → significant decrease from 2005 to 2007 due to change in the analytical methods → value of 2007 ~1 % of that of 2002; - total activity (excluding H-3, S-35, Co-60) → constant between 2002 and 2004 → fluctuating from 2005 to 2007;	- H-3 → steady decrease from 2002 to 2004 → increase from 2004 to 2006 → values in 2007 at the level of 2004; - Co-60 → increase in 2007 due to an unplanned transfer of ion exchange resin into a sump in the effluent treatment plant; - all other radionuclides → decrease in 2007 due to extended maintenance outage;	- relatively steady; - Co-60 → decrease in 2007 to a third of its 2002 value;
Emissions to air	annual emissions to air reported			

	UNITED KINGDOM		
	Hinkley Point B	Hunterston B	Torness
System to reduce discharges	- main sources of radioactive liquid effluents: • reactor gas dryers → remove water from the gas coolant to tritiated water storage tanks; • pond water treatment plants → radionuclides from corrosion of cladding material, leaching of graphite sleeves etc. • drainage from radiation controlled areas; • activity from storage tanks → soluble steel activation and fission products; - Active Effluent Treatment Plant (AETP) or equivalent system: • separation of oils, particulate and treated liquids → at last final monitoring and delay tanks; • almost totally duplicated; • removal of particulates by filtration; • reduction of dissolved activity by non-regenerable ion exchange units → only in cases of significant increase in the level of radionuclides; - Pond Management: • pond water → most radioactive contributor to effluents transferred to AETP; • defective or leaking fuel elements → first in dry buffer storage → then separate water-tight container for decay → at last fuel cooling ponds → minimization of releases to fuel storage ponds; • closed pond water treatment system → discharges to sea only for small quantities of liquid following treatment; • pond water continuously recirculated through deep bed sand filters and ion exchange filter beds; • control of chloride ion concentration → reduction of the chance of fuel corrosion in the pond; • monitoring of pond radiochemical factors → sampling and analysis; • addition of boron to prevent critical events in the pond → increase of boron level in discharges; - liquid effluent treatment: • a number of particulate filters → for instance sand pressure filters and back-up filters; • ion exchange resins to remove soluble radioactivity from the cooling ponds optimized by pre-filtration; • active effluent treatment system → liquid effluents treated and filtered for final disposal → sludge directed to long-term storage for subsequent specialist disposal; • tritiated water storage tanks → retention of organic compounds floating on water surface → reduction of organically bound tritium; - liquid abatement techniques: • fuel integrity; • delay tanks; • ion exchange; • coolant chemistry; - aerial abatement techniques: • HEPA filters;		
Efficiency of abatement systems	- ion exchange and chemical adsorption → radionuclide dependant; - HEPA filtration → 99,98 %;		
Annual liquid dis-charges	annual liquid discharges reported		

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM		
	Hinkley Point B	**Hunterston B**	**Torness**
Trend analysis of liquid discharges	- relatively steady up to 2006; - significant decrease in all radionuclides discharges in 2007 due to an extended outage for maintenance;	- no significant variation from 2002 to 2005; - S-35 → decrease by over a factor of 2 from 2002 to 2005; - general decrease in 2007 due to an extended outage for maintenance;	- trends in discharges → remained stable;
Emissions to air	annual emissions to air reported		

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM		
	Sizewell B	**Oldbury**	**Wylfa**
System to reduce discharges	- main sources of radioactive liquid effluents: • reactor coolant system/boron recycling system → fission and activation products → borated water processed by the Chemical and Volume control System into the Boron Recycle System (BRS); • reactor coolant drainage tank; • fuel storage pond cooling and clean-up system; • resin transfer, storage and encapsulation plant; • active drains from radiation controlled areas; • leaks from secondary-side plant; - two discharge systems: • via Liquid Radioactive Waste system (LRWS) for the main sources; • via a dedicated system for other sources of liquids including the turbine steam and feed water system → possibility of redirection to LWRS if significant amounts of radioactivity; - existing design features and operating processes to minimize radioactive waste: • limited use of the hard-facing material Stellite within the reactor cooling system → high cobalt content; • Chemical and Volume control System → decontamination of reactor coolant and control of the rate of the nuclear reaction inside the reactor core using demineraliser and filters → wastewater treated before sent to LWRS; • Boron Recycle System (BRS) → tanks for let down reactor coolant → decay of short-lived radionuclides → transfer to LRWS; • Fuel Storage Pond Cooling and Clean-up System → control of contamination of Fuel Storage Pond and of removal of the heat → water almost entirely recycled, only a small amount touted to LRWS → fuel storage pond water chemistry minimizes corrosion of	- radioactive liquid effluents from reactor and fuel handling operations as well as laundry operations: • major source for liquid alpha and beta discharges → corrosion and subsequent leakage of spent fuel elements stored in cooling ponds; • main source for liquid tritium discharges → desiccant used to capture water vapour; - control of the pond storage conditions → minimization of releases; - pond management: • alkalinity of pond water at pH > 11,5 → stable protective film on the Magnox surface; • very low anion concentrations using ion exchange plant; • removal of particulate through high-rate pond water filtration; • maintaining pond temperature → minimizing temperature-dependent rate of Magnox corrosion; • use of fuel storage skips that do not show significant paint damage; • removal of lugs and spacers from fuel pins immediately before being dispatched for reprocessing; - liquid effluent treatment: • IONSIV cartridge for removal of radiocaesium at source; • pond purge water → removal of any particulate material in the Pond Water Filtration Plant (PWFP) → storage in final delay tanks → discharged only if chemical and radioanalytical conditions within the authorized limits; • other aqueous effluents → passed through 5 µm sand pressure filters in the AETP → removal of residual particulate matter → collected in delay tanks → discharged with the cooling water if activity is acceptably low, optionally dilution;	- radioactive liquid effluents from reactor and fuel handling operations as well as laundry operations: • main source for liquid tritium discharges → desiccant used to capture water vapour; - AETP: • dry spent fuel store → effective elimination of the source; • lower levels of aqueous effluents; • removal of particulate by gravity settling channels; - liquid abatement techniques: • delay tanks; • FilTore → advanced particulate removal system; • 6 months delay of liquids from the gas dryer system→ decay of S-35; - aerial abatement techniques: • HEPA filters on contaminated ventilation systems; • charcoal iodine absorbers (emergency only); • sintered metal candle filters on blowdown stack;

	UNITED KINGDOM		
	Sizewell B	**Oldbury**	**Wylfa**
System to reduce discharges continued	- the fuel-cladding: • Reactor Coolant System → fission and activation nuclides → in parts transferred to LRWS and collected in resins → frequent change of resin beds → resins disposed as Low Level Waste; • Solid Radioactive Waste System → two low level and two intermediate waste spent resin storage tanks → super-natant liquid decanted to the Resin transfer System Sto-rage Tank → excess water filtered by cartridge filters or demineralisers within LRWS; - liquid effluent treatment: • a number of particulate filters → e. g. sand pressure or back-up filters; • ion exchange resins to remove soluble radioactivity from the cooling ponds optimized by pre-filtration; • active effluent treatment system → liquid effluents treated and filtered for final disposal → sludge directed to long-term storage for subsequent specialist disposal; • secondary neutron sources used in control of the reactor's run-up → by-product of the sources tritium → replaced in 2003 by a new design to produce less tritium; - liquid abatement techniques: • fuel integrity; • delay tanks; • ion exchange; • coolant chemistry; - aerial abatement techniques: • HEPA filters; • chemical adsorption;	- liquid abatement technologies: • Caesium Removal Unit (CRU) → non-regenerable resin; • Ion Exchange Plants: → cation unit to remove Na^+ and some soluble metal ions → regeneration with sulphuric acid; → anion unit to remove sulphates, silica, chloride and other non-metallic elements → regeneration withNaOH; • Particulate Filters: → fine filters of 5 to 10 micron often in conjunction with course filters (15 micron) → removal of particulate from the waste stream; → sand pressure filters; - liquid abatement techniques: • delay tanks; • sand filters; • facet filters → for filtration by sedimentation an inertial capture; • ion exchange resin caesium removal units; - aerial abatement techniques: • HEPA filters on contaminated ventilation systems; • charcoal iodine absorbers (emergency only); • sintered metal candle filters on blowdown stack;	

	UNITED KINGDOM		
	Sizewell B	**Oldbury**	**Wylfa**
Efficiency of abatement systems	- ion exchange and chemical adsorption → radionuclide dependant; - HEPA filtration → 99,98 %;	- efficiency of CRU → 60 % - 98 % → depending on the time for which they are used; - ion exchange plants efficient at removing Sr-90, S-35 and Cs; - HEPA filtration → 99,99 % → two yearly checks;	- efficiency of FilTore-filters: • 97,7 % for 10 micron particles; • 90 % for 5 micron particles; - HEPA filtration → 99,98 %; - reactor gas chemistry control since 2005 → reduction in boiler leaks from 12 in 2004/2005 to 6 in 2006;
Annual liquid discharges	annual liquid discharges reported		
Trend analysis of liquid discharges	- H-3 → slight decrease since 2003 due to change in the neutron sources; - total activity (excl. H-3) → steady decrease from 2002 to 2007;	- gradual decrease from 2002 to 2007; - ~40 % decrease for the group “other radionuclides” during the period;	- H-3 → quite variable with differences >30 % from year to year; - other radionuclides → steady decrease to a value in 2007 being ~16 % of that in 2002;
Emissions to air	annual emissions to air reported		

Discharges

	UNITED KINGDOM				
	Berkeley	**Bradwell**	**Hinkley Point A**	**Hunterston A**	**Trawsfynydd**
System to reduce discharges	- main sources of liquid effluents: • reactor and fuel handling operations; • laundry operations; • reactor (defuelling and) decommissioning operations; - liquid effluent treatment: • filtration of aqueous effluents prior to discharge → removal of particulate, e.g. with sand pressure filters; • removed particulates stored for future encapsulation; • effluents collected in delay tanks → sampling and analysis → acceptable low activity → discharge via station's pipelines using coolant or alternative water for considerable dilution;				
	- liquid abatement techniques: • sand pressure filters (10 micron); • Funda filters; - aerial abatement techniques → HEPA filters;	- liquid abatement techniques: • sand filters in pond water treatment plant; • non regenerable ion exchange resins in pond water treatment plant; • sand filters on effluent plant; - aerial abatement techniques → HEPA filters;	- liquid abatement techniques: • natural settlement; • delay tanks for treated effluents → since 2008; • fine filters; • cross flow filtration → planned for 2009; • ion exchange resin → reduction of Cs- and Sr-isotopes → planned for 2009; - aerial abatement techniques → HEPA filters on contaminated ventilation systems since 2008;	- liquid abatement techniques: • delay tanks; • SPF, ion exchange removed → awaiting new IONSIV; - aerial abatement techniques: • HEPA filters; • no shield cooling or iodine filters;	- liquid abatement techniques: • sand pressure filters; • ion exchange units; - aerial abatement techniques → HEPA filters on contaminated ventilation systems;
Efficiency of abatement systems		- ion exchange → up to 100 % dependent on usage → resin change at ~50 % efficiency; - HEPA filtration → 99,999 %;			
Annual liquid discharges	annual liquid discharges reported				

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM				
	Berkeley	**Bradwell**	**Hinkley Point A**	**Hunterston A**	**Trawsfynydd**
Trend analysis of liquid discharges	- similar level for all radionuclides from 2002 to 2004; - increase in the discharges of all radionuclides in 2005; - decrease in 2006 and 2007;	- similar level of Cs-137 and other radionuclides from 2002 to 2005; - decrease in 2006 and significantly in 2007 due to the end of defuelling stage; - H-3 discharges: • strong decrease of from 2002 to 2003; • small increase from 2003 to 2005; • level in 2006 similar to the 2005 level; • significant decrease in 2007;	- H-3 and Cs-137: • decrease from 2002 to 2005; • small increase in 2006 and 2007, but lower than the 2002 level; - increase of other radionuclides due to decommissioning of the reactor cooling ponds;	no significant changes throughout the period	- decrease throughout the period; - exception for Sr-90 and other radionuclides → peaks in 2004
Emissions to air	annual emissions to air reported				

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM		
	Chapelcross	Dungeness A	Sizewell A
System to reduce discharges	- main sources of liquid effluents: • reactor and fuel handling operations; • spent fuel ponds → irradiated fuel stored under water before being dispatched for reprocessing; • laundry operations; • reactor defuelling and decommissioning operations; - management procedures at transitional sites : • reduction of arisings of radioactive waste; • reduction of effluent arisings; - aqueous effluents: • fitration → removal of residual matter; • accumulation in delay tanks → sampling and analysis; • discharged via the station's cooling or other water → activity is acceptable low and considerable diluted; - all changes in the plant configuration or introduction of projects → assessment of the impact on the radioactivity discharges;		
	- all fuel previously stored in ponds dispatched to Sellafield; - fuel in reactor in dry store → defuelled and dispatched directly to Sellafield without interim storage; - remaining pond water → not currently discharged; - liquid waste from defuelling and decommissioning activities → discharged via settling and discharge tanks; - liquid abatement techniques: • delay tanks → decay of short half-life radionuclides; • settling tanks; • ion exchange units → mainly for removal of Sr-90 and Cs-137; - aerial abatement techniques → HEPA filters → on contaminated ventilation systems;	- pond management: • control of pond temperature and pH → optimum conditions to prevent corrosion of the fuel; • leaking fuel → dispatched as soon as possible → minimization of Cs-137 discharges; - Magnox Dissolution Plant (MXP): • reduction of the volume of solid waste from the removal of lugs etc. from the external surface of the spent fuel elements; • dissolution of essentially inactive debris in carbonic acid → residue of insoluble mildly-radioactive solid; • process effluents passes through a sand bed and a 5 µm cartridge filter → discharged with the station's other routine active effluents; • dissolution of a new type of material → slight changes in discharges → increase of H-3, but significant reductions in Cs-137 levels;	- treatment of liquid waste remained similar to the last report; - failure of the recirculation line in 2007 → outstage for repair/replacement of the system; - update of the Effluent Treatment Plant systems in 2003 → implementation of Submersible Caesium Removal Unit → Ionsiv resin; - liquid abatement techniques: • delay tanks→ decay of short half-life radionuclides; • settling tanks; • ion exchange → mainly for removal of Sr-90 and Cs-137; • sand pressure filters → reduction of particulates; • Submersible Caesium Removal Unit → Ionsiv resin; - aerial abatement techniques → HEPA filtration;

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM		
	Chapelcross	**Dungeness A**	**Sizewell A**
System to reduce discharges continued		- liquid abatement techniques: • delay tanks→ decay of short half-life radionuclides; • settling tanks; • ion exchange → mainly for removal of Sr-90 and Cs-137; • 5 µm Doulton filters ; • Submersible Caesium Removal Unit → Ionsiv resin; • pond temperature and water chemistry; - aerial abatement techniques → HEPA filtration;	
Efficiency of abatement systems	ion exchangers → depending on the levels of other ions present in the liquid → e.g. Na+ and Mg+;	- ion exchangers → depending on the levels of other ions present in the liquid → e.g. Na+ and Mg+; - settling tanks → varies between individual radionuclides, also dependent on particle size distribution in waste stream; - HEPA filtration → 99,99 %;	- ion exchangers → depending on the levels of other ions present in the liquid → e.g. Na+ and Mg+; - sand pressure filters: • varies between individual radionuclides; • depends upon particle size distribution in waste stream; - settling tanks → for decay of gas drier liquors in particular S-35; - HEPA filtration → 99,99 %;
Annual liquid dis-charges	annual liquid discharges reported		
Trend analysis of liquid discharges	- H-3 → decrease since 2003 → in 2007 3 % of the 2003 value; - total beta → decrease since 2003 → in 2007 1 % of the 2003 value; - total alpha: • decrease since 2002 → in 2007 ~16 % of the 2002 value • peak in 2003 due to emptying of one of the ponds;	- H-3: • significant decrease from 2002 to 2004; • increase since 2005 due to a campaign to dispose of a 2 years backlog of gas processing liquors; - Cs-137 and other radionuclides → steady decrease since 2002;	- H-3: • strong variation in discharges; • increase in 2003; • significant decrease in 2004 and 2005; • further increase in 2006 and 2007; - Cs-137 and other radionuclides: • similar level between 2002 and 2006; • significant 50 % decrease in 2007 due to cessation of operation;
Emissions to air	annual emissions to air reported		

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM			
	Dounreay	**Harwell**	**Windscale**	**Winfrith**
System to reduce discharges	- source of liquid discharges: • mainly from decommissioning of the reprocessing facilities and fuel cycle areas → H-3, total beta (including Na-22 and K-40), total alpha (excluding Cm-242), Sr-90 and Cs-137; • liquid H-3 mainly from the dissolution of alkali metals (Na, K) used as fast reactor coolants; • destruction of liquid sodium coolant from 2004 to 2007 → received solution of NaCl contaminated with various fission and activation products; - liquid effluent treatment: • filtration at source; • ion exchange when Cs-137 is expected to be significant; • high activity liquid wastes → cementation for disposal as solid; • aqueous solutions from sodium destruction operations → filtration and ion exchange to remove the majority of Cs-137; • effluents from the Shaft → ion exchange plant; - prior to discharge: • sampling; • analyses of the samples: → trend monitoring of cumulative discharges; → comparison with internal limits;	- source of liquid discharges → result of waste management operations: • decommissioning operations; • commercial tenants on the site; • liquid wastes received from neighbouring research and development organizations; - liquid wastes directed to the Liquid Effluent Treatment Plant (LETP) → three streams: • medium level active liquors → collected in carboys and monitored before being sent to LETP; • low level active liquors → held in delay tanks at the individual buildings before being transferred to LETP by site active drainage system or by tanker; • trade wastes → very low radioactivity content → directly to LETP → generally discharged without treatment after monitoring; - treatment processes include: • chemical flocculation → precipitation of alpha and beta activity; • dynasand filters → removal of precipitate; • filtrate → pumped in holding tanks and discharged after measurements; • slurry → pumped into setting tanks → cementation after sampling;	- source of liquid discharges → waste remediation; - management controls: • minimization of liquid and aerial effluents throughout decommissioning and operational processes; • solid waste preferred to liquid waste, but liquid waste preferred to gaseous waste → simplifies containment; • prevention of excess water consumption from handwashing facilities; • at WAGR collection of liquid effluents in storage vessels prior to sampling and transfer; - additional local management controls: • monitoring of the collection tanks and subsequent transfer to bowser; • in-line filter used at the transfer from tank to bowser → remove of particulate material; - all liquid wastes transferred by pipeline/tanker to Sellafield site for treatment and discharge → see Sellafield site;	- source of liquid discharges from: • buildings used for commercial research and development purposes by tenants; • waste processing work of Waste Management Technology Ltd.; - liquid effluent treatment: • minimization of waste arisings at source; • pH adjustment before discharged at pH 8,0-8,5; • no further treatment; - additional measurements: • gross alpha; • gross beta; • tritium; • free chlorine content; • suspended solids content; • chemical oxygen demand;

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM			
	Dounreay	**Harwell**	**Windscale**	**Winfrith**
System to reduce discharges continued		- modifications in effluent treatment in the late 1990s: • reduction of volume arisings; • more targeted treatment for the removal of beta emitters; • sampling of the effluent in the treatment tank for analysis → decision of the best suited chemical treatment to remove the principal radionuclides Sr-90 and Cs-137;	-	
Efficiency of abatement systems	- ion exchange → DF 10 to 10x → removal of Cs; - ultrafiltration → DF 100; - HEPA filtration → DF 1000;	- typical decontamination factors: • for alpha removal → DF 10-20; • for beta removal → DF 3-5; - delay tanks → 5-25 % by settling; - chemical precipitation → 70-90 %; - evaporation → 99-99,99 %; - HEPA filtration → 99,98 %; - radon gas delay or containment trapping → 99,9 %;		- delay tanks → 5-25 % by settling; - HEPA filtration → 99,98 %; dehumidifier of scrubber (planned for 2025) → >30 %;
Annual liquid discharges	annual liquid discharges reported		annual liquid discharges → Sellafield	annual liquid discharges reported

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM			
	Dounreay	**Harwell**	**Windscale**	**Winfrith**
Trend analysis of liquid discharges	- small fraction of authorized limits; - fluctuation of H-3 discharges due to dis-solution of alkali metals; - steady decrease of Sr-90; - other radionuclides remained at or below the minimum detectable activity;	- generally reduction in both volume and activity terms; - liquid discharges within the authorized limits; - substantially decrease of H-3 in 2003 due to reduced receipts of tritiated water (4 % of the previous value) → remained at that level since then; - decrease of Co-60 by ~80 % of the 2002 value; - generally decrease of the other radio-nuclides, but not so significant;	trends in discharges→ Sellafield	- remain low → very small fraction of the authorized discharge limits; - increase of H-3 in liquid discharges → result of processing work by WMT Ltd - short-term increase in other radionuclides → decommissioning operations
Emissions to air	emissions to air reported	- emissions to air reported; - revised authorization requires measure-ments of: • iodine; • Rn-2210 and Rn-222; • Kr-85;	emissions to air reported	

SITE SPECIFIC INFORMATION
Discharges

<table>
<tr><th rowspan="2">2. DISCHARGES</th><th colspan="4">UNITED KINGDOM</th></tr>
<tr><th>Calder Hall</th><th>Sellafield</th><th>Capenhurst</th><th>Springfields</th></tr>
<tr><td>System to reduce discharges</td><td colspan="2">- general sources of liquid effluents arising from:
• fuel reprocessing and storage operations;
• decommissioning of the Calder Hall reactors;
• on-site decommissioning operations;
• processing of legacy wastes;
• research and development activities;
- liquid effluents in reprocessing:
• liquors from reprocessing plant with highest levels of activity → directly to Waste Vitrification Plant for incorporation in solid glass → no discharges;
• medium active liquors → separated in a number of waste streams depending on their composition and activity;
• effluents from Magnox reprocessing operations concentrated and collected in storage tanks → Medium Active Concentrate (MAC) → since 2003 fresh MAC arisings also vitrified → no longer liquid discharges;
• liquid wastes from solvent washing operations form Magnox and THORP reprocessing plants → Salt Evaporator Concentrate (SEC);
• further liquid waste from purges of liquids from ponds and from the treatment of spent solvent used in reprocessing operations;
- liquid wastes from nitric acid dissolution process and other processes contain:
• fission products;
• activating products;
• actinides;
- sources of the most significant radionuclides:
• H-3 → from reprocessed Magnox fuel → ~90 % discharged to sea;
• C-14 → from Magnox reprocessing → majority from caustic scrubbers which remove C-14 from atmospheric discharge;
• Co-60 → mainly from storage and handling of BWR/PWR fuel and THORP fuel pond;
• Sr-90 → >99 % removed in the highly active liquid waste stream;
• Ru-106 → found in highly and medium active liquid waste streams → vitrfication;
• I-129 → main source – THORP and from treatment of the ventilation air stream by caustic scrubbing;
• Cs-137 → from Magnox reprocessing and historical arisings in highly and medium active liquid waste streams → vitrified or encapsulated;
• Pu / Am → Pu > 99 % recovered during reprocessing → >99,9 % of remaining Pu in waste streams vitrified or encapsulated → main source of liquid discharges of Pu and Am from SETP;</td><td>- source of liquid effluents:
• decommissioning operations;
• operation of the centrifuge plants;
• UCL laboratories;
• laundry facilities;
• liquid discharges arising from the operation of wet scrubbers on the older centrifuge plants;
- waste streams of decontamination plant :
• contain
→ uranium radionuclides;
→ small amounts of Tc-99;
→ very small amounts of Np-237;
• segregated;
• held in delay tanks for sampling;
• discharge to Rivacre Brook;
- liquid discharges of SL site:
• fitting of a dry scrubber in place of a wet one to the waste incinerator on SL site → in virtually no liquid discharges from the facility;
• small quantities of radioactive liquid effluent from decommissioning activities;
- management of liquid waste stream on UCL site:
• treatment of bulk aqueous waste by conventional wastewater processes;
• decontamination/removal of degradation products → reuse of fluorinated hydrocarbons;
• decontamination/removal of other contaminants → reuse of non-fluorinated hydrocarbons where possible;
• removal and recovery of U from U-contaminated aqueous liquors → followed by conventional wastewater treatment;</td><td>- source of liquid effluents:
• commercial operations;
• residue processing including recovery of U;
• treatment of legacy material;
- examples of liquid waste:
• liquors from off-gas scrubbers used to minimize aerial discharges;
• spent production process liquors;
• liquors arising as secondary waste from decontamination processes;
• rainwater run-off from potentially contaminated areas;
• effluent from the site laundry;
- effluents are sampled and analysed prior to discharge;
- Uranium from liquors:
• recovered through chemical and physical processing;
• fed back into the fuel fabrication process;
- applied technologies:
• precipitation and flocculation technologies → use of selective reagents to remove uranium species from solution;
• physical separation technologies:
→ centrifugation of flocculation to remove particles;
→ hydrocylone removes entrained solids of decontamination liquors;
→ evaporation for recycling distillates as backwash;
• filtration techniques:
→ frame and press filters for process effluents and slurry;
→ basket filters for laundry effluents;
→ oil separators for separation oil and aqueous liquids;</td></tr>
</table>

<table>
<tr><th rowspan="2"></th><th colspan="4">UNITED KINGDOM</th></tr>
<tr><th>Calder Hall</th><th>Sellafield</th><th>Capenhurst</th><th>Springfields</th></tr>
<tr><td></td><td colspan="2">- main (site-wide) treatment plants:
• Highly Active Liquor Evaporation and Storage plant (HALES) → evaporation of highly active liquid waste to reduce the volume → at last vitrification in Waste Vitrifcation Plant (WVP) → storage in robust, stainless steel containers;
• Salt Evaporator → concentration of liquids for interim decay storage → treatment in the Enhanced Actinide Removal Plant (EARP) → reduction of Pu and short-lived fission products such as Zr-95, Nb-95 and Ru-106;
• SIXEP → array of regenerable sand bed pressure filters → pH reduction processes → ion exchange columns in order to remove especially Sr- and Cs-isotopes;
• EARP → precipitation of iron by increasing the pH value → coprecipitation of Pu, Am and some beta-emitters → removal of beta-emitters, particularly Cs, by using ion exchanger Na-Ni-hexacyanoferrat → ultrafiltration → solid precipitate encapsulated in cement and low active liquor collected and analysed prior to discharge;
- specific treatment of Tc-99:
• continuation of research and development work into the use of tetraphenylphosphonium bromide (TPP) to precipitate Tc-99 from older MAC already in store and which is in compatible with vitrification due to its higher salts content → until 2003;
• use of the existing vitrification process for future arisings of MAC from Magnox reprocessing → in operation since 2004 → >95 % Tc-99 transferred for encapsulation → significant reduction of Tc-99;
- treatment plants specific to THORP:
• waste arisings minimized at source;
• waste streams treated according to their activity levels;
• medium active salt streams → sent to Salt Evaporator → EARP concentration process;
• medium active salt-free liquids → concentrated within THORP → transferred to vitrification;
• flushings from fuel containers → sent to EARP → remaining low level effluent stream sent to SETP;
• caustic scrubber → removal of radioiodine and C-14 from fuel dissolver off-gases → C-14 precipitated using barium and encapsulated in cement;
• treated liquor discharged to sea after analysis;
- other treatment plants:
• Solvent Treatment Plant (STP) → destroys the solvents → aqueous residue contains the bulk of the radioactivity → sent to EARP;
• Floc Retrieval → storage of the alumino-ferric flocs produced up to 1987 → now retrieved and treated in EARP for encapsulation;• Segregated Effluent Treatment Plant (SETP) → for low level effluent streams not directed to EARP → neutralization → mixed with alkaline effluent streams → removal of high specific gravity particulates using a hydrocyclone;</td><td>• number of measures to minimize the arising and transfer of liquid radioactive waste;
• counter-flow system → decontamination rinse water is re-circulated into the process;
• dry ice gun → removal of surface contamination → reduction of liquid decontaminants;
• electrically heated product and feed cylinders → elimination of potential for radioactive liquid effluents;
• recovery of residues from decontamination processes;
• use of disposable paper overalls;
• segregation of residues from laboratory analyses and U-recovery;
- no abatement measures at laundry or laboratory effluents → small quantities and low activity concentrations
- management of effluents at UCL enrichment plant:
• dry Gaseous Effluent Ventilation Systems (GEVS) replaces a wet venture scrubber system → contamination captured on HEPA filters and reduction of liquid effluents;</td><td></td></tr>
</table>

	UNITED KINGDOM			
	Calder Hall	**Sellafield**	**Capenhurst**	**Springfields**
System to reduce discharges continued	• Local Effluent Treatment Plant (LETP) → reduction of discharges from removal of sludge from Pile fuel storage pond; • Waste Encapsulation Plant (WEP) → trials with sludge and old waste retrieved → encapsulation was successful → further trials in order to understand legacy waste behaviour; • SIXEP → trials with silo liquor → effective treatment for liquid waste → enables immobilization of activity within the solid phase; - future waste treatment facilities: • Silos Direct Encapsulation Plant → for waste from Magnox swarf storage silo → operational after 2010; • Sludge Packaging Plant → to get directly disposable products → active commissioning after 2010; • Box Encapsulation Plant and Product Store → for retrieved waste from legacy ponds → active commissioning after 2015;		-	
Efficiency of abatement systems	- SIPEX → DF ~300 for Cs; - EARP → DF >1000 for alpha-emitters and >10 for beta-emitters; - electrostatic precipitation → typically 103; - cyclone scrubbing → variable; - HEPA filtration → 102 – 104; - condensers/dehumidifiers → dependent on feed - caustic scrubbers → dependent on chemical species, nuclide and other aspects; - torit blow-back filter → typically 103; - peabody scrubber → ~103;		efficiency of HEPA filters 99,97 % → reduction of gaseous discharges by a factor of ~ 10;	- efficient removal of uranium particulates; - efficiency of HEPA filters 99,99 %;
Annual liquid discharges	annual liquid discharges of the site regarding the main pipeline and the factory sewer → reported;		annual liquid discharges reported	

SITE SPECIFIC INFORMATION
Discharges

	UNITED KINGDOM			
	Calder Hall	Sellafield	Capenhurst	Springfields
Trend analysis of liquid discharges	- general downward trend in all discharges from the main site pipeline; • sometimes lower discharges linked to the low reprocessing throughput rates; • decrease of total alpha discharges around 35 % from 2002 to 2007; • decrease of Tc-99 discharges >90 % from 2002 to 2007 → now similar to levels before treatment of stored MAC commenced in 1994; • decrease of total beta discharges > 70 % from 112 TBq in 2002 to less than 30 TBq in 2007; • decrease of liquid C-14 discharges from 17 TBq in 2003 to < 5 TBq in 2007; • discharges from the factory sewer remained relatively constant; - expected trends in liquid discharges: • discharges of liquid total alpha after 2020 less than 0,2 TBq/a; • discharges of Tc-99 after 2016 below 1 TBq/a; • discharges of liquid total beta after 2020 less than 50 TBq/a;		- Tc-99, U-alpha-activity and U-daughters → decrease by over an order of magnitude; - H-3 → decrease by almost an order of magnitude; - non-U-alpha-activity, primarily Np-237 → increase;	- decrease of liquid discharges due to cessation of uranium Ore Concentrate purification in 2006; - liquid alpha activity in 2007 → ~ 12 % of the discharge in 2002; - liquid beta discharges in 2007 → reduction of 97 % in comparison with 2002 ; - reductions in the discharge of other radionuclides also evident;
Emissions to air	- radioactive aerial effluent discharges from ventilation air of all facilities; - reduction of discharges to atmosphere: • use of HEPA filters → reduction of particulate activity; • wet scrubbers → where significant volatile activity is present; • electrostatic precipitators; • packed beds; • chemical clean-up systems; • condensers; • pre-heaters → to prevent condensation in the filters; • caustic scrubber → installed in highly active liquor evaporation → significant reduction of volatilised C-14; - emissions to air → reported: • discharges to air remained below 1 TBq/a; • decrease of Kr-85 discharges due to low reprocessing throughput; • discharges of Ar-41 and S-35 ceased with the closure of Calder Hall reactors in 2003; • H-3 discharges varied due to reprocessing rates → discharge in 2007 ~30 % of that in 2002;		- emissions to air arise from: • incinerator gases; • ventilation air from decommissioning operations; - emissions to air reported	emissions to air reported

Annex 9: Summary of Site Specific Information – Environmental Impact

SITE SPECIFIC INFORMATION
Environmental Impact

	BELGIUM			
	Doel	Tihange	Fleurus	Mol-Dessel
Concentration of radio-nuclides of samples of water, sediment and fish	- no detectable alpha- and beta-activity concentrations (excluding H-3) referring to radioactive discharges from the sites; - discharges of H-3 from the PWRs can increase the tritium concentrations in surface water of rivers by 10 Bq/l to 30 Bq/l;			
Environmental monitoring programme	- environmental surveillance program in the vicinity of the sites by FANC's radiological monitoring program; - measurement of environmental samples of: • sediment and water in rivers and North Sea ; • and flora in freshwater and marine water; • soil; • air; • rain; • milk; • foodchain; • drinking water;			
Quality assurance of environmental moni-toring	The Belgian laboratories have to be in possession of the BELAC certificate (granted by the Belgian Federal Public Service of Economy) which is based upon the European Norm EN 45001 and later on and ISO 17025. So our labs are required these quality assurance certificates.			

SITE SPECIFIC INFORMATION
Environmental Impact

	FRANCE				
	Belleville-sur-Loire	Le Blayais	Cattenom	Chinon	Civaux
Concentration of radio-nuclides of samples of water, sediment and fish	results of measurements (sediments, algae, fish, seafood) for the marine sites reported				
Environmental monitoring programme	- program for controlling discharges and monitoring the environment: • established by the operator; • defined in the discharge permit; - controls on discharges; • check of figures stipulated in the authorizing order both for withdrawals of water and for radioactive discharges; • defined for each parameter covered by a license application → activity, activity concentration and emission rate; - environmental-monitoring measurements performed by the operator → assessment of the impact of the installation's operations: • periodic measurements of certain radiochemical parameters → activity concentrations or specific activity; • continuous monitoring of these parameters; • radioecologic surveys; - radioecologic measurements: • carried out around the nuclear sites; • land-based and aquatic ecosystems → annual monitoring particularly addressed to H-3 and gamma-emitting radionuclides; • supplemented by ten-years studies in order to cover a greater variety of matrices and radionuclides; • compared with radioecologic data collected before the startup of the facility (zero point);				
Quality assurance of environmental moni-toring					

SITE SPECIFIC INFORMATION
Environmental Impact

	FRANCE				
	Dampierre-en-Burly	**Fessenheim**	**Flamanville**	**Golfech**	**Gravelines**
Concentration of radio-nuclides of samples of water, sediment and fish	results of measurements (sediments, algae, fish, seafood) for the marine sites reported				
Environmental monitoring programme	- program for controlling discharges and monitoring the environment: • established by the operator; • defined in the discharge permit; - controls on discharges; • check of figures stipulated in the authorizing order both for withdrawals of water and for radioactive discharges; • defined for each parameter covered by a license application → activity, activity concentration and emission rate; - environmental-monitoring measurements performed by the operator → assessment of the impact of the installation's operations: • periodic measurements of certain radiochemical parameters → activity concentrations or specific activity; • continuous monitoring of these parameters; • radioecologic surveys; - radioecologic measurements: • carried out around the nuclear sites; • land-based and aquatic ecosystems → annual monitoring particularly addressed to H-3 and gamma-emitting radionuclides; • supplemented by ten-years studies in order to cover a greater variety of matrices and radionuclides; • compared with radioecologic data collected before the startup of the facility (zero point);				
Quality assurance of environmental moni-toring					

SITE SPECIFIC INFORMATION
Environmental Impact

<table>
<tr><th rowspan="2"></th><th colspan="4">FRANCE</th></tr>
<tr><th>Nogent-sur-Seine</th><th>Paluel</th><th>Penly</th><th>Saint Laurent des Eaux</th></tr>
<tr><td>Concentration of radio-nuclides of samples of water, sediment and fish</td><td colspan="4">results of measurements (sediments, algae, fish, seafood) for the marine sites reported</td></tr>
<tr><td>Environmental monitoring programme</td><td colspan="4">- program for controlling discharges and monitoring the environment:
• established by the operator;
• defined in the discharge permit;
- controls on discharges;
• check of figures stipulated in the authorizing order both for withdrawals of water and for radioactive discharges;
• defined for each parameter covered by a license application → activity, activity concentration and emission rate;
- environmental-monitoring measurements performed by the operator → assessment of the impact of the installation’s operations:
• periodic measurements of certain radiochemical parameters → activity concentrations or specific activity;
• continuous monitoring of these parameters;
• radioecologic surveys;
- radioecologic measurements:
• carried out around the nuclear sites;
• land-based and aquatic ecosystems → annual monitoring particularly addressed to H-3 and gamma-emitting radionuclides;
• supplemented by ten-years studies in order to cover a greater variety of matrices and radionuclides;
• compared with radioecologic data collected before the startup of the facility (zero point);</td></tr>
<tr><td>Quality assurance of environmental moni-toring</td><td></td><td></td><td></td><td></td></tr>
</table>

SITE SPECIFIC INFORMATION
Environmental Impact

	FRANCE	
	CEA Fontenay aux Roses Centre	**CEA Saclay Centre**
Concentration of radio-nuclides of samples of water, sediment and fish	- no direct discharge into the marine environment; - dilution factors from urban sewerage to: • discharge into Seine → about 33000; • to the mouth of the Seine → about 330000; - average activity concentration discharged into the urban sewerage: • about 20 Bq/m³ for alpha-emitters; • about 300 Bq/m³ for beta-emitters;	- radionuclide concentrations are very low; - levels of Sr-90, Cs-137 and Pu-239/Pu-240 comparable to those in the North sea → annual average concentrations in 2007: • tritium → 35 Bq/l; • C-14 → < 0,7 Bq/l; • Cs-137 → 5,5E-03 Bq/l; • Pu-239/Pu-240 → 4,9E-06 Bq/l;
Environmental monitoring programme	- environmental monitoring program for liquid discharges: - continuous monitoring performed to effluents passing into the centre's drainage channels and from these into the urban sewage downstream from all the outflow points at the centre; - similar checks on the groundwater, re-emergence points and lakes; - sampling frequency varies from daily to annual sampling; - mainly analyses of total alpha and total beta, H-3 and C-14;	- monitoring carried out over a radius around 5 km; - around 9000 samples a year → more than 24000 radiological measurements; - light tritium effect perceptible locally;
Quality assurance of environmental moni-toring	- support units with ISO 9901 certification; - analysis laboratories accredited according to standard ISP;	- analysis laboratories accredited according to standard ISP; - environmental management system since 2002 based on continuous improvement of environmental performance; - ISO 14001 certification since 2004;

	FRANCE **AREVA NC de La Hague** former: Établissement COGEMA
Concentration of radio-nuclides of samples of water, sediment and fish	- measurements of radionuclides in various bio-indicators according to regulatory registers: • terrestrial compartment: → ground; → herbs and vegetation; → milk; → fruits and vegetables; → meat; • marine compartment: → coastal and deep sea water; → sand; → sediments; → seaweeds; → limpets; → fishes; - results monthly sent to ASN → published in the annual report of environment monitoring; - annual mean concentrations in coastal water, focus, limpets and fishes reported;
Environmental monitoring programme	- detailed environmental programme established every year → communicated to ASN in consistency with the ministerial order defining: • types of measurements; • frequencies; • associated sampling; • analysis methods; - monitoring of marine compartment: • coastal samples → sand, seaweeds, limpets; • deep sea samples→ water, sediments; • flat and round fishes; • scallop shells; • crabs, oysters, mussels, lobsters - monitoring of terrestrial compartment: • rainwater; • vegetation; • milk and other foods;

	FRANCE **AREVA NC de La Hague** former: Établissement COGEMA
Environmental monitoring programme continued	- monitoring of hydrologic compartment: • drinking waters; • small streams; • ground waters; - independent complementary sampling by IRSN's LRC (Cherbourg-Octeville Radioecological Laboratory) → extensive water movement studies in the North Sea using Sb-125 discharged by La Hague site → results of the study used to determine the dilution on site effluents in the sea in view of the impact assessment; - annual comparison of the operator's measurements with the LRC's measurements until 2006 within the context of GRNC's impact assessment → resulting advice from this assessment;
Quality assurance of environmental moni-toring	- environmental management system complying with ISO 14001:2004 standard → obtained in 2005 and renewed in 2007 → environmental impact of the activities systematically assessed; - COFRAC accreditation (French national accreditation organism) concerning analyses and measures → obtained in 1996, last renew in 2003 and 2008; - regular calibration of detectors with secondary standards traceable to primary standards and intercomparison exercises, both national and international; - cross measurements required by ASN: • operator sends samples to a laboratory that has been agreed by ASN; • analyses of selected samples according to a programme defined by ASN; • operator has to check the results to consistence with his own;

SITE SPECIFIC INFORMATION
Environmental Impact

	GERMANY				
	Biblis A	**Biblis B**	**Brokdorf**	**Brunsbüttel**	**Emsland**
Concentration of radio-nuclides of samples of water, sediment and fish	- data of environmental annual measurements documented in the annual report "Environmental Radioactivity and Radiation exposure" published by the German Ministry of Environment, Nature Conservation and Nuclear Safety; - no detectable alpha- and beta-activity concentration, excluding H-3;				
Environmental monitoring programme	- environmental monitoring programme described in REI: • performed in the vicinity of the NPPs; • regarded media: → river water; → plants; → milk; → meat; → fish; → soil;				
Quality assurance of environmental moni-toring					

SITE SPECIFIC INFORMATION
Environmental Impact

	GERMANY				
	Grafenrheinfeld	Grohnde	Krümmel	Mülheim-Kärlich	Neckarwestheim 1
Concentration of radio-nuclides of samples of water, sediment and fish	- data of environmental annual measurements documented in the annual report "Environmental Radioactivity and Radiation exposure" published by the German Ministry of Environment, Nature Conservation and Nuclear Safety; - no detectable alpha- and beta-activity concentration, excluding H-3;				
Environmental monitoring programme	- environmental monitoring programme described in REI: • performed in the vicinity of the NPPs; • regarded media: → river water; → plants; → milk; → meat; → fish; → soil;				
Quality assurance of environmental moni-toring					

SITE SPECIFIC INFORMATION
Environmental Impact

	GERMANY				
	Neckarwestheim 2	Obrigheim	Philippsburg 1	Philippsburg 2	Stade
Concentration of radio-nuclides of samples of water, sediment and fish	- data of environmental annual measurements documented in the annual report "Environmental Radioactivity and Radiation exposure" published by the German Ministry of Environment, Nature Conservation and Nuclear Safety; - no detectable alpha- and beta-activity concentration, excluding H-3;				
Environmental monitoring programme	- environmental monitoring programme described in REI: • performed in the vicinity of the NPPs; • regarded media: → river water; → plants; → milk; → meat; → fish; → soil;				
Quality assurance of environmental moni-toring					

SITE SPECIFIC INFORMATION
Environmental Impact

	GERMANY				
	Unterweser	**Würgassen**	**URENCO Gronau**	**Hanau**	**Advanced Nuclear Fuels GmbH**
Concentration of radio-nuclides of samples of water, sediment and fish	- data of environmental annual measurements documented in the annual report “Environmental Radioactivity and Radiation exposure” published by the German Ministry of Environment, Nature Conservation and Nuclear Safety; - no detectable alpha- and beta-activity concentration, excluding H-3;				
Environmental monitoring programme	- environmental monitoring programme described in REI: • performed in the vicinity of the NPPs; • regarded media: → river water; → plants; → milk; → meat; → fish; → soil;				
Quality assurance of environmental moni-toring					

SITE SPECIFIC INFORMATION
Environmental Impact

	GERMANY				
	GKSS Geesthacht	**Helmholtz-Zentrum Berlin** former: Hahn-Meitner-Institut	**Jülich Research Centre**	**Institute for Technology of Karlsruhe**	**Verein für Kernverfahrenstechnik und Analytik Rossendorf e. V.**
Concentration of radionuclides of samples of water, sediment and fish	- data of environmental annual measurements documented in the annual report “Environmental Radioactivity and Radiation exposure” published by the German Ministry of Environment, Nature Conservation and Nuclear Safety; - no detectable alpha- and beta-activity concentration, excluding H-3;				
Environmental monitoring programme	- environmental monitoring programme described in REI: • performed in the vicinity of the NPPs; • regarded media: → river water; → plants; → milk; → meat; → fish; → soil;				
Quality assurance of environmental monitoring					

	NETHERLANDS					
	Kernenergiecentrale Borssele	**Kerncentrale Dodewaard**	**URENCO**	**Onderzoeks Locatie Petten or Petten site**	**Reactor Institute Delft**	**COVRA**
Concentration of radio-nuclides of samples of water, sediment and fish	data concerning the concentration of radionuclides in samples of water, sediment and fish reported					
Environmental monitoring programme	- consists of measuring water samples and suspended particles at 10 location in inland waters and 11 location at sea by the Rijkswaterstaat Centre of Water Management; - frequency of sampling variable per year per nuclide and per location - normally: • for each of the alpha, rest beta and tritium activity measurements average 12 times per year per location; • Ra-226, Sr-90, Sr-89, Po-210 and gamma activity between 4 and 13 times per year per location; - national target levels of activity of radionuclides in the environment for inland waters: • total alpha activity concentration 1.0E+02 Bq/m³; • rest beta activity concentration 2.0E+02 Bq/m³; • tritium activity concentration 1.0E+04 Bq/m³;					
Quality assurance of environmental moni-toring	- Environmental monitoring for the determination of alpha, gamma and beta activities according to NEN 5622, NEN 5623 and NEN 6421 (NEN – Dutch quality assurance standard) - Monitoring of alpha and beta emitters according to KTA 1504 (KTA – German safety standard)					

SITE SPECIFIC INFORMATION
Environmental Impact

	NORWAY	
	Institute for Energy Technology Kjeller	**Institute for Energy Technology Halden**
Concentration of radio-nuclides of samples of water, sediment and fish	- representative samples at three location in the Nitelva River: • water samples; • sediment samples (measurements of the top 10 cm); - measurements of concentrations of radionuclides in fish of all types; - data reported;	- Cs-137 → the only anthropogenic nuclide detected in environmental samples; - discharge point: • until 2006 discharge point at the shore of the river (use of municipal pipe line); • since 2006 discharge point in the middle of the river (new discharge pipe line); - activity of Cs-137 in shore samples and fish; - data reported
Environmental monitoring programme	- following IFE's environmental programme approved by NRPA: • water samples → 3x per year at 8 locations in the river; • sediments → 1x per year at 8 locations of the river; • water plants → 2x per year at 1 location in the river; • fish → species used for consumption during the summer period; - analysation of the samples in the IFE's laboratories; - annual report to NRPA;	- environmental monitoring programme includes: - bottom sediments from previous discharge area in the river Tista → 1x per year (no sedimentation in the new discharge area); - sediment samples from sand beaches along the fjord → 1x per year; - fish from the river discharge area in Iddefjord → 1x per year; - grass from neighbouring farms → 2x per year; - precipitant (rain, snow) from two locations → once a fortnight.
Quality assurance of environmental moni-toring	- all work tasks, including measurement of activity, are described in detail in working instructions and procedures by IFE's internal Health and Safety Department; - criteria of non-conformity also defined in these procedures; - IFE's Health and Safety Department is member of the IAEA's ALMERA network of Radioanalytical laboratories for analysis of environmental samples.	all work tasks, including measurement of activity, are described in detail in working instructions and procedures;

SITE SPECIFIC INFORMATION
Environmental Impact

	PORTUGAL **Campus de Sacavém**
Concentration of radio-nuclides of samples of water, sediment and fish	
Environmental monitoring programme	
Quality assurance of environmental moni-toring	

SITE SPECIFIC INFORMATION
Environmental Impact

	SPAIN			
	Almaraz	José Cabrera	Trillo	Juzbado
Concentration of radio-nuclides of samples of water, sediment and fish	concentrations of Mn-54, Co-60 and Cs-137 in samples of river water, sediment and fish reported;			concentrations of U-isotopes in samples of river water, sediment and fish reported;
Environmental monitoring programme	environmental monitoring program in a 30 km area around the NPPs;			environmental monitoring program in a 10 km area around the plant;
	monitoring of: - main pathways of human exposure to radiation; - other ecosystem elements that are good indicators;			
Quality assurance of environmental monitoring				

SITE SPECIFIC INFORMATION
Environmental Impact

	SWEDEN			
	Ringhals 1	Ringhals 2	Ringhals 3	Ringhals 4
Concentration of radio-nuclides of samples of water, sediment and fish	- concentrations of Cs-137 in the environment caused by several sources: • fallout from the Chernobyl accident in 1986; • atmospheric nuclear bomb tests; • discharges from European nuclear reprocessing facilities; - concentrations of Co-60, Mn-54 and Co-58 are low → no detectable trends - examples of radionuclide measurements in sediment and fish reported			
Environmental monitoring programme	environmental monitoring programme for: - biotic and abiotic parts in the aquatic environments; - biotic and abiotic parts in the terrestrial environments			
Quality assurance of environmental moni-toring	- environmental monitoring programme describes in detail sampling, sample preparation and measurement - implemented in local instructions; - analyses done at a special low-background laboratory at the site; - further quality assurance: • analysis aims for detection limit better than 1 Bq/kg for typical activation product; • instruments' calibration against certified standards; • weekly checks of detector stability; • energy calibration in connection with every analysis; • annual checks through round-robin exercises; - check of the environmental analyses through randomly selected sub-samples by SSM (analyses at independent laboratories);			

SITE SPECIFIC INFORMATION
Environmental Impact

	SWITZERLAND					
	Beznau (KKB)	**Gösgen (KKG)**	**Leibstadt (KKL)**	**Mühleberg (KKM)**	**Waste Treatment and Interim Storage (ZWILAG)**	**Paul Scherrer Institute (PSI)**
Concentration of radio-nuclides of samples of water, sediment and fish	- liquid discharges of all Swiss nuclear facilities into the Rhine catchment area; - the environmental data can be traced back to a single discharge source only partially, because 5 nuclear facilities are located at the river Aare and one facility is located at the river Rhine; - gammaspectrometric measurements of sediment in the river Rhine near Basel show: • observation of traces of radionuclides originating from nuclear facilities; • highest concentration values observed: → for Co-58 6.3 Bq/kg due to discharges of Beznau NPP; → for Cs-137 due to the historic fallout; - data reported;					
Environmental monitoring programme	permanently sampling of river water and sediments at three locations downstream of the NPPs: - at Hagneck dam (downstream Mühleberg NPP); - at Klingnau dam (downstream PSI, ZWILAG and KKB, KKM and KKG) → most activity measured here due to the liquid discharges of KKB which is the closest to the sampling point; - near Basel (downstream of all Swiss nuclear facilities);					
Quality assurance of en-vironmental monitoring	- no formal quality assurance system applied, but annual checks; - accreditation according to ISO/IEC 17025:2005: • testing laboratory for analyses in the field of environmental radioactivity of the BAG; • testing laboratory for radioactivity and dose rate measurements of the ENSI;					

SITE SPECIFIC INFORMATION
Environmental Impact

<table>
<tr><th rowspan="2"></th><th colspan="5">UNITED KINGDOM</th></tr>
<tr><th>Dungeness B</th><th>Hartlepool</th><th>Heysham 1</th><th>Heysham 2</th><th>Hinkley Point B</th></tr>
<tr><td>Concentration of radio-nuclides of samples of water, sediment and fish</td><td>representative environmental monitoring data from the whole site (Dungeness A+B) reported</td><td colspan="2">representative environmental monitoring data reported</td><td></td><td>representative environmental monitoring data reported</td></tr>
<tr><td rowspan="2">Environmental monitoring programme</td><td colspan="5">- environmental monitoring programme:
• undertaken by British Energy;
• for the principal radionuclides;
• for the pathways of potential significance;
- re-defined within the Compilation of Environment Agency Requirements (CEARs) → in force since 2007;
- required routine sampling of:
• intertidal sediments;
• fish;
• crustaceans;
• molluscs;
• seaweed (as available);
- required measurements:
• gamma spectroscopy results for
→ Co-60 and Cs-137 as well as for any other identified radionuclide;
→ K-40 in addition for sediment due to indicator of grain size;
• gamma dose rates on beaches;
• contact dose rate on fishing nets and equipment;
• monitoring of the beach strandline;</td></tr>
<tr><td>common monitoring programme with adjacent to Magnox stations:
- discharge into the same environment;
- the impact of the different stations cannot be distinguished;</td><td></td><td></td><td></td><td>common monitoring programme with adjacent to Magnox stations:
- discharge into the same environment;
- the impact of the different stations cannot be distinguished;</td></tr>
<tr><td>Quality assurance of environmental monitoring</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Environmental Impact

<table>
<tr><th rowspan="2"></th><th colspan="3">UNITED KINGDOM</th></tr>
<tr><th>Hunterston B</th><th>Torness</th><th>Sizewell B</th></tr>
<tr><td>Concentration of radio-nuclides of samples of water, sediment and fish</td><td colspan="2">,</td><td>representative environmental monitoring data for the whole site (Sizewell A+B) reported</td></tr>
<tr><td rowspan="2">Environmental monitoring programme</td><td colspan="2">- environmental monitoring programme:
• revised by SEPA (Scottish Environment Protection Agency);
• new authorizations in force since 2007;
• SEPA documents not equivalent to CEAR documents;
- required routine sampling of:
• intertidal sediments;
• fish;
• crustaceans;
• molluscs;
• seaweed (as available);
- required measurements:
• gamma spectroscopy results for Co-60 and Cs-137 as well as for any other identified radionuclide;
• gross beta;
• gamma dose rates on beaches;</td><td rowspan="2">- environmental monitoring programme:
• undertaken by British Energy;
• for the principal radionuclides;
• for the pathways of potential significance;
- re-defined within the Compilation of Environment Agency Requirements (CEARs) → in force since 2007;
- required routine sampling of:
• intertidal sediments;
• fish;
• crustaceans;
• molluscs;
• seaweed (as available);
- required measurements:
• gamma spectroscopy results for
→ Co-60 and Cs-137 as well as for any other identified radionuclide;
→ K-40 in addition for sediment due to indicator of grain size;
• gamma dose rates on beaches;
• contact dose rate on fishing nets and equipment;
• monitoring of the beach strandline;

- common monitoring programme with adjacent to AGR or PWR stations:
• discharge into the same environment;
• the impact of the different stations cannot be distinguished;</td></tr>
<tr><td>common monitoring programme with adjacent to Magnox stations:
- discharge into the same environment;
- the impact of the different stations cannot be distinguished;</td><td></td></tr>
<tr><td>Quality assurance of environmental monitoring</td><td colspan="3"></td></tr>
</table>

SITE SPECIFIC INFORMATION
Environmental Impact

	UNITED KINGDOM			
	Oldbury	**Wylfa**	**Berkeley**	**Bradwell**
Concentration of radio-nuclides of samples of water, sediment and fish	representative environmental monitoring data reported			representative environmental monitoring data reported
Environmental monitoring programme	environmental monitoring programme: - for the principal radionuclides; - for the pathways of potential significance;		common monitoring programme with adjacent to AGR or PWR stations: - discharge into the same environment; - the impact of the different stations cannot be distinguished;	environmental monitoring programme
Quality assurance of environmental moni-toring	–			

SITE SPECIFIC INFORMATION
Environmental Impact

	UNITED KINGDOM		
	Hinkley Point A	**Hunterston A**	**Trawsfynydd**
Concentration of radio-nuclides of samples of water, sediment and fish			representative environmental monitoring data reported
Environmental monitoring programme	common monitoring programme with adjacent to AGR and PWR stations: - discharge into the same environment; - the impact of the different stations cannot be distinguished;		environmental monitoring programme
Quality assurance of en-vironmental monitoring			

SITE SPECIFIC INFORMATION
Environmental Impact

	UNITED KINGDOM		
	Chapelcross	**Dungeness A**	**Sizewell A**
Concentration of radio-nuclides of samples of water, sediment and fish	representative environmental monitoring data reported	representative environmental monitoring data from the whole site (Dungeness A+B) reported	- representative environmental monitoring data for the whole site (Sizewell A+B) reported
Environmental monitoring programme	environmental monitoring programme by Magnox Site Licence Companies		
		common monitoring programme with adjacent to AGR and PWR stations: - discharge into the same environment; - the impact of the different stations cannot be distinguished;	
Quality assurance of en-vironmental monitoring	–		

	UNITED KINGDOM			
	Dounreay	**Harwell**	**Windscale**	**Winfrith**
Concentration of radionuclides of samples of water, sediment and fish	- environmental monitoring data reported; - routinely sampling of: • seaweed; • winkles; • crab; • lobster; - measurements of: • gamma emitting radionuclides → principally Cs-137 and Co-60; • alpha emitting radionuclides → Pu-238, Pu-239+Pu-240, Am-241; • beta emitting radionuclides → Sr-90 and Pu-241;	- representative activity concentration data reported; - samples from the Thames region: • fish; • lilies; • water; • silt; - activity concentrations typically between 0,1 % and 1 % of the Generalised Derived Limits published by Health Protection Agency (HPA) → exception Cs-137-activity concentration of silts (5 % - 10 % of GDLs);	- sampling relating to liquid discharges not required; - environmental sampling due to liquid and aerial discharges from both Windscale and Sellafield performed by Sellafield;	- representative environmental concentration data reported; - activity concentrations of radionuclides in environmental media → typically 0,1 % to 1 % of the GDLs published by HPA;
Environmental monitoring programme	- routine environmental monitoring programme; - additionally Site Wide Environmental Study (SWES) in 2003/04: • production of a baseline for future assessment; • wider range of environmental materials → fish, seawater and seabed sediments; • results much less than 1 % of the calculated site specific derived limits;	- environmental monitoring of the Thames region; - no marine monitoring;		
Quality assurance of environmental monitoring				

SITE SPECIFIC INFORMATION
Environmental Impact

<table>
<tr><th rowspan="2"></th><th colspan="4">UNITED KINGDOM</th></tr>
<tr><th>Calder Hall</th><th>Sellafield</th><th>Capenhurst</th><th>Springfields</th></tr>
<tr><td>Concentration of radio-nuclides of samples of water, sediment and fish</td><td colspan="2">- activity concentrations in seafood:
• concentrations of Cs, Pu and Am → relatively constant;
• decrease of total beta concentrations in lobster by about a factor of 3, but not in crab;
• decline of average Tc-99-concentrations:
→ in lobster and crab ~10 % of the 2002 levels;
→ in winkles <2 % of the 2002 concentrations;
- activity concentrations in seawater:
• generally similar to those of recent years → mostly below detectable limits;
• total beta activity between 12 Bq/l and 16 Bq/l;
- activity concentrations in sediments → fluctuated with little evidence for an overall trend;
- data reported;</td><td>- activity concentrations of radionuclides in various media reported;
- levels of Tc-99 in environmental samples, especially cockles and shrimps → substantial decrease;
- concentrations of other radionuclides → relatively steady or decreased → mostly below detection limits;</td><td>- activity concentrations of radionuclides in various media reported;
- activity concentrations in fish generally below detection limits;
- Cs-137 values → caused by discharges from the Sellafield site in West Cumbria;
- level of Tc-99 in shrimps → fallen by over 75 % of its 2002 value;
- activity concentrations in other environ-mental samples also fallen in the regarded period;</td></tr>
<tr><td>Environmental monitoring programme</td><td colspan="2">marine environmental monitoring programme:
- for a variety of species in a number of locations;
- annually reviewed;</td><td>environmental monitoring programme:
- silt sampling at two locations;
- additional samples of water and water weed;</td><td>- environmental monitoring at various locations around 15 km from the discharge point:
• surface sediments → quarterly;
• shellfish → biannually;
• surface beta gamma dose rates;
- routinely analysis of:
• K-40;
• Cs-137;
• Pa-234m;
• Th-228, Th-230, Th-232;
• Am-241;
• Np-237;
• total U;</td></tr>
<tr><td>Quality assurance of environmental moni-toring</td><td colspan="4">–</td></tr>
</table>

Annex 10: Summary of Site Specific Information – Radiation Doses to the Public

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	BELGIUM			
	Doel	**Tihange**	**Fleurus**	**Mol-Dessel**
Annual individual effective dose	- no values of the effective dose received from 2006 to 2009, but probably ≤ previous years → doses of the same order of magnitude; - average of the real committed dose within the last 10 years: • liquid discharge → 2.3·10-3 mSv/a; • atmospheric discharge → $18 \cdot 10^{-3}$ mSv/a;	average of the real committed dose within the last 10 years: - liquid discharge → 2.5·10-3 mSv/a; - atmospheric discharge → $47 \cdot 10^{-3}$ mSv/a;		average of the real committed dose within the last 10 years: - liquid discharge → 625·10-6 mSv/a; - atmospheric discharge → 60·10-6 mSv/a;
Total exposures	average of the real committed dose within the last 10 years → $19 \cdot 10^{-3}$ mSv/a	average of the real committed dose within the last 10 years → $49 \cdot 10^{-3}$ mSv/a		average of the real committed dose within the last 10 years → $685 \cdot 10^{-6}$ mSv/a
Critical group	calculations both for liquid and for atmospheric discharges made under conservative assumptions			
Exposure Pathways				
Methodology to estimate doses				
Site specific factors				
Site specific target annual effective dose	dose constraint of the nuclear site: - liquid discharge → 0.23 mSv/a; - atmospheric discharge → 0.18 mSv/a; - total → 0.37 mSv/a;	dose constraint of the nuclear site: - liquid discharge → 0.08 mSv/a; - atmospheric discharge → 0.19 mSv/a; - total → 0.21 mSv/a;		dose constraint of the nuclear site: - liquid discharge → 0.2 mSv/a; - atmospheric discharge → 0.3 mSv/a; - total → 0.5 mSv/a;

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	FRANCE				
	Belleville-sur-Loire	Le Blayais	Cattenom	Chinon	Civaux
Annual individual effective dose		annual total effective dose due to liquid discharges including H-3 and calculated C-14 between 2005 and 2008 → 0,37 mSv/a to 0,49 mSv/a;			
Total exposures					
Critical group		reference group → "Le Bastion"			
Exposure Pathways		- food intake: • root vegetables → 52,5 kg/a; • leafy vegetables → 14,4 kg/a; • fruiting vegetables and fruits → 62,1 kg/a; • milk → 84,4 kg/a; • meat → 47,5 kg/a; • fish → 18,3 kg/a; • molluscs → 2,3 kg/a; • crustaceans → 2,3 kg/a; - external exposure: • exposure on the beach → 100 h/a; • swimming with ingestion of seawater (1 L/a) → 20 h/a;			
Methodology to estimate doses		- calculation of the dose a recent requirement of the regulations → performed annually for the adults in the reference group's population for all sites - transfer functions between activity and dose updated in 2006;			

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	FRANCE				
	Belleville-sur-Loire	Le Blayais	Cattenom	Chinon	Civaux
Site specific factors					
Site specific target annual effective dose					

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	FRANCE				
	Dampierre-en-Burly	Fessenheim	Flamanville	Golfech	Gravelines
Annual individual effective dose			annual total effective dose due to liquid discharges including H-3 and calculated C-14 between 2005 and 2008 → 0,16 mSv/a to 0,28 mSv/a;		annual total effective dose due to liquid discharges including H-3 and calculated C-14 between 2005 and 2008 → 0,23 mSv/a to 0,26 mSv/a;
Total exposures					
Critical group			reference group → “La Berquerie”		reference group → “Petit Fort Philippe Nord”
Exposure Pathways			- food intake: • root vegetables → 31,4 kg/a; • leafy vegetables → 4,6 kg/a; • fruiting vegetables and fruits → 59,6 kg/a; • milk → 97,8 kg/a; • meat → 47,8 kg/a; • fish → 13 kg/a; • molluscs → 6,7 kg/a; • crustaceans → 7,1 kg/a; - external exposure: • exposure on the beach → 100 h/a; • swimming with ingestion of seawater (1 L/a) → 20 h/a;		- food intake: • root vegetables → 93 kg/a; • leafy vegetables → 11,8 kg/a; • fruiting vegetables and fruits → 42,3 kg/a; • milk → 68,9 kg/a; • meat → 44,3 kg/a; • fish → 24,4 kg/a; • molluscs → 6,8 kg/a; • crustaceans → 6,8 kg/a; - external exposure: • exposure on the beach → 100 h/a; • swimming with ingestion of seawater (1 L/a) → 20 h/a;
Methodology to estimate doses			- calculation of the dose a recent requirement of the regulations → performed annually for the adults in the reference group’s population for all sites - transfer functions between activity and dose updated in 2006;		- calculation of the dose a recent requirement of the regulations → performed annually for the adults in the reference group’s population for all sites - transfer functions between activity and dose updated in 2006;

SITE SPECIFIC INFORMATION

Radiation Doses to the Public

	FRANCE				
	Dampierre-en-Burly	**Fessenheim**	**Flamanville**	**Golfech**	**Gravelines**
Site specific factors					
Site specific target annual effective dose					

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	FRANCE			
	Nogent-sur-Seine	Paluel	Penly	Saint Laurent des Eaux
Annual individual effective dose				
Total exposures				
Critical group				
Exposure Pathways				
Methodology to estima-te doses				
Site specific factors				
Site specific target an-nual effective dose				

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	FRANCE		
	CEA Fontenay aux Roses Centre	**CEA Saclay Centre**	**AREVA NC de La Hague** former: Établissement COGEMA
Annual individual effective dose	annual dose for individuals of the critical group for the period 2003-2008: - between 7,1E-7 mSv/a and 1,4E-7 mSv/a; - mean value → 6,1E-7 mSv/a	- very low local impact of liquid discharges; - estimations from several scenarios: • order 1 µSv/a → for individuals from a local company consuming 2 L/d underground water containing 100 Bq/L tritium; • order 3 µSv/a → for fishermen consuming 8 kg/a fish caught in the new pond at Saclay (due to C-14); • < 0,1 µSv/a → for farmers consuming cultivated products by using subterranean groundwater;	- annual effective doses of the marine reference group (Goury fishermen) for marine discharges → doses between 0,0024 mSv and 0,0057 mSv; - since 1995 annual effective dose practically constantly decreasing → more than 2 orders of magnitude below the dose limit of 1 mSv/a; - the dose caused by tritium is negligible besides the one resulting from the other radionuclides → < 1 %;
Total exposures			- average value in France for exposures → 3,2 mSv/a; - exposure to the Goury fishermen reference group: • arising from sources except nuclear facilities → 6,55 mSv/a; • by neighbouring nuclear facilities without La Hague → 0,00081 mSv/a → 0,012 % of the one of other sources in addition; • by La Hague → 0,007 mSv/a → additionally 0,11 % to the one of other sources;
Critical group	individuals: - working 8 h/d in fields fertilized with slurries from the purification centre at Achères; - irrigated with water from the Seine;		- according to the 96/29 EURATOM directive; - exposure to a given source: • relatively uniform; • representation of individuals who are more particularly exposed to the source through their usual domestic, occupational and leisure activities; - French recommendation in 1996 → use of real groups of persons for the critical group, not purely hypothetical groups;

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	FRANCE		
	CEA Fontenay aux Roses Centre	**CEA Saclay Centre**	**AREVA NC de La Hague** former: Établissement COGEMA
Critical group continued	individuals: - working 8 h/d in fields fertilized with slurries from the purification centre at Achères; - irrigated with water from the Seine;		- reference group for the marine pathway → Goury fishermen: • longer lasting contact with the sea; • consumption of seafood above the average; • coastal point with the highest concentrations of radionuclides; • seafood of local origin at the point of highest activity concentrations;
Exposure Pathways	exposure pathways for the critical group: - exclusively consumption of products cultivated in fields fertilized with slurries from Achères; - consumption of fish caught in the Seine downstream from Achères; - drink of reprocessed water from the Seine;		- consideration of two compartments: • terrestrial; • marine; - kinds of effluents in the marine compartment: • most of the radionuclides in soluble form; • but also colloids or polymers; • or adsorbed on solid particles; - pathways to man in the marine environment include: • ingestion of seafood; • external exposure; - for the general population only leisure activities on the beaches are considered; - spray of seawater no significant pathway to man → only for bio-indicators;
Methodology to estimate doses	doses estimated using “ABRICOT” code → employing a source term which corresponds to the effective discharges		- use of the software ACADIE including: • operators’ discharge values; • area specific parameters for dietary and living habits;

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	FRANCE		
	CEA Fontenay aux Roses Centre	**CEA Saclay Centre**	**AREVA NC de La Hague** former: Établissement COGEMA
Methodology to estimate doses continued			- assumptions: • exposure time for external exposure of fishermen → 7 h/d and 365 d/a; • seafood diet conservatively taken as one of the 95th percentile; • total annual sea food consumption → ~127 kg (from local origin >70 kg); • rest of food → ~236 kg (from local origin > 67 kg); - dispersion factors, concentration factors, corrective factors from studies of the GRNC; - external exposure factors → ministerial order or Federal Guidance 12; - body dose coefficients for inhalation /ingestion according to 96/29 EURATOM Directive;
Site specific factors			
Site specific target annual effective dose			no targets for the annual effective dose;

SITE SPECIFIC INFORMATION

Radiation Doses to the Public

	GERMANY				
	Biblis A	Biblis B	Brokdorf	Brunsbüttel	Emsland
Annual individual effective dose	- water-pathway → max. 0,2 µSv/a; - air-pathway (for the whole site) → decrease from 1 µSv in 2003 to 0,3 µSv in 2008;		- water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → 0,3 to 0,7 µSv/a;	- water-pathway → generally < 0,1 µSv/a; - air-pathway → 0,5 to 2 µSv/a;	- water-pathway → 0,7 to 2 µSv/a; - air-pathway → 0,3 to 0,7 µSv/a;
Total exposures					
Critical group					
Exposure Pathways					
Methodology to estima-te doses					
Site specific factors					
Site specific target an-nual effective dose					

SITE SPECIFIC INFORMATION

Radiation Doses to the Public

	GERMANY				
	Grafenrheinfeld	**Grohnde**	**Krümmel**	**Mülheim-Kärlich**	**Neckarwestheim 1**
Annual individual effective dose	- water-pathway → 0,3 to 0,7 µSv/a; - air-pathway → 0,1 to 0,3 µSv/a;	- water-pathway → 0,2 to 0,5 µSv/a; - air-pathway → 0,3 to 0,6 µSv/a;	- water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → 0,2 to 2 µSv/a;	- water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → generally ≤ 0,1 µSv/a;	- water-pathway → 0,1 to 0,4 µSv/a; - air-pathway → generally ≤ 0,1 µSv/a;
Total exposures					
Critical group					
Exposure Pathways					
Methodology to estimate doses					
Site specific factors					
Site specific target annual effective dose					

SITE SPECIFIC INFORMATION

Radiation Doses to the Public

	GERMANY				
	Neckarwestheim 2	**Obrigheim**	**Philippsburg 1**	**Philippsburg 2**	**Stade**
Annual individual effective dose	- water-pathway → 0,4 to 0,8 µSv/a; - air-pathway → 0,7 to 1 µSv/a;	- water-pathway → decrease from 0,3 to ≤ 0,1 µSv/a; - air-pathway → decrease from 4 to 0,2 µSv/a;	- water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → 3 to 5 µSv/a;	- water-pathway → generally ≤ 0,2 µSv/a; - air-pathway → generally ≤ 0,3 µSv/a;	- water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → decrease from 0,5 to ≤ 0,1 µSv/a;
Total exposures					
Critical group					
Exposure Pathways					
Methodology to estima-te doses					
Site specific factors					
Site specific target an-nual effective dose					

SITE SPECIFIC INFORMATION

Radiation Doses to the Public

	GERMANY				
	Unterweser	**Würgassen**	**URENCO Gronau**	**Hanau**	**Advanced Nuclear Fuels GmbH**
Annual individual effective dose	- water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → generally ≤ 0,2 µSv/a;	- water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → generally ≤ 0,2 µSv/a;	- water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → generally ≤ 0,1 µSv/a;	- only from 2003 to 2005; - water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → generally ≤ 0,1 µSv/a;	- water-pathway → generally ≤ 0,1 µSv/a; - air-pathway → generally ≤ 0,1 µSv/a;
Total exposures					
Critical group					
Exposure Pathways					
Methodology to estimate doses					
Site specific factors					
Site specific target annual effective dose					

SITE SPECIFIC INFORMATION

Radiation Doses to the Public

	GERMANY				
	GKSS Geesthacht	**Helmholtz-Zentrum Berlin** former: Hahn-Meitner-Institut	**Jülich Research Centre**	**Institute for Technology of Karlsruhe**	**Verein für Kernverfahrenstechnik und Analytik Rossendorf e. V.**
Annual individual effective dose					
Total exposures					
Critical group					
Exposure Pathways					
Methodology to estimate doses					
Site specific factors					
Site specific target annual effective dose					

Radiation Doses to the Public

	NETHERLANDS		
	Kernenergiecentrale Borssele	**Kerncentrale Dodewaard**	**URENCO**
Annual individual effective dose	effective dose via the marine exposure pathway reported	effective dose via the marine exposure pathway reported	the maximum contribution to the annual dose due to discharges and emissions far less than 1 µSv
Total exposures	- total exposure including those from historic discharges is not estimated; - the estimated individual effective dose is already low compared to the dose limit for members of the public in case of normal operation;		
Critical group	- homogeneous group of the population for which the individual dose due to the group is the highest; - for dose estimates the group is composed by adults in accordance with the Dutch regulation guidelines; - reference behaviour is that behaviour, which maximizes the dose, given a certain contamination in the environment and includes all living habits such as working and eating; - to determine the reference behaviour only realistic assumptions have to be taken into account;		
Exposure Pathways	- consumption of seafood (mussels, shrimps and sea fish); - ingestion of drinking water; - ingestion via deposition to surface water from emissions to air;		
Methodology to estima-te doses	based on: - models by Van Hienen et al.; - actual discharge data.		based on modelling by RIVM
Site specific factors	- site specific factors have been calculated for the most relevant radionuclides by NRG; - Te-123m hasn't been taken into account;	site specific factors for the most relevant radionuclides published by Van Hienen et al. and corrected using the DCCs of EURATOM 96/29;	–
Site specific target an-nual effective dose	- site internal target 8 nSv/a for the reference group; - realisation around 5.5 nSv/a (all discharges)	not defined	

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	NETHERLANDS		
	Onderzoeks Locatie Petten or Petten site	**Reactor Institute Delft (RID)**	**COVRA (Centrale Organisatie Voor Radioactief Afval)**
Annual individual effective dose	annual effective dose reported	maximum individual effective dose far below 0.009 µSv/a.	- with respect to the liquid discharges the site of COVRA can be well compared to the NPP Borssele; - maximum individual effective dose far below 0.001 µSv/a. (assumption → all gamma emitting radionuclides Co-60)
Total exposures	- total exposure including those from historic discharges is not estimated; - the estimated individual effective dose is already low compared to the dose limit for members of the public in case of normal operation;		
Critical group	- homogeneous group of the population for which the individual dose due to the group is the highest; - for dose estimates the group is composed by adults in accordance with the Dutch regulation guidelines; - reference behaviour is that behaviour, which maximizes the dose, given a certain contamination in the environment and includes all living habits such as working and eating; - to determine the reference behaviour only realistic assumptions have to be taken into account;		influence of the reactor HOR on the marine environment only due to deposition of atmospheric emissions;
Exposure Pathways	- consumption of seafood (mussels, shrimps and sea fish); - ingestion of drinking water; - ingestion via deposition to surface water from emissions to air;		
Methodology to estimate doses	based on models by Van Hienen et al.;	based on: - models by Van Hienen et al.; - actual discharge data.	based on models by Van Hienen et al.;
Site specific factors	site specific factors published by Van Hienen et al.		COVRA and NPP Borssele located within a few kilometres → site specific factors due to NPP Borssele
Site specific target annual effective dose	not defined		

	NORWAY	
	Institute for Energy Technology Kjeller	**Institute for Energy Technology**
Annual individual effective dose	average annual effective dose to individuals within the critical group from liquid discharges and emission to outdoor air reported;	- average annual effective dose to individuals within the critical group from liquid discharges and emission to outdoor air reported; - the drop in dose after 2005 doesn't represent a reduced release, but is a result of a new methodology for calculating doses → implementation of the PC-CREAM computer code;
Total exposures	- total annual effective dose to the public for discharges to the receiving water and for emissions to air can't be measured; - model calculations based on exposure pathways and public behaviour; - critical groups for liquid discharges and emissions to air are not the same → doses should not be added;	
Critical group	- hypothetical group defined by the food consumption and living habits; - estimation of doses based on theoretical radionuclide concentration in the mentioned local river environment situated 100 km from the sea and calculated from discharge values; - doses represent the adult population; - children with their habits don't receive doses that deviate significantly from adults; - calculation of collective dose from liquid discharges includes also the population in all municipalities around the lake Øyern; - age distribution in the population in all municipalities around the lake Øyern: • 3.3 % infants (0–2 years); • 19.7 % children (2–17 years); • 77.0 % adults (>17 years);	- hypothetical group defined by the food consumption and living habits; - estimation of doses based on theoretical radionuclide concentration in the environment and calculated from discharge values; - dose represents an average in a group with an age distribution identical to the age distribution of the Norwegian population; - children with their consumption and living habits don't receive doses that deviate significantly from the average;
Exposure Pathways	- calculation of effective dose to the critical group based on: • annual consumption of 20 kg fish from the river; • 100 h/a occupancy on the riverbank; - negligible contribution to doses → bathing and boating;	calculation of effective dose to the critical group based on: - annual consumption of 30 kg fish from the part of the Iddefjord close to the discharge of the river Tista; - 200 h/a occupancy on the beaches in the part of the Iddefjord close to the discharge of the river Tista; - 50 h of bathing in the fjord; - 1000 h/a of boating.
Methodology to estimate doses	modelling of transfer of radionuclides in the environment and doses to critical groups based on a model described in EUR 15760 EN	

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	NORWAY	
	Institute for Energy Technology Kjeller	**Institute for Energy Technology**
Site specific factors	- no site specific factors are used; - only a Kd factor for Co-60 and Cs-137 for the actual river sediments determined by IFE's Health and Safety Department	- no site specific factors are used; - estimates based on default factors described in the used model;
Site specific target annual effective dose	- discharge limits defined by NRPA based on a limiting annual effective dose of 1 µSv to individuals of the critical group; - target values are not implemented;	

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	PORTUGAL **Campus de Sacavém**
Annual individual effective dose	
Total exposures	
Critical group	
Exposure Pathways	
Methodology to estimate doses	
Site specific factors	
Site specific target annual effective dose	

Radiation Doses to the Public

<table>
<tr><th rowspan="2"></th><th colspan="4">SPAIN</th></tr>
<tr><th>Almaraz</th><th>José Cabrera</th><th>Trillo</th><th>Juzbado</th></tr>
<tr><td>Annual individual effective dose</td><td colspan="4">effective dose below the present authorized limit</td></tr>
<tr><td>Total exposures</td><td colspan="3">reported</td><td></td></tr>
<tr><td rowspan="2">Critical group</td><td colspan="4">- corresponds to critical groups as defined by ICRP-60;
- includes three age groups who receive the highest doses according to EC Radiation protection 129:
• infants (1-2 years);
• children (7-12 years);
• adults (> 17 years);
- hypothetical but realistic group;</td></tr>
<tr><td>- critical group for liquids → adults (> 17 years) with the main exposure pathways river shoreline deposits and fish consumption;
- critical group for gases → infants (1-2 years) with the main exposure pathways non-leafy vegetables consumption and inhalation;</td><td>- critical group for liquids → infants (1-2 years) with the main exposure pathways potable water ingestion, cow milk, non-leafy vegetables;
- critical group for gases → infants (1-2 years) with the main exposure pathways exposure to the cloud and non-leafy vegetables (until 2006) as well as exposure to deposits on the ground and non-leafy vegetables (since 2007);</td><td>- critical group for liquids → infants (1-2 years) with the main exposure pathways non-leafy vegetables, fruits and grain consumption, cow milk;
- critical group for gases → infants (1-2 years) with the main exposure pathways non-leafy vegetables, fruits and grain consumption, cow milk;</td><td>- critical group for liquids → infants (1-2 years) with the main exposure pathways potable water and vegetables;
- critical group for gases → adults (> 17 years) with the main exposure pathways inhalation and vegetables;</td></tr>
<tr><td>Exposure Pathways</td><td colspan="4">exposure pathways:
- external exposure to the cloud (only noble gases are considered);
- inhalation;
- external exposure to deposits on the ground (gaseous effluents) and on the shorelines (liquid effluents);
- drinking water;
- fish, seafood and shellfish;
- leafy vegetables;
- cereals, vegetables, roots and fruits;
- meat (beef, goat, pork);
- milk (goat, cow);</td></tr>
</table>

	SPAIN			
	Almaraz	José Cabrera	Trillo	Juzbado
Exposure Pathways continued	- exposure pathways for liquids: • river shoreline deposits; • ingestion of fish, milk (goat/sheep) and meat; - exposure pathways for emissions: • inhalation; • deposits on ground surface; • ingestion of vegetables, milk and meat;	- exposure pathways for liquids: • river shoreline deposits; • ingestion of potable water, vegetables, fish, milk (goat/sheep) and meat; - exposure pathways for emissions: • inhalation; • exposure to the cloud; • deposits on ground surface; • ingestion of vegetables, milk and meat;	- exposure pathways for liquids: • river shoreline deposits; • ingestion of potable water, vegetables, fish, milk (goat/sheep) and meat; - ex exposure pathways for emissions: • inhalation; • exposure to the cloud; • deposits on ground surface; - ingestion of vegetables, milk and meat;	- exposure pathways for liquids • river shoreline deposits; • ingestion of potable water, vegetables, fish, milk and meat; - exposure pathways for emissions: • inhalation; • exposure to the cloud; • deposits on ground surface; • ingestion of vegetables, milk and meat;
Methodology to estima-te doses	- methodology described in ODCM's; - calculation model given in NRC-Regulatory Guide 1.109; - general aspects of the methodology: • local characteristics, population habits and land and water usage are site specific; • Gaussian models-straight line trajectory used for atmospheric dispersion; • hydrological dispersion considers specific characteristics of the effluent receiving water body; • generic values → period of animals on pasture, time from production and consumption; • local specific values → food consumption rate, irrigation rate, humidity; • site specific exposure pathways; - dose coefficients used in calculation: • for ingestion and inhalation → specified in Spanish regulations and Euratom 96/29 Directive; • for external exposure to the cloud → specified in BSS (Safety Series No.115); • for external exposure to deposits on the ground or shoreline deposits → included in the US EPA Federal Guidance Report 13;			
Site specific factors	site specific activity-dose factors for all nuclides included in libraries used in labo-ratory analyses are calculated	calculation of doses monthly using activity-dose conversion factors included in the Regulations	site specific activity-dose factors for all nuclides included in libraries used in la-boratory analyses are calculated	
Site specific target an-nual effective dose			target release values in terms of annual dose for the different considered groups of radionuclides → in 2008 target value of the effective dose 4,5E-3 mSv/a;	

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	SWEDEN			
	Ringhals 1	Ringhals 2	Ringhals 3	Ringhals 4
Annual individual effective dose	- effective dose to an individual in the critical group, from one year of releases of radioactive substances to air and water from all facilities located in the same geographically delimited area: < 0.1 mSv/a; - integration of the effective dose (dose from external radiation and the committed effective dose from internal exposure) over a period of 50 years; - calculating dose to individuals in the critical group both children and adults; - dose coefficients for intake and inhalation specified in Council Directive 96/29/EURATOM, Appendix III; - largest contribution to the dose caused by emissions of C-14; - dose contribution from emissions for many years larger than the one from discharges, but at the end of reporting period the contributions are about the same (excluding C-14) → decreasing trend; - revision to more realistic models in 2002 → shift towards lower doses in particular for doses from C-14;			
Total exposures				
Critical group	- individuals whose exposure to a source is reasonably uniform and representative of that of the individuals in the population who are the more highly exposed to that source; - includes six age groups according to Council Directive 96/29/EURATOM; - hypothetical but realistic; - consideration of average habits and exposure situations; - critical group for a specific year is that age group that received the highest dose as a result of that's year's releases;			
Exposure Pathways	- radioecological and dose models revised in 2002: • updating data used in the calculations; • investigating which data are dependent on age of the exposed individual; • more detailed description of the environment around the plant; • new model for uptake of C-14 in plants; - most important exposure pathways: • inhalation; • external irradiation from radioactive substances in the air and the ground; • consumption of meat, milk, cereals, roots, fruits, grown berries, vegetables and fish; • consumption of game, mushrooms and wild berries (except Barsebäck site); • consumption of shell-fish (additional for Ringhals site); • drinking water (only Forsmark site and Studsvik site); - exposure pathways are treated separately in the calculations; - release-to-dose factors calculated for more than 150 radionuclides;			

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	SWEDEN			
	Ringhals 1	Ringhals 2	Ringhals 3	Ringhals 4
Methodology to estimate doses	- in 2002 revised model developed by Studsvik Eco & Safety; - basic compartment model tested in international model validation studies;			
Site specific factors	for each radionuclide a site-specific release-to-dose factor is calculated reflecting the conditions representative for the site			
Site specific target annual effective dose	- no site-specific target annual effective dose; - constraint of 0.1 mSv/a is valid for all nuclear sites, irrespective of the number of sources within the site;			

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	SWITZERLAND					
	Beznau	**Gösgen**	**Leibstadt**	**Mühleberg**	**Waste Treatment and Interim Storage (ZWILAG)**	**Paul Scherrer Institute (PSI)**
Annual individual effective dose	- annual effective doses to a member of the reference group due to liquid discharges of all Swiss nuclear facilities → < 1 µSv for the last six years; - evaluated with the models of the Inspectorate's Guideline G14;					
Total exposures	- yearly doses calculated for individual members of the population in the vicinity of the Swiss nuclear facilities → see Table 3; - calculated exposures of the reference group dominated by the C-14 emission due to the NPPs; - reported values below the source –related dose guide value of 0.3 mSv/a; - effective dose < 10 µSv/a → according to Swiss legislation no further efforts are necessary to reduce radioactive releases and the resulting doses;					
Critical group	- assumptions for dose calculation for an individual: - individual is living and working at the place with the highest total dose resulting from: • immersion; • inhalation; • ground radiation; • ingestion; - food which an individual consumes is produced locally; - drinking water and fish for consumption come from the river downstream of the facility;					
Exposure Pathways	- considered pathways: - immersion from the plume; - inhalation; - ground radiation; - ingestion of fruits, vegetables, milk, meat, fish and drinking water from the downstream of the facility;					
Methodology to estima-te doses	- methodology laid down in the Inspectorate's Guideline G14; - models and parameters used in this guideline based on : • international recommendations (IAEA, ICRP, etc.); • regulations from other countries (e. g. German administrative regulation for the determination of the radiation exposure caused by radioactive emissions from nuclear facilities);					

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	SWITZERLAND					
	Beznau	**Gösgen**	**Leibstadt**	**Mühleberg**	**Waste Treatment and Interim Storage (ZWILAG)**	**Paul Scherrer Institute (PSI)**
Site specific factors	site specific factors to estimate the dose: - dispersion factor for the emissions → determined by a statistical analysis of the weather parameters measured at the meteorological tower near the facility; - mean value of the water flow.					
Site specific target annual effective dose	- source-related dose guide value for a nuclear site → 0.3 mSv/a; - target annual effective dose only defined in case of relevant superposition of immission of facilities owned by different licensees: • PSI → target dose 0.25 mSv/a; • ZWILAG → target dose 0.05 mSv/a;					

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	UNITED KINGDOM			
	Dungeness B	**Hartlepool**	**Heysham 1**	**Heysham 2**
Annual individual effective dose	- annual individual effective dose for the whole site (Dungeness A+B) reported; - effective doses consistently >5 µSv/a → average around 10 µSv/a;	- annual individual effective dose reported; - effective doses generally <5 µSv/a;	- annual individual effective dose reported; - annual effective dose of 75 µSv in 2003; - steady decrease to a value of 37 µSv in 2007;	
Total exposures				
Critical group	- the most exposed members of the public from all discharges from the regarded site; - the most exposed individuals from liquid discharges generally associated with: • external exposure over beaches sediments; • consumption of local fish and shellfish; - characteristics of the relevant groups determined by habit surveys;			
Exposure Pathways				
Methodology to estimate doses	doses estimated on basis of: - survey data; - environmental monitoring programme;			
Site specific factors				
Site specific target annual effective dose	dose constraint of 300 µSv/a → all estimated doses significant lower			

SITE SPECIFIC INFORMATION

Radiation Doses to the Public

	UNITED KINGDOM			
	Hinkley Point B	**Hunterston B**	**Torness**	**Sizewell B**
Annual individual effective dose	- annual individual effective dose reported; - increase of the annual effective dose to a value of 40 µSv in 2006 due to discharges from the station Hinkley Point B; - decrease of the annual effective dose in 2007 → 29 µSv;	- annual individual effective dose reported;	- annual individual effective dose reported; - effective doses generally <5 µSv/a;	- annual individual effective dose for the whole site (Sizewell A+B) reported; - effective doses generally <5 µSv/a;
Total exposures				
Critical group	- the most exposed members of the public from all discharges from the regarded site; - the most exposed individuals from liquid discharges generally associated with: • external exposure over beaches sediments; • consumption of local fish and shellfish; - characteristics of the relevant groups determined by habit surveys;			
Exposure Pathways				
Methodology to estimate doses	doses estimated on basis of: - survey data; - environmental monitoring programme;			
Site specific factors				
Site specific target annual effective dose	dose constraint of 300 µSv/a → all estimated doses significant lower			

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	UNITED KINGDOM			
	Oldbury	**Wylfa**	**Berkeley**	**Bradwell**
Annual individual effective dose	- annual individual effective dose reported; - steady increase from 8 µSv in 2002 to 18 µSv in 2007 due to revised habit data; - effective doses to the members of the public include a component from the decommissioning Berkley station;	- annual individual effective dose reported; - decrease of the effective dose to critical group from 16 µSv in 2002 to 7 µSv in 2007; - minimum value of <5 µSv reported in 2004;	- annual individual effective dose for the critical group → include a contribution from operational site "Oldbury";	- annual individual effective dose for the critical group reported; - trends in effective dose → slightly fluctuation with effective doses between 10 µSv/a and 20 µSv/a;
Total exposures				
Critical group	critical group → consumers of fish and shellfish, who also spend time on intertidal sediments;		critical group → consumers of fish and shellfish, who also spend time on intertidal sediments;	
Exposure Pathways				
Methodology to estimate doses				
Site specific factors				
Site specific target annual effective dose	dose constraint of 300 µSv/a → all estimated doses significant lower;			

SITE SPECIFIC INFORMATION

Radiation Doses to the Public

	UNITED KINGDOM		
	Hinkley Point A	**Hunterston A**	**Trawsfynydd**
Annual individual effective dose	annual individual effective dose for the critical group → include a contribution from operational site "Hinkley Point B";	annual individual effective dose for the critical group → include a contribution from operational site "Hunterston B";	- annual individual effective dose for the critical group reported; - trends in effective dose → decreased by a factor of 3 to a value of 10 µSv in 2007;
Total exposures			
Critical group			critical group → consumption of freshwater and external dose to anglers;
Exposure Pathways			
Methodology to estima-te doses			
Site specific factors			
Site specific target an-nual effective dose			

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	UNITED KINGDOM		
	Chapelcross	**Dungeness A**	**Sizewell A**
Annual individual effective dose	- annual individual effective dose reported; - effective doses: • reduction from 39 µSv in 2002 to 24 µSv in 2007; • including a contribution from Sellafield;	- annual individual effective dose for the whole site (Dungeness A+B) reported; - effective doses consistently >5 µSv/a → average around 10 µSv/a;	- annual individual effective dose for the whole site (Sizewell A+B) reported; - effective doses generally <5 µSv/a;
Total exposures			
Critical group	critical group in the vicinity of Chapelcross	see Dungeness B	see Sizewell B
Exposure Pathways		see Dungeness B	see Sizewell B
Methodology to estimate doses			
Site specific factors			
Site specific target annual effective dose	dose constraint of 300 µSv/a → all estimated doses significant lower		

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	UNITED KINGDOM			
	Dounreay	Harwell	Windscale	Winfrith
Annual individual effective dose	- annual effective dose reported; - doses: • calculated from discharge information; • cross-checked against the results of environmental sample analyses; - sample analysis results include contri-butions from: • historic discharges; • discharges of other sites; • discharges of weapons tests and Cher-nobyl fallout;	annual effective dose to the critical group → < 10 µSv during the reported period;		- annual effective dose reduced from 7 µSv in 2002 to < 5 µSv for each year since 2004; - doses of the critical group from liquid discharges and emissions in 2007 → estimated to each 0,2 µSv
Total exposures				
Critical group	- relevant reference group → adults with a mean consumption rate of 0,5 kg/a of winkles → annual effective dose ~ < 5 µSv/a; - other groups and their main exposure pathways: • sea-fishermen → handling of nets; • sea-fishermen → handling of nets and consumption of locally caught fish and crustaceans; • visitors of the Geos (rocky inlets) - these groups are considered separately → doses are less than those of the reference group;	hypothetical critical group for modeling and assessing the impact;	critical group only associated with aerial discharges;	- hypothetical critical group → consumers of seafood caught in Weymouth Bay; - critical group for liquid discharges defined by FSA consuming: • 210 g/d fish; • 110 g/d whelks; • 70 g/d crabs;
Exposure Pathways	main exposure pathways from liquid discharges → collection and consumption of winkles;			exposure pathways used for calculation: - consumption of seafood; - exposure to contaminated beach sediment; - inhalation of resuspended beach sediment and seaspray;

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	UNITED KINGDOM			
	Dounreay	Harwell	Windscale	Winfrith
Methodology to estimate doses		modeling includes: - consumption of fish, crustaceans, mollusks and seaweed; - exposure due to inhalation; - sediment exposure via beach occupancy; - pathways where applicable; - effect from past discharges;		
Site specific factors				
Site specific target annual effective dose				

	UNITED KINGDOM			
	Calder Hall	**Sellafield**	**Capenhurst**	**Springfields**
Annual individual effective dose	- annual effective dose to members of the critical group: • between 200-300 µSv/a; • decrease to 210 µSv in 2007 due to reduction of Tc-99 concentrations in marine organisms and slow reduction of actinides concentrations; • light increase in the period 2003/2004 due to increases in the rates of seafood consumption; • significant fraction of the consumption dose from historic discharges (actinides); - annual effective dose to members of other relevant groups → annually reported by the Site operator and regulatory authorities → for houseboat dwellers the effective doses decreases from 120 µSv to ~70 µSv; - data of effective dose for members of all relevant groups reported;		- annual effective dose arising from liquid site discharges estimated to → ~ 10 µSv/a; - annual effective dose arising from gaseous discharges → order on nSv/a;	calculated annual effective doses to the most exposed groups: - from fish and shellfish consumption → t ~ 20 µSv throughout the period mainly due to historic discharges of Am-241 and Cs-137 from Sellafield; - for houseboat dwellers in the Ribble Estuary → gradually decrease from 120 µSv to ~ 75 µSv; - for anglers and wildfowlers → between 7 µSv and 30 µSv;
Total exposures	contribution from historic discharges → >2/3 of the total dose received;			
Critical group	- marine critical group: • high rate consumers of fish/shellfish from local waters of the Irish Sea; • spend time on local beaches; - other relevant groups: • houseboat dwellers on the Ribble river in Lancashire; • stakenet fishermen in southwest Scotland;			potentially exposed groups include: - fishermen; - seafood consumers; - children playing in inter-tidal areas; - houseboat dwellers; - anglers; - wildfowlers;
Exposure Pathways	- main pathways for liquid discharges: • internal exposure from consumption of seafood → particularly fish and shellfish; • external gamma radiation from exposed intertidal sediments → particularly fine silts and mud of estuaries and harbours; • inhalation of airborne radioactivity; • exposure to airborne radioactivity; - habits applicable to marine exposure pathways → see Table II.2.85; - crossover in pathways recognized → quantitative determination only by modeling;		critical pathway for liquid discharges → inadvertent ingestion of water or silt by children playing in or near Rivacre Brook;	

SITE SPECIFIC INFORMATION
Radiation Doses to the Public

	UNITED KINGDOM			
	Calder Hall	**Sellafield**	**Capenhurst**	**Springfields**
Methodology to estimate doses				doses to members of the public → estimated using a combination of measurements and modeling
Site specific factors				
Site specific target annual effective dose				

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