OSPAR COMMISSION

Protecting and conserving the North-East Atlantic and its resources

Overview of national statements on the 7th round of implementation of PARCOM Recommendation 91/4

Radioactive Substances Series

2020

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.

Contents

Executive Summary

This document provides an overview of the national statements on the 7th round reporting of OSPAR Contracting Parties on the implementation of the Best Available Technology (BAT) on Radioactive Discharges under PARCOM Recommendation 91/4.

Implementation reports and national statements for the 7th round of reporting were received from Belgium, France, Germany, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. All of them are compiled in Annex 1. Denmark has not been able to provide its implementation report or national statement.

Récapitulatif

Le présent document donne un aperçu des déclarations nationales sur le 7ème cycle de notification des parties contractantes OSPAR concernant la mise en œuvre de la meilleure technologie disponible (BAT) relative aux rejets radioactifs en vertu de la recommandation PARCOM 91/4.

Des rapports de mise en œuvre et des déclarations nationales ont été reçus de la Belgique, de la France, de l'Allemagne, des Pays-Bas, de la Norvège, du Portugal, de l'Espagne, de la Suède, de la Suisse et du Royaume-Uni. Le Danemark n'a pas été en mesure de fournir un rapport de mise en œuvre ou une déclaration nationale.

Introduction

This report provides an overview of the 7th round reporting of OSPAR Contracting Parties on the implementation of the Best Available Technology (BAT) on Radioactive Discharges under PARCOM Recommendation 91/4.

PARCOM Recommendation 91/4 concerns the use of Best Available Techniques (BAT), to minimise and, as appropriate, eliminate any pollution caused by radioactive discharges from all nuclear industries, including research reactors and reprocessing plants, into the marine environment. The Recommendation requests that Contracting Parties to the OSPAR Convention report on a four-year basis on progress in the implementation of BAT in such facilities.

So far and under PARCOM Recommendation 91/4 there have been seven rounds of reporting. OSPAR has published the following reports to assess the implementation of this measure:

- Third round reporting (publication 175/2003 - ISBN 1-904426-21-2)
- Fourth round of reporting (publication 351/2008 - ISBN 978-1-905859-90-0)
- Fifth round of reporting (publication 559-2012 –ISBN 978-1-907390-02-9)
- Sixth round of reporting (publication 726/2016 - ISBN 978-1-911458-48-7)

During the 2016-2019 four-year period, OSPAR Contracting Parties have produced their national report for the 7th round of reporting on the national implementation of the Best Available Technology (BAT) on Radioactive Discharges under PARCOM Recommendation 91/4. The information was submitted according to the OSPAR "Guidelines for the submission of information about, and assessment of, the application of BAT in nuclear facilities" (OSPAR Agreement 2004-03). The guidelines for reporting were revised for the 3rd round reporting. Table 1 shows the list of implementation reports for the 7th round of reporting including the publication number and the reporting period.

Implementation Report of PARCOM Recommendation 91/4 on radioactive discharges		
Contracting Party	Publication	Reporting period
Belgium	768/2020 - ISBN 978-1-913840-07-5	2014-2018
France	750/2019 - ISBN 978-1-911458-90-6	2012-2017
Germany	749/2019 - ISBN 978-1-911458-89-0	2011-2016
The Netherlands	22/2018 - ISBN 978-1-911458-62-3	2012-2015
Norway	751/2019 - ISBN 978-1-911458-91-3	2012-2017
Portugal	770/2020 - ISBN 978-1-913840-08-2	2014-2018
Spain	766/2020 – ISBN 978-1-913840-08-2	2014-2018
Sweden	724/2018 - ISBN 978-1-911458-64-7	2012-2016
Switzerland	748/2019 - ISBN 978-1-911458-88-3	2012-2017
The United Kingdom	723/2018 - ISBN 978-1-911458-63-0	2012-2016

Table 1: Contracting Parties Reporting in 7th Round and their Reporting

In 2012, at the time of adopting the overview assessment of the 5th round of reporting on the implementation of PARCOM Recommendation 91/4 prepared by Germany, RSC agreed to simplify the next overview. In 2015, in the context of preparations for the overview assessment of the 6th round of implementation reporting on PARCOM Recommendation 91/4, RSC discussed the necessary arrangements for conducting a more practical and straightforward approach. Different options were explored and finally it was decided that Contracting Parties would build on national statements for preparing an overall statement. The 6th round of implementation reporting on the PARCOM Recommendation 91/4 compiled national statements on the implementation of PARCOM Recommendation 91/4, based on guidance provided by the Secretariat, in conjunction with the Chair of RSC.

For the overview assessment of the 7th round of reporting on the implementation of PARCOM Recommendation 91/4 the Secretariat followed the same guidance as provided for the 6th round of reporting and invited Contracting Parties to provide Executive Summaries of their national reports with a common outline. In order to present a harmonised and straightforward report, the following information was requested:

a. *National arrangements for the implementation of BAT*: brief overview of national legislation implementing BAT; with a focus on new legislation in place since the last round of reporting;
b. *Systems and abatement techniques to reduce discharges*: short summary of systems and abatement technologies employed by Contracting Parties individually or in combination and the extent to which abatement techniques are in line with BAT in the industry;
c. *Effectiveness of BAT in reducing liquid discharges:* short description of overall trends in the discharges of alpha, beta and gamma emitters; and
d. *Conclusion*s: closing paragraph stating whether in light of the information provided BAT is applied in the nuclear installations.

Implementation reports and national statements were received from Belgium, France, Germany, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. All of them are compiled in Annex 1. Denmark has not been able to provide its implementation report or national statement.

The information presented in Annex I indicates that:

a. National legislation is in place for the implementation of BAT in the nuclear industry, with Contracting Parties having incorporated BAT into their legislative and regulatory texts;

b. Abatement systems and optimisation processes have been applied by Contracting Parties, individually or in combination, in order to reduce, prevent or eliminate discharges of radioactive substances into the marine environment. The operational and management techniques vary from country to country and in countries from one nuclear installation to another. Mechanisms are in place to ensure that procedures and technical solutions applied in the nuclear industry are consistent with international best practices on the abatement of discharges. Waste;

c. In most cases reductions in alpha and beta/gamma discharges have been achieved or if not, the low levels are maintained. As regards tritium, in general the overall downward trend continues, although in some countries the tritium activity presents a global steady trend or even a slightly increase for specific facilities;

d. Contracting Parties applied BAT and BEP in their nuclear installations to keep the radiological impact of radioactive substance discharges extremely low in the marine environment and for population close to facilities. Indicators for discharges, environmental impact and radiation doses to the public have been used for the BAT/BEP assessment.

OSPAR Recommendation 2018/01 on Radioactive Discharges supersedes PARCOM Recommendation 91/04 on Radioactive Discharges. The purpose of OSPAR Recommendation 2018/01 is to prevent and eliminate pollution caused by radioactive discharges from all nuclear industries and their associated radioactive waste treatment facilities and decommissioning activities, by applying the best available techniques (BAT) and the best environmental practice (BEP). After 2019 Contracting Parties will report every six years on the implementation of this Recommendation following the Guidelines for the submission of Information about, and Assessment of, the Application of BAT in Nuclear Facilities under OSPAR Agreement 2018-01.

Annex 1

National Statements

Belgium

1. National arrangements for the implementation of BAT/BET in terms of the OSPAR Convention in Belgian legislation and regulation. General information.

The Royal Decree of July 20th 2001 *(General Regulations for the Protection of the population, workers and the environment against the dangers of Ionising Radiation - GRPIR*) and the Belgian policy are based on EC Directives, on international conventions and on recommendations of appropriate international bodies like the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA).

The major principles in these regulations are justification of exposure, optimisation (ALARA), dose limits. The Royal Decree introduces also a notion of dose constraint (optimisation principle-ALARA): the discharge limits have to be based on a fraction of the public annual limit of 1 mSv (20 to 55% of the annual limit depending of the nuclear site, see the seventh Belgian Parcom Report of 2020).

2. Systems and abatement techniques to reduce discharges

For an overview, refer to the seventh Belgian PARCOM report.

Nuclear sites have followed the development of best techniques and use a vast variety of systems and best available efficiency abatement techniques to reduce discharges: delay tanks, chemical precipitation, ion-exchange, filtration (HEPA, active carbon), osmosis and evaporation. Depending of the system, efficiencies of 90% to 99,9% are reached.

For the 2001-2014 period, following factors have influenced the reduction of radioactive liquid releases: i.e. more liquid wastes are evaporated to solid wastes instead of being released in rivers, replacements of steam generators allow to recover the “blow-down” waters which induced a significant decrease of liquid releases.

3. Effectiveness of BAT in reducing liquid discharges

Trends lines figures of the discharges of nuclear sites (see seventh Belgian PARCOM report) show that, for the last 15-20 years, alpha, beta/gamma and tritium releases have strongly decreased. With exception for the last couple of years - more precise for the period of 2015-2018 - for Tihange NPP regarding beta/gamma discharges. This is due to, among other things, the long-term shutdown of multiple reactors in order to perform structural integrity verifications, repairs and maintenance.

Comparisons with UNSCEAR ranges show that: Tritium discharges are near the lower end limit of the range, Non-tritium discharges into water are always below the level of the range since more than 15 years, Liquid releases have decreased.

4. Conclusions

For nuclear sites, calculations made for liquid (and atmospheric) discharges under conservative assumptions show that the maximum effective doses to the population in the vicinity of the nuclear sites are well below the national limits of 1 mSv/a (maximum limit including all atmospheric and liquid contributions). The average effective dose for the years 2014-2018 are (despite being calculated in a conservative manner):

Compared to the national limit of 1 mSv/y:

- For Tihange NPP < 0.25% (liquid) and < 2.3% (atmospheric) or in total < 3% representing < 0.03 mSv/y;
- For Doel NPP < 0.08% (liquid) and < 1% (atmospheric or in total about 1% representing 0.01 mSv/y

Compared to the dose constraints:

- For Tihange NPP < 3% (liquid) of 0.08 mSv/y and about 14% (atmospheric) of 0.19 mSv/y;
- For Doel NPP < 0.4% (liquid) of 0.23 mSv/y and about 5% (atmospheric) of 0.18 mSv/y.

In 2018, total doses to the most critical person due to those releases (1-2 years children) is 0.049 mSv for Tihange and 0.020 mSv for Doel NPPs.

The radiological surveillance programme conducted in Belgium shows that the radiological situation of the Belgian territory is in general perfectly satisfactory.

In the marine environment, natural radioactivity (^{40}K) is mainly responsible for the radioactivity of the different sections of the marine environment. Artificial radioactivity is generally not detectable: concentrations are of the order of the detection limits. Traces of ^{137}Cs are revealed in the marine sediments and the fish (barely significant). No other artificial radioactivity is demonstrated in fish.

In Belgium, nuclear sites apply the latest BAT and BEP.

France

France presented in February 2019 its report[1] on progress made in applying the Best Available Technology in the context of the seventh round of the implementation of the PARCOM recommendation 91/4 on radioactive discharges.

1. National arrangements for the implementation of BAT

France has fully incorporated the best available techniques (BAT) into its legislative and regulatory texts. The BAT appear in the front rank of the principles that control nuclear activities in France:

- The 13th June 2006 Act concerning transparency and security in the nuclear field, called the “transparency and nuclear safety” - “TSN Act”, now codified in books I and V of the Legislative Environment Code reinforced in 2015 with the Energy Transition for Green Growth Act (LTECV Act) of 2015). It has in particular given this system an “integrated” nature, that is to say that it seeks to

[1] French Implementation Report of PARCOM Recommendation 91/4 on radioactive discharges - 2019 : https://www.ospar.org/work-areas/rsc

prevent the hazards and detrimental effects of any type that the BNIs could create: accidents - whether nuclear or not, pollution - whether radioactive or not, waste – whether radioactive or not, etc.

- Amended decree 2007-1557 of 2nd November 2007, codified in 2019 in books V of the Regulatory Environment Code concerning BNIs and regulation of the nuclear safety of the transport of radioactive substances, defines the framework in which the BNI procedures are carried out and covers the entire lifecycle of a BNI, from its authorization decree to commissioning, to final shutdown and decommissioning. In BNIs regulation, the BAT are to be understood in the sense of the Directive on industrial emissions 2010/75/EU (IED) thereby fully encompassing the definition given in the OSPAR Convention.
- The best available techniques are also required by order of 7th February 2012 and ASN resolution n° 2013-DC-0360 of 16th of July 2013 amended establishing the general technical requirements concerning the limits and methods of withdrawals and discharges subject to permitting that are carried out by basic nuclear installations. In particular, this order requires that the limits for discharges must be established and regularly reviewed on the basis of the best available techniques (article 4.1.2).

2. Systems and abatement techniques to reduce discharges

The procedures and techniques applied in the French nuclear industry are consistent with BAT.

<u>Nuclear Fuel Reprocessing Plant</u>: Site of “La Hague”

The methods selected by the operator ORANO (formerly AREVA) to minimise the radioactive discharges and emissions from the ORANO Cycle La Hague site are based upon a continuous approach. The management method for liquid discharges remains the “new effluent management”, which is based on using evaporators that concentrate radioactivity sent to vitrification and purify the distillate that is either recycled into the process or discharged practically free of radioactivity. The general principles applied for the design and the operation are the following ones:

- Use of a very stringent system of containment to prevent losses, a minimum of two complete physical barriers being installed between the radioactive material and the environment.
- Use of the natural radioactive decay as a basis principle, in order to substantially decrease the activity of the short half-life radionuclides. Fuel, after reception, is driven towards storage pools, where it stays for an average period of around 5 years (as an example the ruthenium 106 residual activity is then reduced by a factor of 32 between the fuel arrival and the beginning of the reprocessing step).
- Optimisation of the destination of by-products (washing solutions, hulls rinsing effluents, solvent washing), the first priority being to recycle them as much as possible into the process.
- Second priority, for the by-products that cannot be recycled, being to send them as much as reasonably possible to solid waste (with a preference for vitrification, and to compaction and/or grouting if it is not possible to vitrify). The remainder is discharged in either the atmosphere or the sea, according to the technical possibilities, in order to minimise the impact on the representative persons.

The strategy of decommissioning or retrieval and conditioning of legacy waste’s operations is to minimize the discharges to favour the evaporation and vitrification’s procedure.

<u>Nuclear Power Stations</u>: EDF NPP’s

EDF French nuclear fleet is distributed on 19 sites for 58 PWRs in operation. In association with strict effluent management, EDF has continued to optimize operating practices to lower radioactive discharges. Radioactive liquid effluents are collected depending on their sources. Then, based on their activity and chemical concentration, they pass through the appropriate systems and undergo different treatment methods to remove most of the radioactivity they contain:

- Liquid effluents/wastes coming from the reactor cooling system, contain fission gases, activated products and chemical compounds. They are sent to the Boron Recycle System which is composed of:
    - Collecting tanks upstream the treatment process.
    - Filtration and demineralization equipment to get effluents free of radioactive compounds (Tritium excepted) and of chemical compounds (boric acid excepted) ;
    - A degasser to extract the dissolved gases and send them to the gaseous effluents/wastes treatment system;
    - An evaporator to separate the distillate of the treated effluents from the concentrate. The distillate consists of low activity water that can either be sent to storage tanks before discharge or recycled.
- Liquid effluents/wastes coming from the auxiliary systems, are collected by a specific drainage system. They are sent to the Liquid Waste Treatment System and treated according to their physical and chemical properties.

Since the commissioning of the nuclear fleet, EDF has endeavored to minimize radioactive discharges by acting on the three levers that are:

- The improvement of effluent <u>collection</u> and <u>treatment</u> circuits (modification of catch basins, installation of additional treatment means, etc.);
- The introduction of strict effluent <u>management</u> aimed at reducing their production at the source.

<u>Research and Development Facility</u>: Alternative Energies and Atomic Energy Commission (CEA) - Paris Saclay center

In the site of Saclay, the radioactive liquid effluent treatment station has benefited from a major renovation program during the last decade, which allows the treatment of approximately 1500 m3 of effluent per year. It is equipped with a new evaporator benefiting from the latest technical progress and from feedback gained after many years. It benefits also from the new process of solidification of the evaporation concentrats by concreting.

The program of denuclearization of the site of Fontenay-aux-Roses, which is still currently in progress, includes the cleanup and complete dismantling of the nuclear installations. This process is accompanied by smaller liquid effluent than during the operational phase.

3. Effectiveness of BAT in reducing liquid discharges

<u>Nuclear Fuel Reprocessing Plant</u>: Site of “La Hague”

The reduction factors for the radioactive liquid discharge limits in discharge permits from 1995 to 2017 is 12.7 for the Fission Products / Activated Products (FP/AP) (excluding tritium) and 12 for the Alpha emitters.

The discharges of the site are in 2017:

- 0.0175 TBq for total – alpha emitters
- 3.99 TBq for total – beta emitters
- 11 900 TBq for tritium
- 7.33 TBq for Carbon-14

<u>Nuclear Power Stations</u>: EDF NPPs

Optimized operating practices in the EDF NPPs have allowed to lower radioactive discharges, dividing by a factor of more than one hundred the liquid activity discharges for all Fission Products / Activated Products

(FP/AP) over 30 years, with the exception of Tritium and Carbon-14 (no abatement technique available). And even though the liquid radioactive discharges have reached an asymptote, the efforts are still kept constant to maintain this low level of discharges.

Since the commissioning of the nuclear fleet, EDF has endeavoured to minimize radioactive discharges by acting on the three levers that are:

- The improvement of effluent collection and treatment circuits (modification of catch basins, installation of additional treatment means, etc.);
- The introduction of strict effluent management aimed at reducing their production at the source.

In accordance with the BAT report presented at the beginning of this year 2019, reported discharge data show that, on average for the entire fleet and per reactor, the liquid activity discharged annually was, in 2017:

- For the AP/ FP, below 0.5 GBq/reactor/year.
- Annual tritium discharges, directly related to the quantity of energy produced and the way boric acid is managed in the reactor, have remained of the same order of magnitude. With no effective treatment available, tritium discharges are between 10 and 35 TBq per reactor per year.
- As for tritium, there is no available industrial abatement technique for Carbon-14 that can be applied in PWRs. About 5% of the total amount of the carbon-14 produced is discharged to the environment through liquid discharges corresponding to an activity between 10 and 20 GBq/year/reactor.

Research and Development Facility: Alternative Energies and Atomic Energy Commission (CEA) - Paris Saclay center

In Saclay site, the factors of decontamination of the radioactive effluents are more than 10 000 for the main alpha, beta or gamma radionuclide emitters, except the tritium and the Carbon-14.

Since the start of the 1990s, there has been also a net reduction in liquid discharges of the site of Saclay, which varies from a factor 5 to 30 depending on the radionuclide or groups of radionuclides considered.

The discharges of the site are in 2017: total alpha emitters : <0.040 GBq, other radionuclides (Beta gamma emitters without H-3 and C-14) : 0.012 GBq, carbon-14 : 0.081 GBq, tritium 8.3 GBq.

The discharges of the Fontenay-aux-Roses site are in 2017: total alpha emitters : 0.00019 GBq, other radionuclides (Beta gamma emitters without H-3 and C-14) : 0.00027 GBq, carbon-14 : <0.0019 GBq, tritium: 0.0052 GBq.

4. Conclusions

The radiological impact of radioactive substance discharges from French nuclear facilities are extremely low. Doses received by the population around the facilities from all pathways are of the order of 1 µSv/y for the population close to NPPs and of the order of 8 µSv/y close to the La Hague reprocessing plant. These doses are also well below natural fluctuations of radioactivity in France and are below the average natural exposure level of around 2.9 mSv/y.

The regulatory framework and operator practices are in place for an effective application of the best available techniques. As a result, a high level of control of radioactive discharges is achieved and the discharges have been reduced drastically, in line with the OSPAR strategy.

The French government requires that the limits are set and periodically reviewed on the basis of the best available techniques, taking into account the economic and social factors, including the feedback from operation experience to maintain the highest level of control of the impact on man and biota.

Germany

1. National arrangements for the implementation of BAT/BET in terms of the OSPAR Convention in German legislation and regulation

Since 2017 the German legislation for the protection against harmful effects of ionising Radiation has been realigned in order to implement the directive 2013/59/EURATOM. The new Radiation Protection Act came finally into force on 31 December 2018, replacing the former Precautionary Radiation Protection Act (StrVG) and covering parts of the previous Radiation Protection Ordinance, which in turn got restructured implementing the former X-Ray Ordinance. Minor changes were further applied to the Atomic Energy Act and other acts and ordinances.

The Atomic Energy Act (AtG), the Radiation Protection Act (StrlSchG) and the associated Radiation Protection Ordinance ensure that the Federal Republic of Germany meets its international obligations in the field of nuclear energy and radiation protection. For each nuclear facility the AtG demands in § 19a a permanent improvement of nuclear safety and an evaluation report on nuclear safety every ten years. The StrlSchG obliges radiation protection supervisors to consider the state of the art in science and technology (BAT/BEP) to avoid unnecessary emissions and to minimise contamination of the environment further, even below dose limits.

Further legal regulations are regulatory guidelines, general administrative provisions and safety standards from the national Committee for Nuclear Technology (Kerntechnischer Ausschuss - KTA).

The two most important regulatory guidelines are the “Guideline concerning Emission and Immission Monitoring of Nuclear Installations (REI)” (under revision), which specifies the requirements for discharge and emission monitoring and contains mandatory measurement programmes, and the “Verification of the Licensee’s Monitoring of Radioactive Effluents from Nuclear Power Plants” defining a control measurement programme by the German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz - BfS). Regulations concerning the calculation of radiation exposure of members of the public are described in the “General Administrative Provision to § 47 StrlSchV”, which is also under revision. For German nuclear installations the current state in science and technology (BAT/BEP) is defined in technical guidelines, such as safety standards, issued by the KTA.

Furthermore conventional technical standards, in particular the national standards of the German Institute for Standardisation (DIN) and also the international standards of ISO and IEC, are applied in the design and operation of all technical installations.

2. Systems and abatement techniques to reduce discharges

German nuclear facilities apply a vast variety of state of the art abatement techniques and operational measures to reduce discharges: for example delay tanks, chemical precipitation, centrifugation, ion-exchange, filtration (HEPA, active carbon), osmosis, evaporation, special operational modes to avoid leaks in fuel elements or permanent monitoring of coolants. More site-specific information are presented in the “Seventh German Implementation Report of PARCOM Recommendation 91/4 on radioactive discharges“.

3. Effectiveness of BAT in reducing liquid discharges

The magnitude of annual liquid discharges from nuclear sites is hardly varying on low level over the past years. The released tritium amount is gradually decreasing (see 7th PARCOM 91/4 report).

The comparison of the normalised discharges from German nuclear power plants (2018) with normalised releases given by UNSCEAR 2016 REPORT (data from 2010) shows that:

- normalised non-tritium discharges from German NPP are by a factor of 1000 below the average value reported by UNSCEAR;

– normalised tritium discharges from German NPP are about 20 percent below the mean value of UNSCEAR.

The regular analyses of environmental samples (river water, groundwater, drinking water, plants, milk, meat, fish, soil) in the vicinity of nuclear faclilites did not reveal any noticeable increased activity concentration – excluding tritium. The environmental measurement data are published in annual reports available from http://www.bfs.de/EN/media/reports/reports_node.html (headings/captions in English, Summary also in French).

Dose calculations made under conservative assumptions reveal that the maximum effective annual dose to the population by nuclear installations is well below the national limit of 300 µSv/a for both the aquatic and aerial pathway. The calculated annual effective dose for adults due to the discharges of radionuclides from NPP regarding the aquatic and aerial pathway is less than 2 µSv/a.

4. Conclusions

Due to strict German legislation for radiation protection and nuclear safety all nuclear facilities sufficiently apply BAT/BEP to reduce radionuclide discharges to a very low and radiologically negligible extent. Monitoring of radioactive discharges and environmental samples by licencees and independent laboratories confirm that the applied BAT/BEP are very effective.

Germany is phasing out the remaining seven NPP step-by-step until 31 December 2022. The high level of radiation protection and nuclear safety in Germany will, of course, persist further. Hence, BAT/BEP are also applied during decommissioning and radioactive disposal management as well as for other industrial or medical nuclear facilities.

The Netherlands

1. National arrangements for the implementation of BAT

The Nuclear Energy Act promulgated on February 21st, 1963 ensures that the Netherlands meets its international obligations in the field of nuclear safety and radiation protection. It also includes the general national regulations for protective and preventive measures, radiation protection, disposal of radioactive waste and irradiated fuel elements in the Netherlands and is the basis for associated regulations.

Policy and national legislation are based on EC Directives, international conventions and recommendations of appropriate international bodies like the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA). This is elaborated in the “Radiation Protection Decree” of July 16th, 2001.

Major principles in the national legislation and regulations are: justification of exposure, optimisation (ALARA) and dose limits. The decree elaborates on the principle of dose constraints. The contribution to the effective dose of a member of the public, as a result of a facility or practice, should not exceed 0,1 mSv per year (10% of the annual dose limit of 1 mSv).

The notable change since the 6th round is the creation of the Authority for Nuclear Safety and Radiation Protection (ANVS) on January 1st, 2015. The ANVS combines expertise in the fields of nuclear safety and radiation protection, as well as security and safeguards. The ANVS is the national authority responsible for the supervision of discharges of radionuclides into air and water. The ANVS became an Independent Administrative Body (“ZBO” in Dutch) on August 1st, 2017.

2. Systems and abatement techniques to reduce discharges

Nuclear installations have followed the development of best techniques and use a vast variety of systems and best available efficiency abatement techniques to reduce discharges. Best Available Technologies (BAT) have been applied to all nuclear installations in the Netherlands: the only operational nuclear power plant, the nuclear waste treatment and storage plant, two research reactors, and the nuclear fuel enrichment plant. The seventh PARCOM report of the Netherlands offers further details.

For completeness:

- the Low Flux Reactor in Petten is no longer in use (since 2010), and has been decommissioned. The nuclear fuel has been removed in 2012.
- The nuclear power plant Dodewaard, which ceased operations in 1997 and is presently in the state of Safe Enclosure, has discharged no radionuclides to water since July 2005.

Compliance with the ALARA principle is considered sufficient evidence that the requirements of BAT/BEP in terms of the OSPAR Convention have been met. All nuclear installations were judged to be compliant with the ALARA-principle.

3. Effectiveness of BAT in reducing liquid discharges

According to the Guidelines, an indication that BAT/BEP has been applied is a downward trend in the liquid discharges. The discharges of all nuclear installations show a downward trend, or have otherwise stabilized around a low level (see the seventh PARCOM report of the Netherlands).

The normalized tritium discharges are equal or less than the reference data for the same type of nuclear power reactor in the UNSCEAR report.

4. Conclusions

The highest radiation dose resulting from the liquid discharges has been assessed for each of the nuclear installations. Each dose is less than one thousandth of the average radiation dose for individuals in the Netherlands. The low levels of radioactivity discharges from all nuclear installations and low levels of radiation exposure in general show BAT/BEP is applied in all nuclear installations in the Netherlands.

Norway

1. National arrangements for the implementation of BAT/BET

The Pollution Control Act 13 March 1981 on Protection against Pollution and Concerning Waste has the purpose of preventing and reducing harm and nuisance from pollution, including discharges to the environment. The legislation states that pollution[2] is forbidden, unless it is specifically permitted by law, regulations or individual permits. The act secures a satisfactory environmental quality based on a balance of interests, which includes costs associated with any measures and other economic considerations. Pursuant to the Act, there are three regulations concerning radioactive pollution and management of radioactive waste:

- Regulation on the Application of the Pollution Control Act on Radioactive Pollution and Radioactive Waste of 1 November 2010
- Regulation on the Recycling of Waste of 1 June 2004
- Regulation on Pollution Control of 1 June 2004

When issuing authorisations under the Pollution Control Act, the Norwegian practice is to focus on BAT, the ALARA-principle and the precautionary principle. Use of BAT regarding discharge of radioactive substances is implemented in the Pollution Control Act 13 March 1981 section 2-3:

[2]Definition of Pollution in Norwegian legislation: radioactive pollution" means radiation from radioactive substances that are or may be harmful or detrimental to the environment. This also includes radiation from naturally occurring radioactive substances when human activity leads to increased radiation exposure to humans or the environment.

Section 2 Guidelines

The Act shall be implemented in accordance with the following guidelines:

> *3. Efforts to avoid and limit pollution and waste problems shall be based on the technology that will give the best results in the light of an overall evaluation of current and future use of the environment and economic considerations.*

Nuclear installations are also regulated in accordance with the Nuclear Energy Act 12 May 1972 on Nuclear Energy Activities, Radiation Protection Act on Radiation Protection and Use of Radiation 12 May 2000 and associated regulations.

2. Systems and abatement techniques to reduce discharges

The following abatement systems for liquid radioactive discharges are employed in the nuclear(research) facilities in Norway:

- Delay tanks (efficiency 67%)
- Sedimentation (efficiency 2-40%)
- Ion exchange filtration system (efficiency 90 - 99%
- Evaporation system (efficiency 95%)
- He3 decontamination system (efficiency 90%)

For emissions to the atmosphere, HEPA filtration and active charcoal filtration are employed.

3. Effectiveness of BAT in reducing liquid discharges

Trends in discharges are generally caused by variations in research activities, production of radiopharmaceuticals, operation of laboratories and waste management facility; no continuing downward trends in the discharges are observed. There are two research reactors in Norway. The two reactors were shut down in 2018 and 2019 and will be decommissioned.

4. Conclusions

Based on the evaluation of BAT/BEP concerning discharges, environmental impact and radiation dose to the public, it is generally concluded that BAT/BEP is applied in the nuclear installations in Norway.

Portugal

1. National arrangements for the implementation of BAT/BET

The Decree-Law 108/2018 of 3 December 2018 establishes the legal regime for radiation protection, transposing Directive 2013/59/Euratom to the Portuguese Law. The Portuguese radiation protection policy is based on UE Directives, on international conventions and on recommendations of appropriate international bodies like the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA).
The above mentioned Decree-Law assigns the Portuguese Environment Agency (APA) as the regulatory authority for Radiological Protection and Nuclear Safety. APA is the Public Institute under the responsibility of the Ministry of Environment, in charge of proposing, developing and monitoring the implementation of environmental and sustainable development policies in Portugal.
The discharge limits are established in order to comply with the dose limits for the public, assuring that they will be well below this limit. The discharge limits are established for each facility taking into account the characteristics of the receiving compartment and its potential impact on the public and the environment. The annual discharge limits defined for the Portuguese Research Reactor (RPI) facility is 500 MBq.
The application of Best Available Techniques (BAT) as part of the national radiation protection programme has been implemented indirectly into the Portuguese law. The terms "justification" and "optimization" are

the centrepieces of the new Portuguese legislation, and are important tools to ensure an ongoing review of all practices where radiation is used in order to minimize the use and to promote substitution of radioactive substances.
There are no nuclear reactors in operation in Portugal. A recent activity within the nuclear area was the full stop of the Portuguese Research Reactor (RPI) at the Instituto Superior Técnico (IST) in 2017 and the transfer of the irradiated fuel in 2019.

2. Systems and abatement techniques to reduce discharges

The Portuguese Research Reactor (RPI) is located at the Technologic and Nuclear Campus of the Instituto Superior Técnico. This campus is structured in three research units: the Nuclear Engineering Laboratory (LEN), integrating the Portuguese Research Reactor (RPI), the Laboratory of Radiological Protection and Safety (LPSR) and the Laboratory of Accelerators and Radiation Technologies (LATR). The implementation of the Radioactive Liquids Effluents Discharge Control Facility (ECoDELiR) in this campus had the objective to use Best Available Technology (BAT), according PARCOM Recommendation 91/4.
ECoDELiR is divided in two groups which can operate independently, in order to collect and store liquids effluents if an eventual accident occurs in the above mentioned research units.
Before discharging the effluents to the Municipal Residual Water Treatment Plant (ETAR), samples are collected from the tanks and they are analyzed in laboratory, by gamma spectrometry with NaI(Tl) detectors, in order to quantify the artificial radionuclides present. Data acquisition and spectrum analysis is done with dMCA-card and software is WinTMCApro 6.0, both from ICx Radiation Inc.
The results are compared with the discharge limits 500 MBq/year (or 740 Bq/L), and if they are below this value the effluents are discharged to ETAR. If not, it is necessary waiting for decay.

IST has a specific Environmental Radiological Monitoring Program for the CTN, with the following main objectives:

- Evaluate the levels of radioactivity in the external environment of the RPI in CTN, as well as its tendency to vary and detect any changes;
- Verify that the discharge limits established by the RPI are respected and allow timely intervention in case of unplanned conditions;
- Contribute to obtain data that allows assessing the exposure of members of the public and workers;
- Establish a data support and organization that facilitates the information to the public and competent entities.

The program is based on the environmental monitoring of external radiation, through the assessment of the environmental gamma dose using continuous measurements and integrated measurements, on the monitoring of atmospheric radioactivity, through the sampling and analysis of aerosols and on the monitoring of the transfer of radionuclides by deposition, through the analysis of rainwater samples and the analysis of samples of the topsoil. It also assesses the discharges (liquid and gaseous) to the environment.
This Monitoring Program for the CTN, generates an annual report received by APA ensuring the application of the Best Available Techniques (BAT) and the Best Environmental Practices (BEP).

3. Effectiveness of BAT/BEP in reducing liquid discharges

The Portuguese Environment Agency, as the competent authority for the radiation protection, ensures the control of radioactive substances and the effective application of a clear policy under which the application of the Best Available Techniques and the Best Environmental Practices (BAT/BEP) are required at all levels. This policy follows closely the requirements and recommendations of competent international bodies and adopts several principles to ensure the application of the precautionary principle and the prevention of pollution.

Taking into account liquid and gaseous effluents, the highest activity in the period of time considered in the time line between 2007 and 2018 was 499 MBq (in 2009), which is under the release limit.

4. Conclusions

Regarding the radiological environmental impact around the RPI for the 2007-2018 periods, the levels of radionuclides found in all the measured matrixes and exposure pathways have been lower than the limit levels approved in the license, representing a small percentage of the annual radiation dose limit to the population.
From the evaluations of the BAT/BEP indicators for discharges, environmental impact and radiation doses to the public it is concluded that BAT is applied in the Portuguese Research Reactor, complying with PARCOM Recommendation 91/4 (*minimise and, as appropriate, eliminate any pollution caused by radioactive discharges from all nuclear industries, including research reactors and reprocessing plants, into the marine environment*).

Spain

1. National arrangements for the implementation of BAT

In Spain the basic laws governing nuclear activities are the Nuclear Energy Act (Law 25/1964, partially reformed by Law 12/2011) and the 15/1980 Law, of April 22nd, creating the Nuclear Safety Council (CSN), amended by Law 33/2007. They are further developed in regulations that provide the framework for standards, guidelines and objectives in this field.

The best available techniques are introduced at different levels of the Spanish legislation and regulation in order to reduce the levels of discharges and the radiological impact to both humans and the environment.

No new legislation on the implementation of BAT/BEP[3] has been approved since the latest implementation round.

1.1 Regulation on Nuclear and Radioactive Facilities

The Regulation governing Nuclear and Radioactive Facilities (approved by Royal Decree 1838/1999, amended by Royal Decree 35/2008) in its Article 8.3 establishes that the licensee must continuously ensure the improvement of the nuclear safety and radiation protection conditions of its facility. To this end, the Best Available Techniques (BAT) and practices must be analysed, in accordance with the requirements that the CSN establishes, and those that are suitable, implemented.

1.2 Regulation on the Protection of Health against Ionising Radiations

The Title V of the Regulation on the protection of health against ionising radiations (approved by Royal Decree 783/2001, amended by Royal Decree 1439/2010) sets up requirements on the system applied to limit emissions and discharges, where several articles deal with the system of limitation, surveillance and control of radioactive effluents. Article 55 specifically stipulates that facilities generating radioactive wastes must be provided with adequate treatment and removal systems in order to ensure that doses due to releases are lower than the limits established in the administrative licences and that they are kept at the lowest possible value.

A specific authorisation is needed for every facility, setting up specific limits, surveillance requirements and conditions for the releases. The authorised limits guarantee that in normal operating conditions, the doses to members of the public will be in accordance with the ALARA principle that is applied in the design of the treatment systems.

[3] BAT/BEP responds to Best Available Techniques/Best Environmental Practices

According to Article 52 during operation, licensees have to demonstrate that every reasonable effort is made, from the generation of wastes to the operation proceedings of the effluent treatment systems, to reduce releases and to keep the radiological impact as low as is technically and economically feasible.

1.3 The Nuclear Safety Council's Instruction IS-26

The instruction IS-26, of 16th June 2010, sets the basic nuclear safety requirements applicable to nuclear installations.

Points 3.19 to 3.21 are related with the Periodic Safety Review (PSR) that licensees have to perform on a ten year basis, following the recommendations of the CSN Safety Guide 1.10. The goal of the PSR will be to make an overall assessment of the behaviour of the installation during the considered period by means of a systematic analysis of all nuclear safety and radiological protection aspects. According to Point 3.21 the nuclear installations must carry out, within the framework of the PSR, the appropriate modifications to converge, wherever it is feasible, with the best nuclear safety and radiological protection practices and standards internationally in effect at the time.

Points 3.24 to 3.27 deal with Dose Limits and Restrictions. In accordance with Point 3.25 the release of radioactive effluents into the environment must comply with the established limits, aiming, in addition, that it must be as low as possible by taking socioeconomic factors and the best available techniques into consideration. In addition, Point 3.27 specifies that the design of nuclear installations must ensure that the radiological consequences that are reasonably foreseeable in future generations are not greater than those allowed for the current generation.

2. Systems and abatement techniques to reduce discharges

A policy to minimize the production of waste is applied in Spanish nuclear power plants. This policy includes aspects such as:

- Surveillance and control of defects in the fuel cladding during operation and refuelling, and the chemical quality and conditions of the coolant systems.
- Reinforcement on the maintenance programs.
- Revision of the operating procedures, optimising the methods applied.
- Segregation and piping of drains.
- Use of low radioactive water for conditioning of solid wastes instead of demineralised water.
- Improvements in the ion-exchange resin treatment system according to the liquid waste characteristics.
- Improvements in the procedures of sampling and analysis.
- Improvements in the procedures of the effluent management and control.
- Decay of the primary coolant prior to its evaporation treatment in the boric acid recovery system.

3. Effectiveness of BAT in reducing liquid discharges

For the period 2014-2018, in the nuclear power plants the absolute total activity excluding tritium shows a global downward trend, while the tritium activity presents a global steady trend.

In the dismantling of José Cabrera both tritium and total activity excluding tritium exhibit a downward trend, meanwhile in Juzbado fuel fabrication plant alpha activity in the liquid discharges presents a steady evolution.

4. Conclusions

The Spanish regulatory system in the field of controlling radioactive substances sets up a framework for the effective application of a clearly stated policy under which the application of BAT is required. This policy follows closely the requirements and recommendations of competent international bodies and adopts several principles to ensure the application of the precautionary principle and the prevention of pollution.

Throughout the years 2014-2018 the doses to the critical group living in the vicinity of the installations have represented a small percentage of the authorize limit.

From the evaluations of the BAT/BEP indicators for discharges, environmental impact and radiation doses to the public it is concluded that BAT is applied in the nuclear Spanish installations.

Switzerland

1. National arrangements for the implementation of BAT

The national legislation defines dose guide values, dose limits, discharge limits as well as environmental monitoring programs, and designates the national authority responsible for the supervision, the nature of inspections and surveillance. The Federal Act and the Ordinance on Radiological Protection, for example, fixes the maximal allowed concentration of radioactive substances in the atmosphere and water at locations accessible to the public, requiring that the weekly mean values of the concentration are below the immission limits. The Ordinance on Contaminants defines the maximum concentration values for radionuclides in food and drinking water as an additional restriction. The maximum concentration values are based on the 10 microSv per year concept. The ordinance for ratification of international resolutions and recommendations is enforced since 2000. This legislation requires that, among others, the PARCOM-recommendation 91/4 has to be considered at the implementation of environmental protection regulations. In 2005, a new nuclear energy legislation came into force. This legislation requires the licensee of nuclear power plants to conduct a periodic safety assessment in a time interval of ten years. The periodic safety assessments are evaluated by the Nuclear Safety Inspectorate (ENSI). Within this frame, the licensee has to assess the liquid and gaseous discharges of his plant and, on request of the Inspectorate, to benchmark them against the corresponding discharges of similar European reactors. In case the discharges are higher than the benchmark, the licensee has to analyze the causes and to suggest measures to reduce these, bearing in mind the appropriateness of the means.

2. Systems and abatement techniques to reduce discharges

In Switzerland, there are four NPP sites, a waste treatment and interim storage facility (ZWILAG) and a research facility (PSI) with relevant liquid discharges. The waste water is collected and treated in batches in all Swiss nuclear facilities.

The used abatement techniques differ from facility to facility. Evaporation, centrifugation, chemical precipitation, ion exchange, cross-flow-nanofiltration and sorption with an inorganic ion exchange powder are used in different combinations.

3. Effectiveness of BAT in reducing liquid discharges

The Swiss nuclear facilities with relevant liquid discharges are in the catchment area of the river Rhine. The total sum of the liquid discharges of all radioactive substances with the exclusion of tritium from all Swiss nuclear facilities were reduced from 35 GBq in 2005 to 1,0 GBq in 2018 by applying BAT. The following improvements were introduced: the Beznau pressurized water reactors apply cross-flow-nanofiltration of waste water since 2007. With this improvement, it achieved the requested reduction to below the target value of 1 GBq per year in terms of radioactivity in the liquid discharges, excluding tritium. At the Gösgen pressurized water reactor the discharges of radioactive substances without tritium are the lowest among the European pressurized water reactors. Nevertheless, the Gösgen NPP has reduced the radioactivity in discharges by a factor of 5 compared to 1994. The liquid discharges of radioactive substances excluding tritium from the Mühleberg and Leibstadt boiling water reactors show a downward trend. This is due to the optimization on the waste water management. Since 2010, Mühleberg NPP has reduced discharges consequently by separating wastewater of different origin for a more specific treatment and by the installation of an evaporator in the contaminated wastewater treatment system. As a consequence, the Mühleberg NPP achieved in 2018 a liquid discharge figure of 0.07 GBq, excluding tritium, the lowest in its operating history. In January 2009, as a result of an inspection, the Inspectorate has required the licensee of ZWILAG to study the possibilities to reduce its liquid discharges. As a result of this study, the licensee reduces since 2010 the Cs-137 content in the liquid discharges by sorption with an inorganic ion exchange powder. At the PSI research facility, the discharges of radioactive substances excluding tritium show a downward trend.

4. Conclusions

Based on the above information, the Inspectorate concludes that the BAT principles are implemented in the Swiss legislation and regulatory practices. Furthermore, progress has been made in the application of such principles in the Swiss nuclear facilities with the clearly stated objective to reduce discharges according to the OSPAR strategy on radioactive substances.

Sweden

This statement according to OSPAR Agreement 2018-01 is based on the official report on the seventh round of implementation according to PARCOM 91/4 for 2012-2016 from Sweden. The information given has been up-dated concerning recent changes in legislation concerning the implementation of BAT and the discharge data has been up-dated for the years 2017-2018. The data is already included in the ODIMS database: https://odims.ospar.org/ and all relevant decisions, agreements and recommendations can be found at https://www.ospar.org/work-areas/rsc .

1. National arrangements for the implementation of BAT

1.1 The Radiation Safety Authority

The Swedish Radiation Safety Authority (SSM) is the authority under auspice of the Swedish Ministry of the Environment with national responsibility within the areas of nuclear safety, radiation protection and nuclear non-proliferation. The SSM works proactively and preventively in order to ensure high levels of nuclear safety and radiation protection in the society.

The SSM has the mandate to issue regulations concerning nuclear safety and radiation protection for nuclear as well as non-nuclear activities. SSM is also responsible to conduct supervision and to control that licensees comply with applicable laws and regulations. Moreover, SSM is fully empowered to issue, with reference to safety, prohibitions and conjunctions combined with fines, as well as to, in individual cases, issue conditions for the operation of a facility an activity.

1.2 Relevant legislation

<u>The Swedish Radiation Protection Act</u>

The aim of the Radiation Protection Act (2018:396) is the protection of man and the environment against harmful effects of radiation. The Act stipulates that the generation of radioactive waste and emissions of radioactive substances shall, as far as possible and reasonable taking into account existing technical knowledge and economic and societal factors, take measures to limit the generation of radioactive waste.

One requirement in the Act stipulates that measures shall be taken to limit the generation of radioactive waste and emissions of radioactive substances as far as possible and reasonable, taking into account existing technical knowledge and economic and societal factors (chapter 3, section 9).

In the explanatory text to the Act (Governmental Bill 2017/18:94) it is clarified that the requirement inter alia, refers to the agreements according to the OSPAR and HELCOM convention on the application of best available technique in order to limit radioactive discharges to the sea, but is also applicable to all emissions to water and sea from nuclear installations in Sweden. This paragraph aims mainly at the protection of the environment and should be used in parallel with the provisions on optimisation of radiation protection (chapter 3 section 5).

<u>The Radiation Protection Ordinance</u>

The Radiation Protection Ordinance (2018:506) contains details pursuant to authorisation for the application of the Radiation Protection Act. The Ordinance authorises the SSM to act as the central administrative authority in the area of radiation protection and to issue regulations concerning radiation protection and environmental monitoring. The ordinance also contains dose limits and dose constraints.

The dose limit for individuals of the general public, resulting from all practices, is 1 milliSievert annual effective dose. This is a requirement in EU BSS. An upper limit for dose restrictions for the public from individual practices is set to 0,1 milliSievert a year. 2 OSPAR Commission OSPAR Agreement 2018-01

<u>The Environmental Code</u>

The Environmental Code is a comprehensive legislation covering a wide range of environmental issues, including provisions on environmental impact assessments, licensing procedures, etc. The Code is applicable to activities generating ionizing radiation in the environment. Such activities are categorized as 'environmentally hazardous', together with numerous other activities. The Code includes requirements on that BAT should be applied in order to prevent, hinder or counteract harm or inconvenience to human health or the environment (chapter 2 section 3).

<u>Regulations issued by the SSM</u>

On the basis of the authorisation granted in the Radiation Protection Ordinance, SSM has issued specific regulations concerning releases of radioactive substances from nuclear facilities “Regulations on the Protection of Human Health and the Environment from the releases of Radioactive Substances from Certain Nuclear Facilities” (SSMFS 2008:23). The regulations entered into force 1st February 2009, and was updated (SSMFS 2018:16). The regulations cover surveillance and monitoring, environmental programmes and quality assurance.

SSM has also issued general radiation safety regulations for all licensed facilities (SSMFS 2018:1). These regulations also cover e.g. methods for dose calculations to individuals in the general public and reporting requirement. Both regulations are applicable for nuclear power plants (NPPs) such as Ringhals NPP.

1.3 Nuclear Power Plant

Ringhals nuclear power plant, operated by Ringhals AB, is a subsidiary of Vattenfall AB. The Ringhals nuclear power plant is located at the Swedish West Coast, approximately 50 km S Göteborg and 15 km N Varberg.

Ringhals is a nuclear power plant with one boiling water reactor, BWR (ASEA Atom, now Westinghouse Electric Sweden AB) and three pressurised water reactors, PWR (Westinghouse). Auxiliary facilities for waste treatment, maintenance, etc., and a shallow land repository for low-level radioactive waste resulting from the operation of the plant.

The plant discharges into Kattegat. There are two adjacent discharge points immediately at the coast line, one for reactor units 1-2, and one for the units 3-4. Emissions to air are predominantly made through the main stack of each reactor unit, i.e. from four emission points.

2. Systems in place to reduce, prevent or eliminate discharges

The liquid waste to be discharged is purified by particle filtration, evaporation and/or ion exchange. To reduce the processing efforts, the liquid waste is segregated according to contents of activity and chemicals (e.g. detergents and particles in floor drain). Low-level fluids are discharged without any further treatment. The judgement of how to treat the waste is based on dose to the critical group rather than on the activity content. At the PWR-sites evaporation is used in the systems for recycling of boron. A summary of the systems in place to reduce, prevent or eliminate discharges to the marine environment is presented in Table 1.

Table 1: Systems in place to reduce, prevent or eliminate discharges and their efficiency

	Ringhals 1		Ringhals 2		Ringhals 3.		Ringhals 4	
	Abatement system	Decont factor/other measure efficiency	Abatement system	Decont factor/other measure efficiency	Abatement system	Decont factor/other measure efficiency	Abatement system	Decont factor/other measure efficiency
Discharges	• Particulate filtration (1974).	2-4	• Particulate filtration (1974)	2-4	• Particulate filtration (1981)	5-10	• Particulate filtration (1983)	5-10
	• Ion exchange filtration (1974)	10-50	• Ion exchange filtration (1974)	5-10	• Ion exchange filtration (1981)	10-50	• Ion exchange filtration (1983)	10-50
	• Large buffer tanks to recycle water from the reactor pool (2008)	10	• Cross-flow filtration in combination with different absorbers and resins (2003)	>100				
	• Evaporator (2011)							
	• Laundry (2011)							
Emissions	• Delay tanks (1974)	Delay time normally 6-12 hours with recombiners in operation	• Decay tanks (1974)		• Decay tanks (1981)	Normally all nuclides except Kr-85 has decayed	• Decay tanks (1983)	Normally all nuclides except Kr-85 has decayed
	• Recombiners (1998)	Volume reduction by a factor 5-10	• HEPA-filtration (1974)	100%	• HEPA-filtration (1981)	100%	• HEPA-filtration (1983)	100%
					• Delay of gas flow from degassing of Charging pumps (2013)	10	• Membran-filtration in the feed water system (2008-2009)	>90% of Ar-41
							• Programme for pH- and redox operational control and oxidising system clean-up operation	Lower dose rates on system surfaces and less activity spread in plant

							during shut-down (since start 1983).	
Changes in management or processes	• Non fuel - leakage operations policy (1995)	Reduction of number of leaking fuel. No fuel leakages during 2001-2016 Very low levels of tramp uranium (below detection limit)	• Non fuel - leakage operations policy (1995)	Reduction of number of leaking fuel. No fuel leakages during 2005-2016 Low levels of tramp uranium	• Non fuel - leakage operations policy (1995)	Reduction of number of leaking fuel. No fuel leakages during 2004-2016 Very low levels of tramp uranium (below detection limit)	• Non fuel - leakage operations policy (1995)	Reduction of number of leaking fuel. One fuel leakage occurred. Very low levels of tramp uranium (below detection limit)
	• Control-rod policy (2008)	Reduction of tritium leakage from control-rods	• Programme for pH- and red-ox operational control and oxidising system clean-up operation during shut-down (late 70s).	Lowered dose rates on system surfaces	• Programme for pH- and red-ox operational control and oxidising system clean-up operation during shut-down (early 80s)	Lower dose rates on system surfaces and less activity spread in plant.	• Programme for pH- and red-ox operational control and oxidising system clean-up operation during shut-down (since start 1983).	Lower dose rates on system surfaces and less activity spread in plant.
	• Minimising air leakage into turbine systems (Ca 1996)	Improved delay time by 2 - 3 times.	• All fuel that will be re-used in the reactor is cleaned from crud using ultra-sonics (2015).	Reduction of source term for activated radionuclides	• All fuel that will be re-used in the reactor is cleaned from crud using ultra-sonics (2015).	Reduction of source term for activated radionuclides	• All fuel that will be re-used in the reactor is cleaned from crud using ultra-sonics (2012).	Reduction of source term for activated radionuclides
	• Separation of waste streams for improved treatments (Ca 2000)		• Separation of waste streams for improved treatments. Some highly contaminated waters are transferred to Ringhals 1 waste treatment plant (Ca 2000).		• Separation of waste streams for improved treatments. Some highly contaminated waters are transferred to Ringhals 1 waste treatment plant (1999).	>10	• Separation of waste streams for improved treatments. Some highly contaminated waters are transferred to Ringhals 1 waste treatment plant (1999).	>10

In 2002, a R&D pilot plant for cross-flow filtration in combination with different absorbers and resins was taken into operation in Ringhals unit 2 (Table 1.4). During normal operations it handles the full volume of waste water. However, it cannot handle the large volumes of water that are discharged in a shut-down transient situation. Improvements on filtration are done in Ringhals 3 and Ringhals 4. New selective filters are now in use.

At Ringhals 1 a large storage tank has been installed in 2008 to make re-use of process water possible. The evaporator equipment at Ringhals 1 has been refurbished and improved. It has been put into operation 2011 and undergone gradual improvements since than which results in significantly decreased releases to water.

Major changes in liquid waste management have taken place in Ringhals 1 (1998), Ringhals 2 (2000), Ringhals 3 (1999) and Ringhals 4 (1999), in order to separate waste streams for improved treatments. For the three PWR:s, some highly contaminated waters are transferred to Ringhals 1 waste treatment plant.

At Ringhals 3 a system for delay of gases released from an auto-ventilation system of the charging pumps has been finally implemented in 2013.

At Ringhals 4 a system for reduction of Argon in make-up water has been tested. This minimizes the production of activated Ar-41.

In 1998 recombiners were installed in Ringhals unit 1 to reduce, prevent and eliminate emissions. This led to increased delay times and a significant reduction of releases of noble gases. The full performance of the system operation was achieved during the year of 2000. Improvements implemented during the time-period are marked as green in Table 1.

3. Effectiveness of BAT in reducing liquid and emissions

The efficiencies of the abatement systems in place in the four Ringhals reactors are summarised in Table 1.

The performance of the liquid waste handling systems depends of several factors related to the operational conditions of the plant. For example at the end-of-cycle large amounts of waste water has to be processed during short periods of time and this high flow causes less effective purification, while at the beginning-of-cycle the flow is low and the conditions are ideal for good purification. In the table the typical performance has been estimated as to represent the entire operational cycle.

All tritium produced in the plants is released to the environment, although not necessarily in the same year as it is produced.

<u>Overall trends in the discharges of alpha, beta and gamma emitters</u>

The absolute discharges of beta-emitters excluding H-3 and total alpha emitters (Bq/a) from reactor units 1 – 4 have remained stable or declined over the time period studied.

On the basis of experience, the operators have introduced more stringent regimes for preventing fuel failures, and for fuel replacement in the case fuel failures occur. The discharges have therefore in recent years returned to values more characteristic of long-term performance in the absence of fuel failures.

During the time period covered in this report (2013 – 2018), one fuel leakage was detected. The leakage occurred at Ringhals 4 in November 2014 and the fuel rod was removed in 2015. The leakage resulted in very small amounts of tramp uranium (at, or below the limit of detection).

Normalisation of discharge data can be a way of comparing discharges between sources of a similar kind. For nuclear power reactors, the discharge data are normalised with regard to net electrical output on an annual basis. The normalised discharges of beta-emitters excluding H-3 and total alpha emitters (Bq/a) from reactor units 1 (BWR) and 2– 4 (PWRs) have remained stable or declined over the time period studied as indicated in Figures 1 – 6.

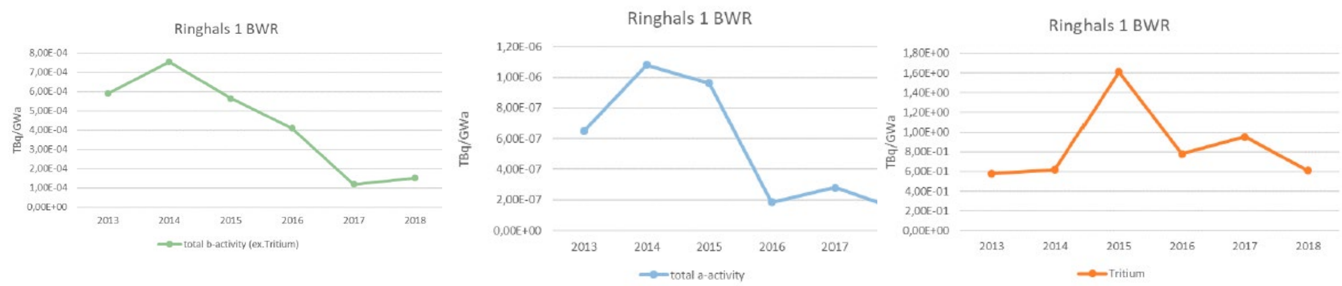

Fig.1, 2 and 3. Normalised discharges from Ringhals Unit 1 for total beta excluding H-3, total alpha and tritium

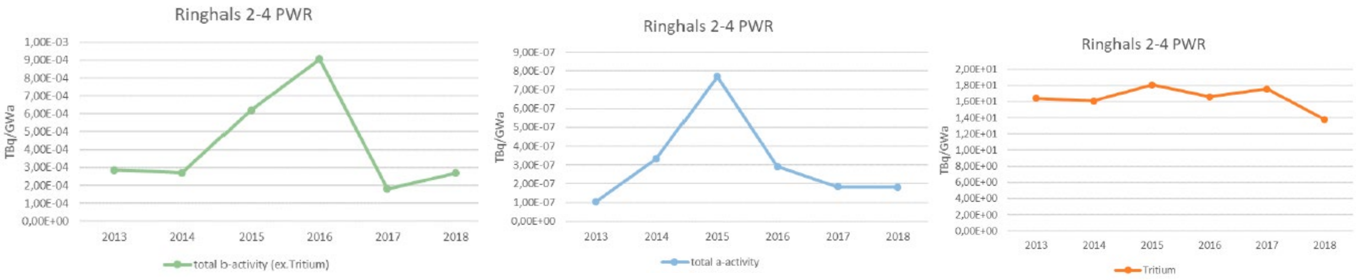

Fig.4, 5 and 6. Normalised discharges from Ringhals Unit 2-4 for total beta excluding H-3, total alpha and tritium

4. Conclusions

The following Table 1.7 summarizes the evaluation concerning BAT/BEP indicators of the site-specific information on Radiation Doses to the Public from Ringhals four reactor units.

The methods for estimating doses are relevant for judging exposure of the population and to comply with dose limits and constraints. Doses are decreasing due to managerial and technical improvements made at the facility.

Table 1.7 Summary Evaluation of Radiation Doses to the Public

Criteria	Evaluation
The BAT/BEP indicators	
• Downward trend in radiation dose	Stable
• Relevant critical group	Yes
• Reliable dose estimates	Yes
• Relevance of target dose	No target dose, but dose constraint for the site
• Relevant quality assurance systems	Yes
Data completeness	Data are complete
Causes for deviations from indicators	No deviations
Uncertainties	
Other information	None

From the evaluations of the BAT/BEP indicators for discharges, environmental impact and radiation doses to the public it is concluded that BAT is applied at the Ringhals nuclear power plant during the time period covered by this report.

United Kingdom

1. National arrangements for the implementation of BAT

The UK submitted its full report in 2017 on the application of BAT in civil nuclear facilities between 2012 and 2016. In summary, regulation of discharges from nuclear licensed sites is through the Environmental Permitting (England and Wales) Regulations 2016 (EPR16), as amended by 2018 Regulations, in England and Wales. In Scotland, legislation has been updated and discharges are now regulated by the Environmental Authorisations (Scotland) Regulations 2018[4] (EASR18). In Northern Ireland discharges are controlled by the Radioactive Substances Act 1993 (as amended).

[4] https://www.sepa.org.uk/regulations/how-we-regulate/environmental-authorisations-scotland-regulations-2018/

EPR16 and EASR18 require BAT (or its equivalent) for the control of discharges in accordance with OSPAR commitments. In England and Wales, the application of Best Available Techniques (BAT) is the means to achieve compliance with the radiological protection principle of optimisation and the application of wider environmental principles. In Scotland and Northern Ireland, the terms of Best Practicable Means (BPM) and Best Practicable Environmental Option (BPEO) continue to be used by the Scottish Environmental Protection Agency (SEPA) and Northern Ireland Environment Agency (NIEA). Further detail is set out in the UK's 2017 BAT report. A review of the UK revised Strategy for Radioactive Discharges 2009 was published in 2018:

https://www.gov.uk/government/publications/uk-strategy-for-radioactive-discharges-2018-review-of-the-2009-strategy.

2. Systems and abatement techniques to reduce discharges

The procedures and techniques applied in the UK nuclear industry are consistent with BAT, BPEO and BPM. Measures are in place, as part of the permit/authorisation review process, to ensure BAT is considered and demonstrated. Where regulators believe it is justified and proportionate, they can, and do, impose improvement conditions. This can include the requirement to review and report periodically on international best practice on the prevention/minimisation of discharges. The Environment Agency also carries out an annual review of the application of BAT within the nuclear industry in England and Wales to support internal planning processes.

The UK 2017 report includes comparisons of the performance of UK plants with similar plants worldwide where appropriate and concluded that prevention/minimisation approaches were consistent with those identified in recent international reports. The development of new techniques to reduce discharges is supported by industry R&D.

The UK 2017 report described in some detail the techniques in use or under development in the UK such as filtration, caustic scrubbers, ion exchange and adsorption, hydrocyclone centrifuges, and electrochemical and electrophysical processes. Following the UK 2017 report, the UK continues to see improvements in the application of BAT to prevent, minimise and characterise discharges. Across the industry there continues to be a strong focus on: in reactor fuel management, managing fuel pond water chemistry and the way fuel and waste is removed from ponds during de-fuelling and decommissioning, in order to prevent and minimise discharges. The UK nuclear sector is also currently developing an aqueous waste good practice guide which is being sponsored by the Nuclear Decommissioning Authority (NDA) and should be available in 2020/21. This will help to consolidate and disseminate best available techniques.

Some recent specific examples include research and development at Sellafield associated with the Enhanced Actinide Removal Plant (EARP) to minimise discharges from post operational clean out and allow the future diversion of existing effluent streams to EARP for enhanced abatement. A new evaporator has been commissioned at Sellafield to treat effluents arising from decommissioning the reprocessing plants.

Capenhurst expects recent modifications to gaseous waste abatement traps in the enrichment plant to further reduce discharges.

The Culham Centre for Fusion Energy which operates the Joint European Torus (JET) fusion reactor has successfully commissioned and operated their materials detritiation facility. This facility works in conjunction with the JET tritium recovery system to significantly reduce tritium discharges from the facility.

3. Effectiveness of BAT in reducing liquid discharges

There has been an overall reduction in discharges over the past two decades which followed the major reductions made in the 1970s and 1980s in the reprocessing sector, noting that significant discharges from this sector in the UK are associated with decommissioning, including arisings from legacy management activities.

The reprocessing sector (Sellafield) saw a 46% fall in total beta and a 44% fall in alpha discharges between 2012 and 2018.

The fuel fabrication sector saw a decrease of beta radionuclides of 94% between 2012 and 2018 and a 67% decrease in alpha discharges.

Overall, beta/gamma discharges from operating power stations were consistent over the period, seeing only minor fluctuations year on year.

The decommissioning sector saw an overall increase in discharges over the period between 2012 and 2018 due to a number of Magnox sites moving from defueling into active decommissioning and a number of changes to the decommissioning activities at Sellafield.

Alpha: Over the period between 2012 and 2018 total alpha discharges were broadly consistent, with the total activity of liquid discharges being 0.17 TBq reported for 2018. Approximately 46% of alpha discharges arose from the reprocessing sector in 2018.

Beta/gamma (excluding tritium): Total beta/gamma discharges have reduced by 20% over the period between 2012 and 2018 with total liquid discharges at 13.5 TBq for 2018.

Tritium: Tritium discharges from all sectors increased by 14% between 2012 and 2018 with reported liquid discharges of 2,860 TBq in 2018, mainly due to an increase in activity from reprocessing at Sellafield. Discharges are dominated by the power generation and reprocessing sectors.

Technetium-99: Discharges of technetium-99 from reprocessing at Sellafield have remained similar between 2012 and 2018 with 0.93 TBq reported for 2018, however discharges remain 60% lower than a decade ago and 200 times less than they were in the mid-1990s.

Reprocessing at THORP ended in November 2018 and the intention is to finish Magnox reprocessing in 2020 whilst retrievals and post operational clean-out (POCO) gathers pace.

4. Conclusions

The application of BAT in the UK brought about, for example, by stringent regulation, considerable investment in abatement plant and process optimisation, better application of the waste management hierarchy, including waste minimisation, and has been effective in continuing to prevent and reduce discharges.

The UK will continue to apply BAT rigorously. Further substantial reductions in discharges may be increasingly difficult to achieve in some areas: in recent years there have been fluctuations in discharges in line with operational throughputs and essential work to reduce hazards and decommission facilities. However, reduction in Sellafield's discharges are already being seen as result of the closure of THORP fuel reprocessing plant in November 2018 and the expected closure in 2020 of the Magnox fuel reprocessing plant will lead to more significant longer term reductions. Sellafield is currently going through a major permit review which is expected to result in significant reductions to permitted discharge limits during 2020.

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