



OSPAR COMMISSION

*Protecting and conserving the
North-East Atlantic and its resources*

Liquid discharges from nuclear installations in 2015



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.

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This report has been prepared by the Expert Assessment Panel of the OSPAR Radioactive Substances Committee, comprising of Mr Andy Mayall (convenor), United Kingdom, Mr Michel Chartier, France and Ms Inge Krol, Germany with the support of Miss Lucy Ritchie of the OSPAR Secretariat.

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Executive summary

This annual report includes 2015 data of liquid radioactive discharges from nuclear installations and temporal trends for the period 1990 - 2015. On this basis, an assessment has been made for the discharges from nuclear power stations, nuclear fuel reprocessing plants, nuclear fuel fabrication and enrichment plants, research and development facilities, and decommissioning and management of legacy radioactive wastes activities. Discharges are reported as total alpha, tritium and total beta activity (excluding tritium) in terabecquerel per year (TBq/y) for each type of nuclear installation.

Discharges of radioactive substances measured as total alpha and total beta activity (excluding tritium) from nuclear installations have decreased over the period 1990 – 2015. Discharges of tritium peaked in 2004.

There is a decrease in the total alpha activity discharged from all nuclear installations over the 25-year period. Discharges are at the lowest reported level since 1990, accounting for around 8% of the peak value in 1993.

The total discharge of tritium in 2015 of about 18,000 TBq is very similar to annual discharges made in recent years and about 14% lower than the peak seen in 2004.

Total beta activity (excluding tritium) from all nuclear installations has decreased markedly since 1990 and is now only about 4% of what it was in 1990. In 2015 total beta discharges were about 20 TBq, a small increase relative to the previous year.

Récapitulatif

Le présent rapport annuel comporte les données de 2015 sur les rejets radioactifs liquides provenant des installations nucléaires et les tendances temporelles pour la période de 1990 à 2015. Une évaluation a été réalisée, à partir de ces informations, portant sur les rejets provenant des centrales nucléaires, des usines de retraitement de combustible nucléaire, des usines de production de combustible nucléaire et des usines d'enrichissement, des installations de recherche et de développement ainsi que des activités de démantèlement de gestion des déchets radioactifs hérités. Les rejets sont notifiés au titre des activités d'alpha total, de tritium et de bêta total (à l'exclusion du tritium) et exprimés en terabecquerel par an (TBq/y) pour chaque type d'installation nucléaire.

La mesure des activités d'alpha total et de bêta total, à l'exclusion du tritium, révèle que les rejets de substances radioactives, provenant des installations nucléaires, ont diminué entre 1990 et 2015. Les rejets de tritium ont atteint leur maximum en 2004.

L'activité d'alpha total rejetée par toutes les installations nucléaires a diminué au cours des vingt-cinq dernières années. Les rejets sont au niveau le plus bas enregistré depuis 1990, représentant environ 8 % du maximum enregistré en 1993.

La quantité totale de tritium rejetée en 2015 d'environ 18 000 TBq est très similaire aux quantités annuelles enregistrées ces dernières années et d'environ 14% inférieure au maximum observé en 2004.

L'activité de bêta total (à l'exclusion du tritium) rejetée par toutes les installations nucléaires a diminué de manière significative depuis 1990 et ne représente actuellement que 4 % du niveau enregistré en 1990. En 2015, les rejets bêta total étaient d'environ 20 TBq, soit une légère augmentation par rapport à l'année précédente.

1. Introduction

Work to prevent and reduce pollution from ionising radiation in the North-East Atlantic was first undertaken within the framework of the former 1974 Convention for the Prevention of Marine Pollution from Land-based Sources (the “Paris Convention”) and then under the 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”), which replaces the Paris Convention and establishes the OSPAR Commission.

At the first Ministerial Meeting of the OSPAR Commission (20-24 July 1998, Sintra, Portugal), an OSPAR Strategy for Radioactive Substances was adopted to guide the future work of the OSPAR Commission on protecting the marine environment of the North-East Atlantic against radioactive substances arising from human activities. This strategy was revised at the third Ministerial Meeting of the OSPAR Commission (23-24 September 2010, Bergen, Norway), where the Strategy of the OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic 2010-2020 (the “North-East Strategy”) was adopted.

The North-East Atlantic Environment Strategy sets out OSPAR’s vision, objectives, strategic directions and action for the period up to 2020. In Part I, the new Strategy gives prominence to the overarching implementation of the ecosystem approach and the need for integration and coordination of OSPAR’s work across themes and groups. In Part II, the Strategy provides its thematic strategies for Biodiversity and Ecosystems, Eutrophication, Hazardous Substances, Offshore Oil and Gas Industry and Radioactive Substances.

The Radioactive Substances thematic Strategy (Radioactive Substances Strategy) sets the objective of *preventing pollution of the OSPAR maritime area from ionising 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 values 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: (1) radiological impacts on man and biota, (2) legitimate uses of the sea, and (3) technical feasibility.

As its timeframe, the Radioactive Substances Strategy further declares that the OSPAR Commission will implement this Strategy progressively by making every endeavour, through appropriate actions and measures to ensure that by the year 2020 discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses, are close to zero.

The Radioactive Substances Strategy provides that in accordance with the provisions of the OSPAR Convention and the findings of the Quality Status Report 2010, the OSPAR Commission will, where appropriate, develop and maintain programmes and measures to identify, prioritise, monitor and control the emissions, discharges and losses of the radioactive substances caused by human activities which reach or could reach the marine environment.

To this end, the Radioactive Substances Strategy requires the OSPAR Commission to continue the annual collection of data on discharges of radionuclides from the nuclear sector. Regular reporting is therefore required in order to review progress towards the targets of the Radioactive Substances Strategy.

1.1 Programmes and measures

Since the mid 1980s, liquid discharges of radioactive substances from nuclear installations have been addressed first under the former Paris Convention and then under the OSPAR Convention. The following relevant measures¹ are applicable² under the OSPAR Convention:

- PARCOM Recommendation 88/4 on Nuclear Reprocessing Plants;
- PARCOM Recommendation 91/4 on Radioactive Discharges³;
- PARCOM Recommendation 94/8 Concerning Environmental Impact Resulting from Discharges of Radioactive Discharges⁴;
- OSPAR Decision 2000/1 on Substantial Reductions and Elimination of Discharges, Emissions and Losses of Radioactive Discharges, with Special Emphasis on Nuclear Reprocessing.

The OSPAR Fourth Periodic Evaluation of the Progress in Implementing the OSPAR Radioactive Substances Strategy, published in 2016 (OSPAR publication 2016/687), has also informed this report.

1.2 Annual reporting

In 1985, Contracting Parties to the former Paris Convention initiated reporting on liquid discharges from nuclear installations. These data have subsequently been submitted annually by Contracting Parties, collated by the Secretariat and, following examination by the Expert Assessment Panel (EAP) of the OSPAR Radioactive Substances Committee, published by the OSPAR Commission in the form of annual reports. At first annual reports were published as part of the OSPAR Commission's general Annual Report, and from 1991 onwards they are published in the form of Annual OSPAR Reports on Liquid Discharges from Nuclear Installations in the OSPAR maritime area. From 1998 onwards, the annual reports also contain an assessment of liquid discharges which include a description of the trends from 1989 until the date of the latest report. Over time, reporting requirements and formats for data collection as regards nuclear installations have been regularly reviewed and updated in the light of experience and ongoing work under the OSPAR Commission. With a view to harmonising the way in which data and information are being established and reported, the OSPAR Commission adopted in 1996 a set of reporting formats for the annual Collection of Data on Liquid Discharges from Nuclear Installations, which were updated in 2010 to include a guide to generate "total- α " and "total- β " discharge data. There was a further update of the set of reporting formats in 2013 (OSPAR Agreement number: 2013-10).

RSC decided at the meeting in 2006, that for data from 2005 onwards, discharges arising from decommissioning and the recovery and conditioning of legacy wastes should be reported separately from operational nuclear discharges. The discharges from such activities were reported as "Exceptional Discharges" and appear in this report in a separate table.

¹ All measures referred to in this section can be downloaded from the OSPAR website www.ospar.org (under "programmes and measures").

² OSPAR Decision 2000/1: France and the United Kingdom abstained from voting.

³ The implementation of this Recommendation requires an assessment to be carried out as to whether BAT is being applied in nuclear installations. Contracting Parties submit national reports that also contain discharge data on a regular basis thereby using the Guidelines for the submission of information about, and the assessment of, the application of BAT in nuclear facilities (reference number: 2004-03).

⁴ Assessments of the effect and relative contributions of remobilised historical discharges and current discharges of radioactive substances, including wastes, on the marine environment have been published in the Quality Status Report 2000 published by the OSPAR Commission in 2000 (ISBN 0 946956 52 9) and in the MARINA II Report published by the European Commission (EC, 2003).

1.3 Parameters monitored and reported

Tables 1-8 of this report contain data on total- α (Table 1), tritium (Table 2), total- β (Table 3), and individual radionuclides (Tables 4-8). Figures 1-3 of this report show trends in discharges of total- α activity, tritium and total- β activity respectively.

Total- α and total- β values are useful as they will encompass the contribution to the overall activity from a wide range of radionuclides which, individually, would be difficult to measure or could be below detection limits. However, total- α and total- β values provide limited information about the potential harm and, as such, information should be based on the characteristics of individual radionuclides. Tritium is reported separately.

There is currently little consistency in the approach adopted by Contracting Parties in the assessment of total- α and total- β quantities. Consequently, for the purposes of this report total- α quantities include measurements that are strictly gross- α . The calculation of total- β varies between Contracting Parties, for example, in some cases it is the sum of individual radionuclide measurements and in other cases gross- β measurements are used.

Total- α represents the measured radioactivity of α -particle emitting radionuclides. These particles are emitted as a result of the decay of certain radionuclides, the so-called α -emitters. Typically, the total liquid discharges of α -emitters from all nuclear sites represent mainly Pu-239, Pu-240 and Am-241 and, to a lesser extent, Th-230, Pu-238 and some other nuclides. Total- β represents the sum of the measured radioactivity of β -particle emitting radionuclides. These particles are emitted as a result of the decay of certain radionuclides, the so-called β -emitters. On average, the total liquid discharges of β -emitters from all nuclear sites represent mainly Ru-106, Sr-90, Pu-241, Cs-137, Tc-99 and, to a lesser extent, a range of other radionuclides. Total- β in this report excludes tritium, which is reported separately.

Tritium (H-3) is an isotope of hydrogen that emits low-energy radiation in the form of β -particles. Tritium is discharged from most nuclear power plants, reprocessing plants and some research and development facilities.

2. Assessment of the liquid radioactive discharges from nuclear installations in 2015

2.1 Introduction

Tables 1 to 3 summarise liquid radioactive discharges from nuclear installations for the period 1990 – 2015; data are taken from the OSPAR Annual Reports on Liquid Discharges from Nuclear Installations⁵. Reported discharges include data from nuclear power stations, nuclear fuel reprocessing plants, nuclear fuel fabrication and enrichment plants, and research and development facilities. Since 2006, discharges from decommissioning are reported separately for some sites. Furthermore in 2014 the Contracting Parties agreed to apply the definitions for ‘operational’ and ‘exceptional’⁶ discharges adopted at RSC 2013 and these definitions were included in the guidance to the revised reporting formats for discharges made in 2013. Such differentiation is becoming particularly important where the magnitude of discharges associated with the recovery of historical and legacy wastes during decommissioning is clearly evident. In recent years, the contribution of ‘exceptional’ discharges from decommissioning has increased.

Table 1 gives discharges of total alpha activity, Table 2 gives tritium discharges and Table 3 gives discharges of total beta activity (excluding tritium) in terabecquerels per year (TBq/y) for each sub-sector. The tables also give the percentage contributions from each sub-sector. Figures 1 to 3 show the trends in annual discharges of total alpha, tritium and total beta (excluding tritium) for the period 1990 to 2015.

2.2 Trends in total alpha discharges

Table 1 and Figure 1 show the total alpha activity discharged from 1990 to 2015. The total discharges of alpha activity from all nuclear installations in 2015 were 0.23 TBq which is similar to the previous year. Annual alpha discharges have fluctuated around 0.2 TBq since 2007, and in 2015 were about 8% of the peak since 1990 (in 1993).

Discharges from the fuel reprocessing sub-sector contributed about 82% of the overall total alpha discharges in 2015 at 0.19 TBq. Operational discharges from Sellafield contributed about 89% (0.17 TBq) to this sub-sector. The variations mainly reflect spent fuel throughput, fuel burn up and period for radioactive decay in the spent fuel prior to reprocessing.

Total alpha discharges arising from decommissioning have been recorded separately since 2006. In 2015 the ‘exceptional’ discharges² from this sub-sector were 0.018 TBq, about 8% of the total from all nuclear installations.

The discharges from the fuel fabrication and enrichment sub-sector contributed about 10% to the total alpha discharge in 2015 at 0.023 TBq, which was a 60% increase over 2014 and returning to a level last seen in 2012. Most of the discharges of total alpha from this sub-sector are due to the discharges from the Springfields fuel fabrication plant in the UK.

Discharges of alpha activity from nuclear power plants and research and development facilities in 2015 were a very small percentage of the total discharge (<1%).

2.3 Trends in tritium discharges

Table 2 and Figure 2 present the discharges of tritium, a weak beta emitter with a low radiological impact. The total discharge of tritium in 2015 of about 18,000 TBq is very similar to annual discharges made in

⁵ Discharge data have been rounded to two significant figures in this assessment report.

⁶ Associated with historical or legacy wastes

recent years and about 14% lower than the peak seen in 2004. Discharges of tritium are dominated by those from the reprocessing sector (86% in 2015, with 76% of the total from Cap de la Hague) and fluctuate largely in accordance with spent fuel reprocessing rates.

During 2015 the discharge of tritium by nuclear power stations decreased by about 7% over the previous year and contributed a similar fraction of about 16% of the total tritium discharges from the nuclear sector. The UK's Advanced Gas-cooled Reactors contributed about 61% (1,700 TBq) of the total from power stations. The Pressurised Water Reactors in France contributed about 30% (830 TBq) of the total from power stations in 2015, which was similar to 2014. There were only small changes in the discharges of tritium from nuclear power stations in other countries.

Tritium discharges arising from decommissioning (exceptional discharges) have been recorded separately since 2006, and continue to be a relatively small and variable contribution depending upon decommissioning and legacy waste management operations. Discharges in 2015 were 52 TBq and although this represents a three-fold increase over the previous year, this was less than 1% of the total across all sub-sectors.

Discharges from other sub-sectors were relatively small.

2.4 Trends in total beta discharges

Table 3 and Figure 3 show that the discharges of total beta activity (excluding tritium) from all nuclear installations has decreased markedly since 1990 and are now only about 4% of what they were in 1990. In 2015 total beta discharges were about 20 TBq, a small increase relative to the previous year.

Historically, total beta discharges have been dominated by discharges from the reprocessing plants at Sellafield and the nuclear fuel fabrication plant at Springfields. In 2015, the reprocessing plants at Sellafield and Cap de la Hague contributed 39% and 23% respectively to operational discharges of total beta activity.

Between the mid-1990s and 2002 total beta discharges from Sellafield were mainly attributable to the radionuclide technetium-99. The contribution from technetium-99 to the total beta discharge at Sellafield has reduced substantially since 2001 and since 2007 the annual discharges have been below 5 TBq. In 2015 the discharge of technetium-99 from Sellafield was 1.7 TBq, similar to discharges in recent years.

Discharges from nuclear fuel fabrication and enrichment sub-sector have decreased substantially since 2006 and are now at around 1% of the level that they were at the peak. In recent years discharges from the fuel fabrication sub-sector have been typically of the order of few terabecquerels and continuing to show a slight downward trend.

Discharges from power stations over recent years have fluctuated but are typically of a similar order to those from the fuel fabrication sector – in 2015 power stations were the second largest contributor (17%) to total discharges after reprocessing (62%).

Discharges from decommissioning, and the management of historical or legacy waste, have increased in recent years and in 2015 were 10% of the total, primarily due to more nuclear sites entering the decommissioning phase and an increase in decommissioning activity.

Discharges from the R&D sub-sector remained as the smallest contributor to total discharges.

Erratum

Quality assurance checking has revealed an error in the transcription of data used to derive the total beta values used for 2013 and 2014 in Table 3 of the previous report for nuclear power plants. The total beta

value for 2014 should be 3.7 TBq and the value for 2013 should be 4.6 TBq. These values have been corrected in this report.

Table 1: Total alpha discharges 1990-2015

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
All Nuclear Installations (TBq)	2.4E+00	2.4E+00	1.8E+00	2.9E+00	1.4E+00	6.8E-01	5.7E-01	3.8E-01	4.3E-01	4.1E-01	3.3E-01	4.1E-01	6.1E-01	6.2E-01	5.4E-01	5.2E-01	3.4E-01	1.9E-01	1.7E-01	1.8E-01	1.8E-01	1.7E-01	1.9E-01	2.0E-01	2.2E-01	2.3E-01
Reprocessing Plants (TBq)	2.2E+00	2.3E+00	1.7E+00	2.7E+00	1.1E+00	4.7E-01	3.2E-01	2.3E-01	2.2E-01	1.7E-01	1.6E-01	2.5E-01	3.9E-01	4.3E-01	3.1E-01	2.7E-01	2.3E-01	1.5E-01	1.4E-01	1.5E-01	1.6E-01	1.4E-01	1.6E-01	1.5E-01	1.8E-01	1.9E-01
% of all installations	91	93	93	94	81	69	56	61	51	41	48	60	63	70	57	52	68	77	83	88	86	85	86	74	83	82
Nuclear Power Plants (TBq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% of all installations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nuclear Fuel Fabrication (TBq)	2.1E-01	1.5E-01	1.0E-01	8.0E-02	1.6E-01	1.2E-01	1.2E-01	1.2E-01	2.0E-01	2.4E-01	1.7E-01	1.6E-01	2.2E-01	1.8E-01	2.3E-01	2.5E-01	1.1E-01	4.4E-02	2.2E-02	1.7E-02	2.1E-02	2.2E-02	2.4E-02	1.6E-02	1.4E-02	2.3E-02
% of all installations	8.6	6.2	5.4	2.8	12	18	21	32	46	58	52	40	36	30	43	48	32	23	13	9.8	12	13	13	8.2	6.6	9.8
Research and Development Facilities (TBq)	2.0E-02	3.0E-02	3.0E-02	1.0E-01	1.0E-01	9.0E-02	1.3E-01	2.7E-02	1.3E-02	3.0E-03	1.8E-03	1.6E-03	2.1E-03	4.4E-03	9.0E-04	1.0E-03	1.2E-04	1.2E-04	9.0E-05	6.2E-05	6.2E-05	7.7E-05	8.9E-05	5.7E-05	7.3E-03	1.3E-04
% of all installations	0.82	1.2	1.6	3.5	7.4	13	23	7.2	3.0	0.73	0.55	0.38	0.34	0.71	0.17	0.2	0.035	0.063	0.052	0.035	0.034	0.047	0.048	0.029	3.3	0.1
Decommissioning (TBq)																	5.8E-04	5.9E-04	6.3E-03	3.6E-03	4.5E-03	2.8E-03	2.3E-03	3.4E-02	1.6E-02	1.8E-02
% of all installations																	0.17	0.31	3.6	2.1	2.5	1.7	1.2	17	7.2	7.9

Table 2: Tritium discharges 1990-2015

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
All Nuclear Installations (TBq)	7.2E+03	8.8E+03	7.7E+03	1.1E+04	1.3E+04	1.5E+04	1.7E+04	1.8E+04	1.6E+04	1.9E+04	1.7E+04	1.6E+04	1.9E+04	2.0E+04	2.1E+04	1.9E+04	1.6E+04	1.6E+04	1.1E+04	1.4E+04	1.4E+04	1.3E+04	1.6E+04	1.8E+04	1.7E+04	1.8E+04
Reprocessing Plants (TBq)	5.0E+03	6.5E+03	5.0E+03	7.5E+03	9.8E+03	1.2E+04	1.4E+04	1.5E+04	1.3E+04	1.5E+04	1.3E+04	1.2E+04	1.5E+04	1.6E+04	1.7E+04	1.5E+04	1.2E+04	1.3E+04	9.0E+03	1.1E+04	1.1E+04	1.1E+04	1.3E+04	1.5E+04	1.4E+04	1.5E+04
% of all installations	69	74	65	68	76	82	80	81	79	82	80	77	81	80	83	81	79	81	80	78	80	81	80	81	82	86
Nuclear Power Plants (TBq)	2.2E+03	2.3E+03	2.7E+03	3.4E+03	3.0E+03	2.7E+03	3.3E+03	3.4E+03	3.4E+03	3.3E+03	3.2E+03	3.5E+03	3.6E+03	3.8E+03	3.6E+03	3.4E+03	3.4E+03	2.9E+03	2.2E+03	2.9E+03	2.8E+03	2.5E+03	3.2E+03	3.4E+03	3.0E+03	2.8E+03
% of all installations	30	26	35	31	24	18	19	19	21	18	20	22	19	19	17	19	22	19	20	22	20	18	20	19	18	16
Nuclear Fuel Fabrication (TBq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% of all installations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Research and Development Facilities (TBq)	1.0E+02	3.2E+01	2.4E+01	8.8E+01	1.2E+02	1.7E+01	1.5E+01	1.6E+01	1.4E+01	1.6E+01	7.0E+00	5.8E+00	1.2E+01	1.8E+01	7.0E+00	1.8E+01	5.4E+00	7.0E+00	6.7E+00	4.7E+00	1.4E+01	5.0E+00	2.5E+00	5.7E+00	6.1E+00	3.9E+00
% of all installations	1.4	0.37	0.31	0.81	0.91	0.11	0.089	0.089	0.086	0.085	0.042	0.037	0.062	0.092	0.034	0.095	0.035	0.045	0.06	0.035	0.1	0.037	0.016	0.031	0.036	0.022
Decommissioning (TBq)																	1.7E+01	2.5E+01	1.1E+01	1.9E+00	8.1E-01	6.0E+00	2.8E+01	2.8E+01	1.7E+01	5.2E+01
% of all installations																	0.11	0.16	0.10	0.014	0.0057	0.045	0.17	0.15	0.1	0.3

Table 3: Total beta (excl tritium) discharges 1990-2015

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
All Nuclear Installations (TBq)	4.9E+02	2.3E+02	2.7E+02	2.5E+02	3.2E+02	3.7E+02	3.3E+02	3.2E+02	2.6E+02	2.6E+02	1.7E+02	2.3E+02	2.3E+02	2.0E+02	2.0E+02	1.1E+02	5.8E+01	3.3E+01	2.7E+01	2.6E+01	2.3E+01	2.6E+01	2.0E+01	2.1E+01	2.1E+01	2.0E+01
Reprocessing Plants (TBq)	3.8E+02	1.8E+02	1.3E+02	1.7E+02	2.0E+02	2.4E+02	1.7E+02	1.7E+02	1.1E+02	1.3E+02	9.8E+01	1.4E+02	1.2E+02	9.7E+01	8.6E+01	5.4E+01	3.7E+01	3.0E+01	2.1E+01	1.8E+01	1.5E+01	1.8E+01	1.2E+01	9.9E+00	1.1E+01	1.2E+01
% of all installations	78	78	50	67	61	66	51	53	42	49	57	61	53	49	42	52	63	89	76	68	64	70	61	47	52	62
Nuclear Power Plants (TBq)	1.0E+01	3.8E+00	8.9E+00	1.1E+01	2.8E+00	3.4E+00	5.2E+00	7.4E+00	2.0E+00	2.0E+00	3.0E+00	4.2E+00	3.6E+00	3.2E+00	1.3E+00	2.0E+00	7.5E-01	4.6E-01	1.5E+00	2.1E+00	3.2E+00	2.2E+00	2.7E+00	4.6E+00	3.7E+00	3.4E+00
% of all installations	2.1	1.7	3.3	4.4	0.86	0.94	1.6	2.3	0.76	0.78	1.7	1.8	1.5	1.6	0.64	1.9	1.3	1.4	5.6	7.9	14	8.6	14	21.90	17.62	17.00
Nuclear Fuel Fabrication (TBq)	9.2E+01	3.9E+01	1.2E+02	6.3E+01	1.1E+02	1.1E+02	1.5E+02	1.4E+02	1.5E+02	1.3E+02	7.1E+01	8.5E+01	1.1E+02	9.7E+01	1.2E+02	1.0E+02	2.1E+01	3.0E+00	4.6E+00	3.3E+00	4.5E+00	5.0E+00	4.5E+00	2.7E+00	2.9E+00	1.8E+00
% of all installations	19	17	45	25	36	31	45	44	57	50	41	37	45	49	57	98	35	8.9	17	12	19	19	23	13	14	9
Reserch and Development Facilities (TBq)	4.5E+00	6.3E+00	6.6E+00	8.2E+00	9.1E+00	7.0E+00	8.1E+00	9.9E-01	6.6E-01	3.6E-01	3.0E-01	4.6E-01	4.6E-01	4.4E-01	4.7E-01	9.5E-02	6.2E-02	1.3E-01	6.7E-02	2.3E+00	1.8E-02	1.5E-02	6.7E-04	6.4E-04	1.4E-01	6.6E-01
% of all installations	0.91	2.8	2.5	3.2	2.8	1.9	2.4	0.31	0.25	0.14	0.17	0.2	0.2	0.22	0.23	0.09	0.11	0.4	0.25	8.7	0.08	0.06	0.0033	0.0030	0.65	3.31
Decommissioning (TBq)																	4.0E-01	4.1E-02	3.8E-01	8.0E-01	5.9E-01	5.9E-01	5.4E-01	3.2E-01	2.8E+00	2.1E+00
% of all installations																	0.019	0.12	1.4	3.0	2.6	2.3	2.7	2	13	10

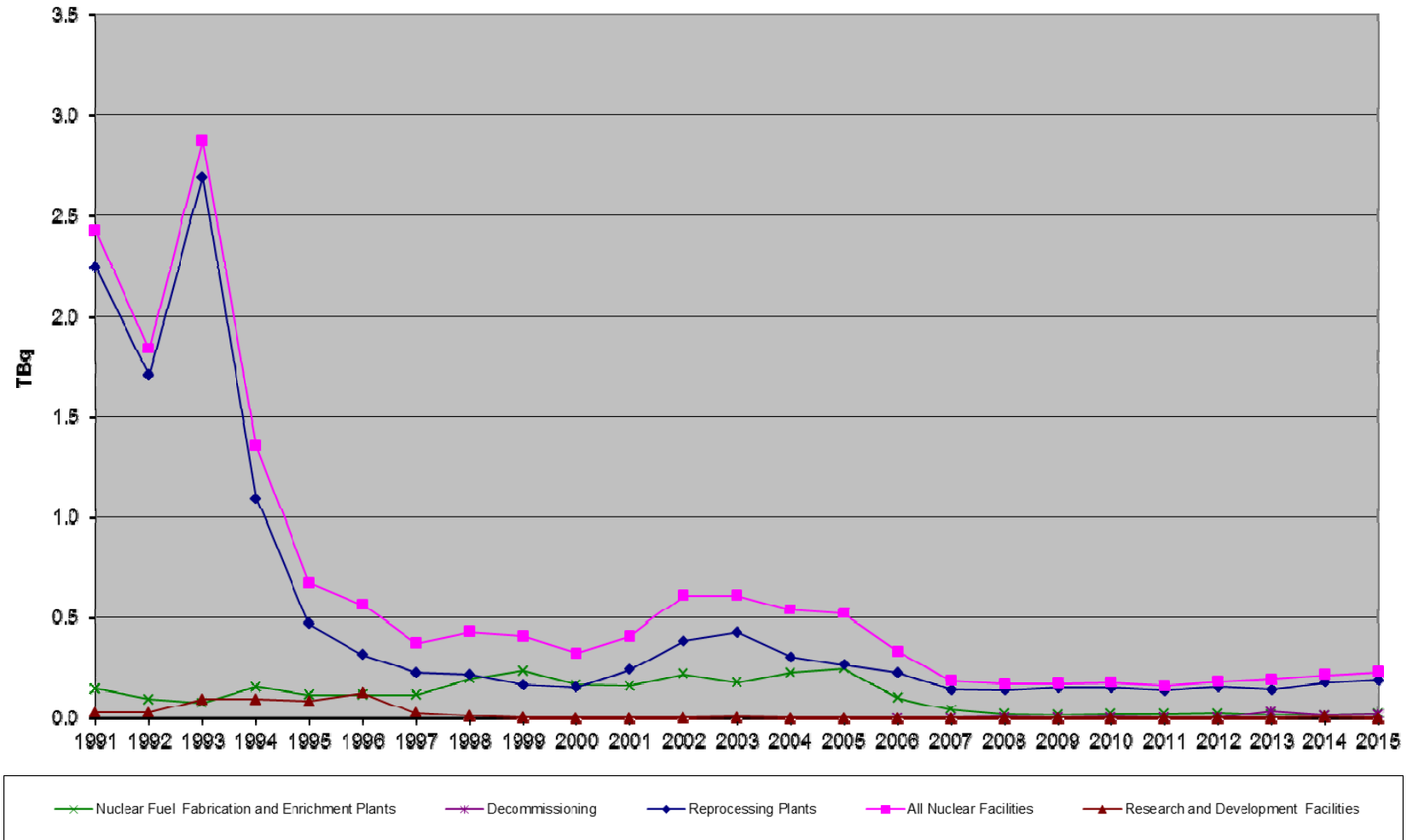


Figure 1: Total alpha activity discharge 1990 – 2015

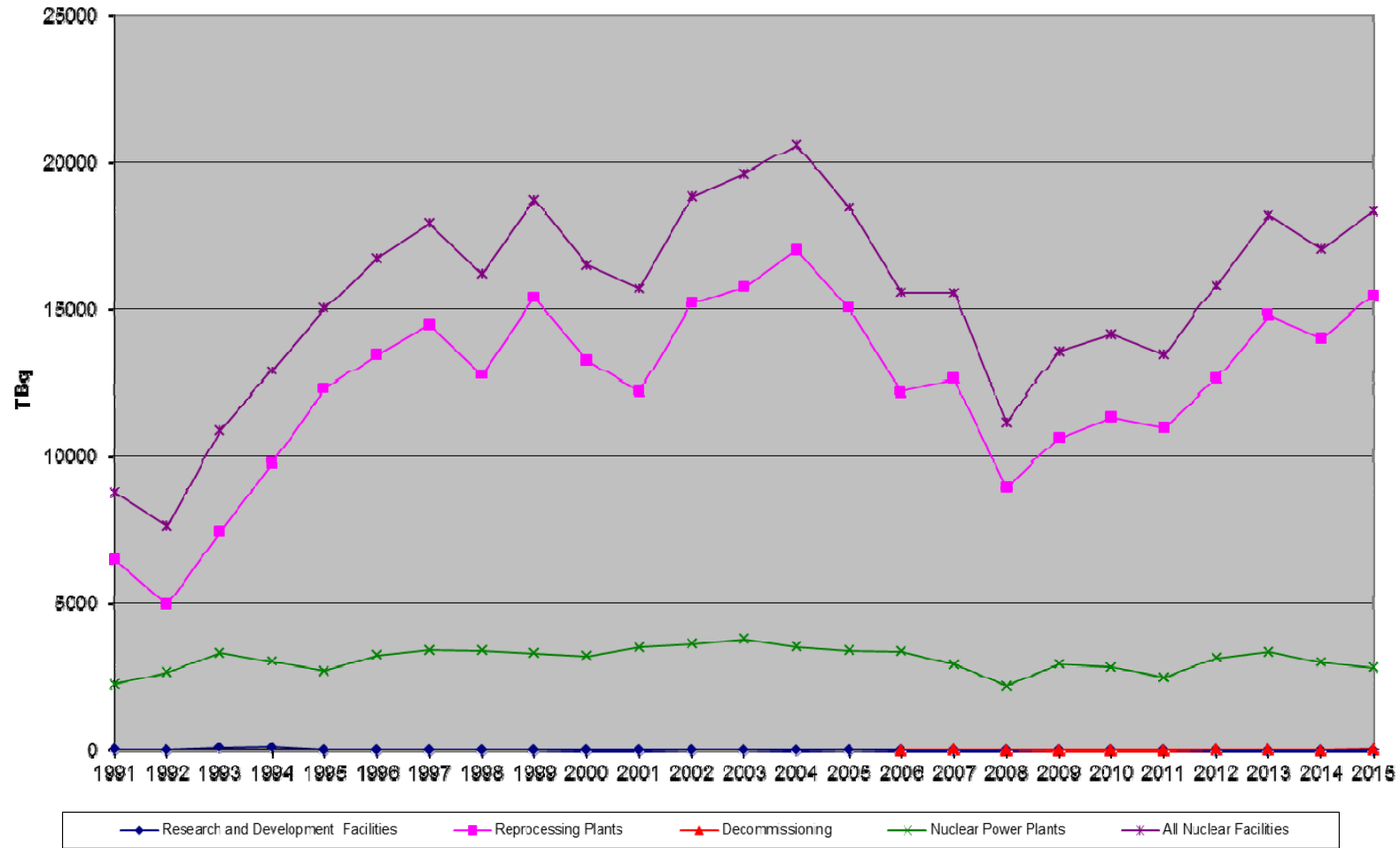


Figure 2: Discharge of tritium 1990 – 2015

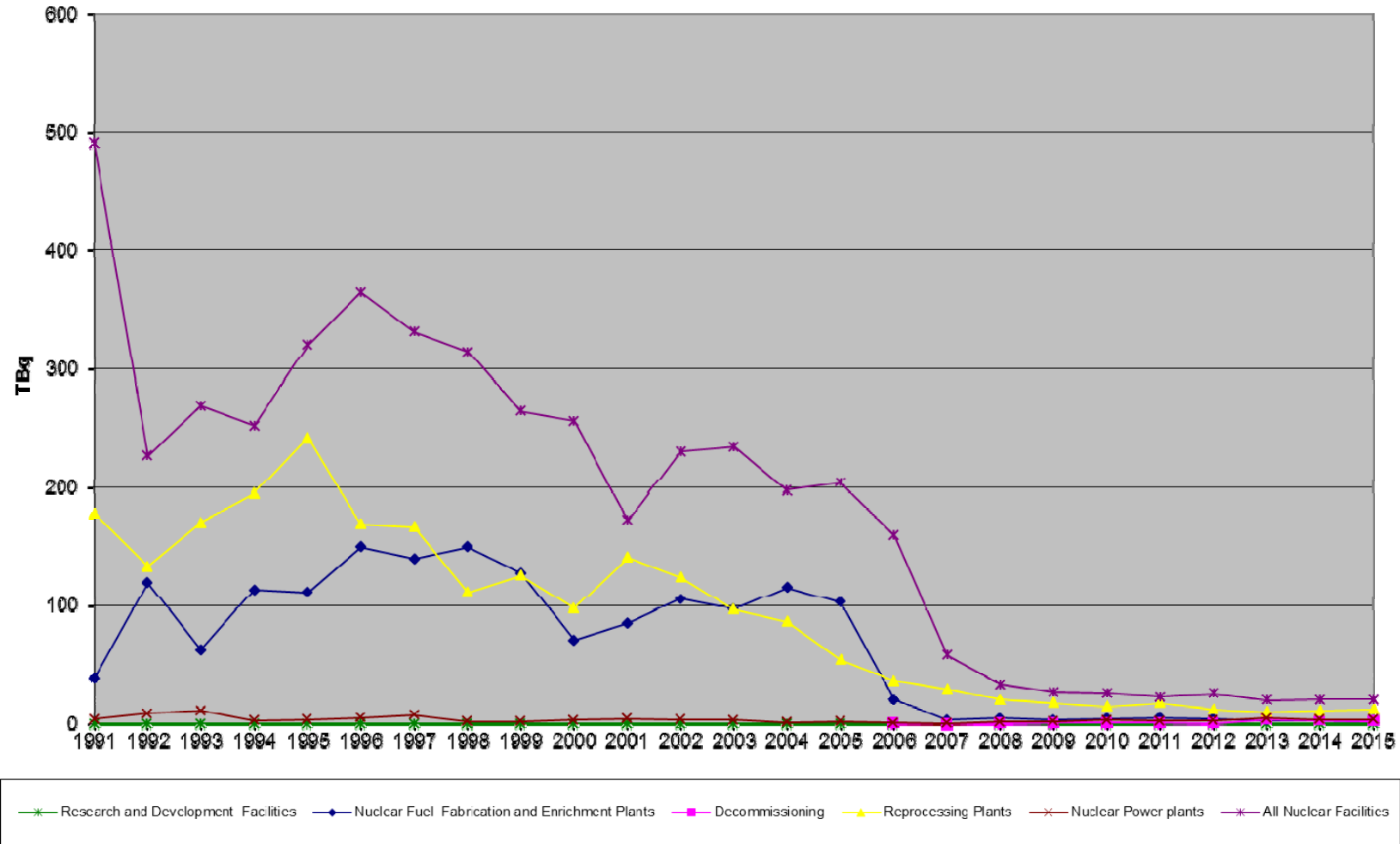


Figure 3: Total beta discharge 1990 - 2015

3. 2015 data and information

This section presents information on the location of the nuclear installations and data and information on liquid discharges for each OSPAR Contracting Party under the following categories of nuclear installations draining into the OSPAR Maritime Area:

Table 4: Nuclear Power Stations;

Table 5: Nuclear Fuel Reprocessing Plants;

Table 6: Nuclear Fuel Fabrication and Enrichment Plants;

Table 7: Research and Development Facilities;

Table 8: Discharges from Decommissioning and Treatment/Recovery of Old Radioactive Waste.

Further detailed information with respect to individual plants is presented in endnotes after the entire set of tables.

The columns, headings and abbreviations used in the tables correspond to the reporting requirements set out in the current reporting format (OSPAR Agreement No. 2013/10). The following abbreviations are used in the tables:

AGR: Advanced Gas Cooled Reactor;

GCR: Gas Cooled Reactor;

UNGG: Natural Uranium Gas Graphite (French equivalent for GCR);

PWR: Pressurised Water Reactor;

THTR: Thorium High Temperature Reactor;

BWR: Boiling Water Reactor;

NA: Not applicable;

NI: No information;

ND: Not detectable.

For radionuclides:

Ag:	Silver	Gd:	Gadolinium	Rh:	Rhodium
Am:	Americium	I:	Iodine	Ru:	Ruthenium
Ba:	Barium	Mn:	Manganese	S:	Sulphur
Be:	Beryllium	Na:	Sodium	Sb:	Antimony
C:	Carbon	Nb:	Niobium	Se:	Selenium
Ce:	Cerium	Ni:	Nickel	Sr:	Strontium
Cm:	Curium	Np:	Neptunium	Tc:	Technetium
Co:	Cobalt	Pm:	Promethium	Th:	Thorium
Cr:	Chromium	Pr:	Praseodymium	U:	Uranium
Cs:	Caesium	Pu:	Plutonium	Y:	Yttrium
Eu:	Europium	Ra:	Radium	Zn:	Zinc
Fe:	Iron	Rb:	Rubidium	Zr:	Zirconium

All data on discharge limits and releases of radionuclides have been entered in the tables using continental decimal system. The data values are expressed in scientific number format, *e.g.* 0,0009 as 9,0E-04.

3.1 Map of nuclear installations

The map shows the location of nuclear facilities in OSPAR countries discharging directly or indirectly to the OSPAR Maritime Area.



3.2 Location of nuclear installations

The location and type of each installation is listed in the table below.

Country / Code	Name of installation	Type	Discharging into
Belgium			
BE1	Doel	NPS	Schelde
BE2	Tihange	NPS	Meuse
BE3	Mol	RDF	River Mol-Neet
Denmark			
DK1	Risø	DMLRW	Kattegat through Roskilde Fjord
France			
FR1	Bellemeville	NPS	Loire
FR3	Cattenom	NPS	Mosel
FR4	Chinon	NPS	Loire
FR5	Chooz	NPS/ DMLRW	Meuse
FR6	Dampierre en-Burly	NPS	Loire
FR7	Fessenheim	NPS	Rhine
FR8	Flamanville	NPS	Channel
FR9	Golfech	NPS	Garonne
FR10	Gravelines	NPS	North Sea
FR11	Nogent-sur-Seine	NPS	Seine
FR12	Paluel	NPS	Channel
FR13	Penly	NPS	Channel
FR14	Saint Laurent	NPS	Loire
FR15	La Hague	NFRP/ DMLRW	English Channel
FR16	Civaux	NPS	Vienne
FR17	Fontenay-aux-Roses	DMLRW	Seine
FR18	Le Blayais	NPS	Gironde Estuary
FR19	Saclay	RDF	Etang de Saclay
Germany			
DE1a	Biblis A	DMLRW	Rhine – Shut down
DE1b	Biblis B	DMLRW	Rhine – Shut down
DE2	Brokdorf	NPS	Elbe
DE3	Brunsbüttel	DMLRW	Elbe – Shut down
DE4	Grafenrheinfeld	NPS	Main
DE5	Grohnde/Emmerthal	NPS	Weser
DE8a	Krümmel/Geesthacht	DMLRW	Elbe – Shut down
DE8b	Geesthacht	RDF	Elbe – Shut down 2010
DE9a	Lingen/Emsland	NPS	Ems
DE9b	Lingen	DMLRW	Ems - via municipal sewer system – Shut down
DE10	Mülheim-Kärlich	DMLRW	Rhine – Shut down
DE11a	Neckar-westheim 1	DMLRW	Neckar – Shut down
DE11b	Neckar-westheim 2	NPS	Neckar
DE12	Obrigheim	DMLRW	Neckar – Shut down
DE13a	Philippsburg KKP1	DMLRW	Rhine – Shut down
DE13b	Philippsburg KKP2	NPS	Rhine
DE14	Rheinsberg	DMLRW	Havel – Shut down
DE15	Stade	DMLRW	Elbe – Shut down
DE16	Rodenkirchen-	DMLRW	Weser – Shut down

Country / Code	Name of installation	Type	Discharging into
	Unterweser		
DE17	Würgassen/Beverungen	DMLRW	Weser – Shut down
DE18	Karlsruhe	RDF	Rhine
DE19	Gronau	NFFEP	Vechte, IJsselmeer
DE24	HMI Berlin	RDF	Havel
DE25	Jülich	RDF	Rur – shut down 2006
The Netherlands			
NL1	Borssele	NPS	Scheldt Estuary
NL3	Almelo	NFFEP	Municipal sewer system
NL4	Delft	RDF	Sewage system
NL5	Petten	RDF	North Sea
Norway			
NO1	Halden	RDF	River Tista (Skagerrak)
NO2	Kjeller	RDF	River Nitelva (Skagerrak)
Portugal			
PT1	Campus de Sacavém	RDF	Tagus River
Spain			
ES1	Almaraz	NPS	Tagus
ES2	José Cabrera	DMLRW	Tagus
ES3	Trillo	NPS	Tagus
ES4	Juzbado	NFFEP	River Tormes - Duero
Sweden			
SE2	Ringhals 1-4	NPS	Kattegat
Switzerland			
CH1	Beznau	NPS	Aare
CH2	Gösgen	NPS	Aare
CH3	Leibstadt	NPS	Rhine
CH4	Mühleberg	NPS	Aare
CH5	Paul Scherrer Institute	RDF	Aare
CH6	ZWILAG Würenlingen	DMLRW	Aare
United Kingdom			
UK1	Berkeley	DMLRW	Severn Estuary
UK2	Bradwell	DMLRW	North Sea
UK4	Chapelcross	DMLRW	Solway Firth
UK5a	Dungeness A	DMLRW	English Channel
UK5b	Dungeness B	NPS	English Channel
UK6	Hartlepool	NPS	North Sea
UK7a	Heysham 1	NPS	Morecambe Bay
UK7b	Heysham 2	NPS	Morecambe Bay
UK8a	Hinkley Point A	DMLRW	Severn Estuary
UK8b	Hinkley Point B	NPS	Severn Estuary
UK9a	Hunterston A	DMLRW	Firth of Clyde
UK9b	Hunterston B	NPS	Firth of Clyde
UK10	Oldbury	NPS	Severn Estuary
UK11a	Sizewell A	DMLRW	North Sea
UK11b	Sizewell B	NPS	North Sea
UK12	Torness	NPS	North Sea
UK13	Trawsfynydd	DMLRW	Trawsfynydd lake
UK14	Wylfa	NPS	Irish Sea

Country / Code	Name of installation	Type	Discharging into
UK15	Sellafield	NFRP and DMLRW	Irish Sea
UK16	Capenhurst	NFFEP	Irish Sea via Rivacre Brook and Mersey Estuary
UK17	Springfields	NFFEP	Irish Sea via River Ribble
UK18	Dounreay	DMLRW	Pentland Firth
UK19	Harwell	DMLRW	River Thames
UK20	Winfrith	DMLRW	Weymouth Bay (English Channel)

NPS: Nuclear Power Stations

NFRP: Nuclear Fuel Reprocessing Plants

RDF: Research and Development Facilities

NFFEP: Nuclear Fuel Fabrication and Enrichment Plants

DMLRW: Decommissioning and Management of Legacy Radioactive Wastes

Table 5 Nuclear Fuel Reprocessing Plants (operational discharges)			
	TBq released per annum	Normed Releases in TBq per Gwye	TBq released per annum
Location Ref	FR15	FR15	UK15
Year	2015	2015	2015
Site	La Hague	La Hague	Sellafield
Discharges to	English Channel	English Channel	Irish Sea
Type of fuel reprocessed	PWR, BWR	1205 tMLi pour 48GWa.e	Magnox, AGR, LWR
Capacity (t/y)	1600		
Tritium	1.37E+04	2.85E+02	1.51E+03
Total-a	2.14E-02	4.46E-04	1.70E-01
Total-b	4.56E+00	9.50E-02	7.70E+00
C14	8.52E+00	1.78E-01	4.93E+00
S35	ND	ND	
Mn54	3.72E-03	7.75E-05	
Fe55	ND	ND	
Co57	1.09E-04	2.27E-06	
Co58	7.87E-04	1.64E-05	
Co60	5.85E-02	1.22E-03	4.77E-02
Ni63	1.06E-02	2.21E-04	
Zn65	ND	ND	
Sr89	ND	ND	
Sr90	2.13E-01	4.44E-03	1.20E+00
(Sr90 + Cs137)	4.26E-01	8.88E-03	
(Zr + Nb95)	ND	ND	9.50E-02
Tc99	2.95E-02	6.15E-04	1.53E+00
Ru103	ND	ND	
Ru106	1.52E+00	3.17E-02	6.55E-01
(Ru + Rh) 106	3.04E+00	6.33E-02	
Ag110m	ND	ND	
Sb124	ND	ND	
Sb125	2.85E-01	5.94E-03	
I129	1.64E+00	3.42E-02	3.59E-01
Cs134	3.33E-02	6.94E-04	5.56E-02
Cs137	5.37E-01	1.12E-02	2.31E+00
Ce144	4.44E-05	9.25E-07	1.88E-01
(Ce + Pr) 144	8.88E-05	1.85E-06	
Pm147	ND	ND	
Eu152	ND	ND	
Eu154	2.01E-04	4.19E-06	
Eu155	1.40E-05	2.92E-07	
Np237	1.40E-04	2.92E-06	3.38E-02
Pu239+240	1.73E-03	3.60E-05	1.26E-01
Pu241	1.43E-01	2.98E-03	2.13E+00
Am241	2.15E-03	4.48E-05	2.66E-02
Cm242	5.44E-06	1.13E-07	
Cm 243+244	1.53E-03	3.19E-05	1.19E-03
Uranium (kg)	1.96E+01		
Notes	-1		-2.00E+00

Table 6 Nuclear Fuel Fabrication and Enrichment Plants (operational discharges) (in TBq/y) (2015 Data)									
Location Ref	Site	Discharges to	Type of Fuel	Capacity (t/y)	Production	Calculated Total-a	Calculated Total-b	Activity	TBq released
DE19	Gronau	Vechte, IJsselmeer	Uranium enrichment					Total-a	
ES04	Juzbado	River Tormes - Duero	PWR, BWR	400	3.23E+02	1.63E-05		Total-a	1.63E-05
UK16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment			2.09E-05		Uranium-a	4.67E-06
UK16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment					Uranium daughters	4.72E-06
UK16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment					Other-a	1.15E-05
UK16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment				4.35E-06	Tc99	4.35E-06
UK16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment					Tritium	
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication			2.29E-02		Total-a	2.29E-02
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication				1.84E+00	Total-b	1.84E+00
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Tc99	6.90E-03
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Th230	1.08E-03
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Th232	1.54E-04
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Uranium-a	1.83E-02
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Np237	1.90E-04

Table 7 Research and Development Facilities (operational discharges) (in TBq/y) (2014 Data)

Location Ref	Site	Discharges to	Reactors Number and Type	Installed Capacity	Calculated Total-a	Calculated Total-b	Radionuclides	TBq released per annum	Notes
BE03	Mol	River Mol-Neet	2				Co60	2.84E-05	
BE03	Mol	River Mol-Neet	2				Cs134	7.00E-06	
BE03	Mol	River Mol-Neet	2				Cs137	5.37E-04	
BE03	Mol	River Mol-Neet	2				H3	1.22E+00	
BE03	Mol	River Mol-Neet	2				Sr90/Y90	3.91E-05	
BE03	Mol	River Mol-Neet	2				Total activity	1.22E+00	
BE03	Mol	River Mol-Neet	2	129 MWth	8.55E-05		Total-a	8.55E-05	(1)
BE03	Mol	River Mol-Neet	2			7.53E-04	Total-b	1.41E-04	
CH05	Paul Scherrer Institute	Aare			2.30E-07		a-emitting radionuclides		
CH05	Paul Scherrer Institute	Aare					Ag110m	5.30E-08	
CH05	Paul Scherrer Institute	Aare					Ba133	4.70E-09	
CH05	Paul Scherrer Institute	Aare					Be7	1.80E-07	
CH05	Paul Scherrer Institute	Aare				1.68E-04	beta-and gamma-emitting radionuclides		
CH05	Paul Scherrer Institute	Aare					Bi207	2.10E-08	
CH05	Paul Scherrer Institute	Aare					Ca47	9.00E-08	
CH05	Paul Scherrer Institute	Aare					Co56	4.10E-09	
CH05	Paul Scherrer Institute	Aare					Co57	1.50E-08	
CH05	Paul Scherrer Institute	Aare					Co58	2.40E-09	
CH05	Paul Scherrer Institute	Aare					Co60	7.60E-06	
CH05	Paul Scherrer Institute	Aare					Cs134	2.50E-08	
CH05	Paul Scherrer Institute	Aare					Cs137	5.90E-05	
CH05	Paul Scherrer Institute	Aare					I125	9.50E-08	
CH05	Paul Scherrer Institute	Aare					Lu172	1.30E-07	
CH05	Paul Scherrer Institute	Aare					Lu173	1.50E-07	
CH05	Paul Scherrer Institute	Aare					Lu177	3.90E-05	
CH05	Paul Scherrer Institute	Aare					Mn54	5.60E-08	
CH05	Paul Scherrer Institute	Aare					Na22	2.60E-07	
CH05	Paul Scherrer Institute	Aare					Pu238/Am241	4.20E-08	
CH05	Paul Scherrer Institute	Aare					Pu239/240	4.20E-08	
CH05	Paul Scherrer Institute	Aare					S35	1.80E-05	
CH05	Paul Scherrer Institute	Aare					Sc46	5.90E-09	
CH05	Paul Scherrer Institute	Aare					Sc47	4.10E-07	
CH05	Paul Scherrer Institute	Aare					Sr90/Y90	3.80E-05	
CH05	Paul Scherrer Institute	Aare					Tb160	3.70E-08	
CH05	Paul Scherrer Institute	Aare					Tb161	5.30E-06	
CH05	Paul Scherrer Institute	Aare					Tritium	6.20E-01	
CH05	Paul Scherrer Institute	Aare					U234/238	1.50E-07	
CH05	Paul Scherrer Institute	Aare					Y88	2.40E-09	
DE18	Karlsruhe	Rhine	No reactors			3.10E-06	Other radionuclides	3.10E-06	
DE18	Karlsruhe	Rhine	No reactors		9.90E-07		Total a-activity	9.90E-07	
DE18	Karlsruhe	Rhine	No reactors				Tritium	4.00E-01	
DE24	HMI Berlin	Havel	1			4.00E-08	Other radionuclides	4.00E-08	
DE24	HMI Berlin	Havel	1				Total a-activity		
DE24	HMI Berlin	Havel	1				Tritium	2.50E-04	
DE25	Jülich	Rur	1			2.00E-04	Other radionuclides	2.00E-04	
DE25	Jülich	Rur	1				Total a-activity		shut down 2006
DE25	Jülich	Rur	1				Tritium	1.20E-01	
DE8b	Geesthacht	Elbe	1			7.40E-06	Other radionuclides	7.40E-06	
DE8b	Geesthacht	Elbe	1		7.10E-10		Total a-activity	7.10E-10	shut down 2010
DE8b	Geesthacht	Elbe	1				Tritium	4.20E-04	
FR19	Saclay	Etang de Saclay	2 research reactors (Orphée + Osiris)			1.00E-05	Other radionuclides	1.00E-05	mesures émetteurs

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FR19	Saclay	Etang de Saclay	2 research reactors (Orphée + Osiris)	4.60E-05	Total-a	4.60E-05	mesure alpha global
FR19	Saclay	Etang de Saclay	2 research reactors (Orphée + Osiris)		Tritium	1.33E-02	mesure tritium
NL04	Delft	Sewage system	1 Research reactor 2 MWth		g-emitting radionuclides		(2)(3)
NL04	Delft	Sewage system	1 Research reactor 2 MWth		Total		(2)(3)(4)
NL05	Petten	North Sea	1 high flux and 1 low flux research reactor		a-emitting radionuclides		(5)(6)
NL05	Petten	North Sea	1 high flux and 1 low flux research reactor		b/g-emitting radionuclides		(5)(6)(7)
NL05	Petten	North Sea	1 high flux and 1 low flux research reactor		Total		(5)(6)(7)
NL05	Petten	North Sea	1 high flux and 1 low flux research reactor		Tritium		(5)(6)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Ag110m	7.50E-07	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Cd109	4.50E-07	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Ce141	2.00E-07	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Ce144	2.30E-07	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Co58	1.10E-06	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Co60	1.40E-05	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Cr51	2.20E-05	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Cs134	2.20E-06	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Cs137	4.60E-05	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		I131	3.90E-06	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Mn54	6.70E-08	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Mn56	ND	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Nb95	1.70E-06	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Sb125	ND	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Sr90	5.90E-06	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Total-a	ND	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator	6.60E-01	Total-b	6.60E-01	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Tritium	6.60E-01	(8)(9)(10)
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator		Zr95	9.90E-07	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Ag110m	3.65E-08	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Am241	1.68E-08	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Ce144	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Co58	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Co60	1.62E-06	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Cs134	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Cs137	2.29E-06	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		I125	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		I131	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Pu238	8.80E-10	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Pu239/240	4.77E-08	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Pu241	NA	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Ru/Rh106	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Ru103	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Ru106	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Sb125	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Sr90	6.50E-07	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor	4.26E-07	Total-a	4.26E-07	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor	4.79E-06	Total-b	4.79E-06	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Tritium	9.15E-01	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Zn65	ND	(8)(9)(10)
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		Zr/Nb95	ND	(8)(9)(10)

Table 8 Discharges associated with historical or legacy wastes (exceptional discharges) (in TBq)

Location Ref	Site	Discharges to	Facility type	Tritium	other radionuclides (1)	Calculated total-a	Calculated total-b	total a-activity	total b-activity (ex.Tritium)	C14	Na22	S35	Co58	Co60	Zn65	Sr90	Zr/Nb95	Tc99	Ru106	Ag110m	Sb125	I129	Cs134	Cs137	Ce144	Np237	Pu239/240	Pu241	Am241	Cm243/244	Uranium (kg)	Notes			
D9b	Lingen	Ems	1 BWR	9.20E-07	1.60E-07		1.60E-07																	1.60E-07								(5)			
D10	Mülheim-Kärlich	Rhine	1 PWR	6.10E-07	1.10E-07		1.10E-07							3.20E-08																			(6)		
D12	Obrigheim	Neckar	1 PWR	3.40E-04	8.00E-05	1.40E-07	8.00E-05	1.40E-07						3.10E-05											1.40E-06								(7)		
D14	Rheinsberg	Havel	1 PWR	4.20E-07	2.80E-06	2.10E-07	2.80E-06	2.10E-07					2.10E-07											1.00E-06									(8)		
D15	Stade	Elbe	1 PWR	7.70E-06	6.30E-09	1.10E-10	6.30E-09	1.10E-10						2.60E-10											3.70E-09								(9)		
ES02	José Cabrera	Tagus	1PWR	1.40E-01	1.52E-04	2.85E-07	1.52E-04							5.03E-05	ND	8.58E-07			ND	ND	ND			ND	ND								(11)		
FR05	Chooz	Meuse	1 PWR	7.80E-04	3.36E-04		3.36E-04							3.86E-06	7.04E-06									3.32E-04	ND								(4)		
FR ?	AMI dont CHI A	Loire	Laboratory + 1 UNGG	9.59E-06	2.31E-06		2.31E-06							3.44E-07										1.97E-06											
FR15	La Hague	English Channel	PWR + BWR			1.30E-03	4.17E-02				ND	ND	ND	7.77E-05	ND	7.72E-03	ND	2.41E-02	ND	ND	ND	ND	ND	2.89E-02	ND	ND	ND	7.38E-03	ND	ND	ND				
FR17	Fontenay-aux-Roses	Seine	No reactors	5.30E-06		4.50E-07	3.40E-07																												
UK01	Berkeley	Severn	2 GCR	6.93E-05	7.20E-05		7.20E-05																	2.17E-04											
UK02	Bradwell	North Sea	2 GCR	3.23E-02	4.39E-03		4.39E-03																	2.20E-04											
UK04	Chapelcross	Solway Firth	4 GCR	8.66E-04	1.24E-03	2.00E-06	1.24E-03	2.00E-06																											
UK05a	Dungeness A	English Channel	2 GCR	3.27E-02	2.63E-03		2.63E-03																	9.10E-03											
UK08a	Hinkley Point A	Severn	2 GCR	3.18E-02	1.88E-01		1.88E-01																	2.08E-02											
UK09a	Hunterston A	Firth of Clyde	2 GCR	3.03E-04	7.17E-04	1.96E-04	7.17E-04	1.96E-04																			7.50E-05								
UK11a	Sizewell A	North Sea	2 GCR	1.98E-02	1.96E-02		1.96E-02																	4.21E-02											
UK13	Trawsfynydd	Trawsfynydd	2 GCR	5.70E-03	9.00E-04		9.00E-04																	3.00E-04										(13)	
UK15	Sellafield	Irish Sea	3 GCR, reprocessing, waste management	2.91E+01		1.67E-02	1.82E+00	1.67E-02	1.82E+00	2.41E-02				3.52E-03	3.88E-01	1.35E-03	1.23E-01	4.82E-02					6.02E-03	1.11E-02	7.74E-01	6.74E-03	2.71E-03	1.34E-02	2.21E-01	2.10E-03	1.07E-07			(14)	
UK18	Dounreay	Pentland Firth	No reactors	5.36E-02	1.22E-03	2.09E-04	1.22E-03	2.09E-04								2.25E-02								2.81E-03											
UK19	Harwell	River Thames	No reactors	1.46E-03		3.52E-06	3.75E-05	3.52E-06	3.75E-05					9.99E-07											7.72E-06										
UK20	Winfrith	Weymouth Bay	No reactors	2.29E+01	1.07E-03	8.68E-06	2.71E-03	8.68E-06																1.64E-03											

3.3 Endnotes to data tables 4 to 8

Table 4

- (1) The value indicated corresponds to the sum of individually assessed nuclides except tritium.
- (2) β -Activity for Tihange/Doel: Sr-89, Sr-90, Fe-55. Other radionuclides for Tihange/Doel: Cr-51, Mn-54, Co-57, Fe-59, Ru-103, Te-123m, Sb-124, I-131, Ba-140, La-140, Ce-141.
- (3) France explains that there is no simple relationship between the production of electricity and discharges of radioactive effluent other than tritium. This is because the amounts of effluent discharged depend on many factors: the condition of fuel cladding (first barrier), the processing carried out in the various existing plants, the operational mode of the reactor (load-following or providing basic power) and, above all, the volume of work carried out during shutdowns for refuelling.

Moreover, electricity is produced according to a programme fixed station by station at national level, and deliberate shutdowns, either during stand-by periods or for work to be carried out, are fixed by national criteria: the end of a natural cycle, arrangements for maintenance depending on the availability of teams of workers, constraints of the national grid and the demand for electricity.

It is easy to understand that a unit can operate over a calendar year and can produce a lot of power if it has been refuelled at the end of the previous year and if it is made to extend its cycle. In this case, the production of effluent will be minimised (no work is carried out). On the other hand, a unit shutdown for a long time (decennial shut-down, typically) will show an increase in the production of effluent and a decrease in the power supplied. During the next year, these two scenarios may be reversed. There is therefore good reason not to attempt a comparison of one site with another over short periods (= 10 years) as regards the quantity of radioactive effluent (other than tritium) discharged for a given amount of electrical energy produced.

In order to eliminate the variability associated with specific operating conditions of each reactor, it is more appropriate for a given year to consider the total amount of electricity generated by the French facilities in the OSPAR area. In 2012, their net electrical output was 315 millions of MWh.

- (4) Data from the producers EDF.
- (5) No power operation since 2011
- (6) "Total- β " values represent an assimilation of β -emitting and γ -emitting radionuclides.
- (7) Regarding the nuclear power plants, the discharge data have been estimated taking into account the criteria set out in Commission Recommendation 2004/2/Euratom of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation.
- (8) Other radionuclides for Almaraz: Cr-51, Mn-54, Fe-55, Fe-59, Co-58, Co-60, Ni-63, Zn-65, Sr-89, Sr-90, Nb-95, Zr-95, Ru-106, Ag-110m, Sb-122, Sb-124, Sb-125, Te-123m, I-131, Cs-134, Cs-137, Ce-144. Other radionuclides for Trillo: Mn-54, Fe-55, Co-58, Co-60, Ni-63, Nb-95, Zr-95, Ag-110m, Sb-124, Sb-125, Te-123m, Cs-134, Cs-137. In both cases activities for Fe-55 and Ni-63 have been estimated from Co-60 using factors that have been obtained as a result of the analysis of annual compound samples.
- (9) Total- α activity reported for Spanish NPP is actually a "Total- α " measurement.
- (10a) The value reported corresponds to the sum of individually assessed α -emitting radionuclides
- (10b) The value reported corresponds to the sum of individually assessed β -emitting radionuclides, excluding H-3 but including the other beta emitting nuclides in the table
- (10c) The value reported corresponds to the sum of the detected radionuclides not mentioned in the table

- (11) For Ringhals unit 1 the following radionuclides were detected: Cr-51, Mn-54, Fe-59, Co-57, Co-58, Co-60, Ni-63, Zn-65, As-76, Zr-95, Nb-95, Ag-110m, Sb-124, Sb-125, Sr-90, Te-123m, Cs-137, I-131, H-3, Pu-238, Pu-239/Pu-240, Am-241, Cm-242, Cm-244
- (12) For Ringhals unit 2 the following radionuclides were detected: Cr-51, Mn-54, Co-58, Co-60, Ni-63, Zr-95, Nb-95, Ag-110m, Sb-122, Sb-124, Sb-125, Sr-89, Sr-90, Te-123m, Cs-137, H-3, Pu-238, Pu-239/Pu-240, Am-241, Cm-242, Cm-244
- (13) For Ringhals unit 3 the following radionuclides were detected: Cr-51, Mn-54, Co-58, Co-60, Ni-63, Zr-95, Nb-95, Ag-108m, Ag-110m, Sb-124, Sb-125, Te-123m, Cs-137, H-3, Pu-238, Pu-239/Pu-240, Am-241, Cm-242, Cm-244
- (14) For Ringhals unit 4 the following radionuclides were detected: Cr-51, Mn-54, Fe-59, Co-57, Co-58, Co-60, Ni-63, Zr-95, Nb-95, Ag-110m, Sb-124, Sb-125, Te-123m, H-3, Pu-238, Pu-239/Pu-240, Am-241, Cm-242, Cm-244
- (15) Total-B value is the sum of the radioactivity of individual radionuclides that do not belong to tritium and alpha emitters.
- (16) Highest values of detection limit for Almaraz (Bq/m³) H-3: 2.25E+04, Co-60: 6.92E+03, Sr-90: 3.13E+02, Cs-137: 7.51E+03, Total-alpha: 8.88E+02. Highest values of detection limit for Trillo (Bq/m³) H-3: 5.01E+04, Co-60: 3.57E+03, Sr-90: 9.90E+02, Cs-137: 2.89E+03, Total-alpha: 8.57E+02.

Table 5

- (1) Discharges of the Centre de Stockage de la Manche (low and intermediate level waste disposal site) are included in the La Hague discharges.
- (2) The values of the liquid discharge limits for tritium and iodine-129 vary depending on the annual mass throughput of uranium in THORP (Thermal Oxide Reprocessing Plant), at Sellafield which was 230 te for 2012/2013.

Table 7

- (1) The installed capacity is the maximum value. The reactors function in a discontinuous way, often at a fraction of their maximum.
- (2) Delft site refers to Research Reactor of Technical University Delft and different laboratories.
- (3) The data represent the total emissions/discharges from the Reactor Institute Delft (RID) complex, including the Research Reactor (HOR) and different laboratories (it is not possible to make a distinction between the various sources). The discharges from the RID-HOR are substantially lower than the total values reported.
- (4) "Total-β" value represents all β-emitting nuclides, including tritium.
- (5) The data represent the total emissions/discharges from the Petten complex. This will lead to an overestimate of the discharges of the reactor (it is not possible to distinguish the discharges from the reactor). The LFR ("Low Flux Reactor") is no longer in use since December 2010.
- (6) Petten site refers to Research reactor of EU-JRC, the low-flux research reactor (no longer in use since December 2010), Hot Cell Laboratories, Mo Production Facilities and Decontamination and Waste Treatment of NRG.
- (7) "Total-β" value represents an assimilation of β-emitting and γ-emitting radionuclides.
- (8) Some radionuclides reported to be discharged in small amounts by IFE are not included as specific nuclides in the spreadsheet.

From IFE Halden, these radionuclides are: Fe-59, Zn-65, Zr-97, Ru-103, Ru-106, Sb-122, Sb-124, Hf-175 and Hf-181

All these have been included in the Total-β.

From IFE Kjeller, these radionuclides are: U-234 and U-238.

All these have been included in the Total-α.

(9) Figure for Total-β does not include tritium.

(10) The highest detection limits are listed in the following tables if available:

Radionuklide (Kjeller)	Highest DL [Bq/m ³]
³ H	2,00E+06
²² Na	1,20E+03
⁵¹ Cr	2,60E+03
⁵⁴ Mn	4,00E+02
⁵⁹ Fe	1,40E+02
⁵⁸ Co	1,00E+02
⁶⁰ Co	7,00E+02
⁶⁵ Zn	9,00E+02
⁹⁰ Sr	5,00E+00
⁹⁵ Zr	4,00E+02
⁹⁵ Nb	1,00E+02
¹⁰³ Ru	9,00E+01
¹⁰⁶ Ru	7,00E+03
^{110m} Ag	3,00E+02
¹²⁴ Sb	1,30E+03
¹²⁵ Sb	1,20E+02
¹²⁵ I	1,60E+04
¹³¹ I	4,00E+01
¹³⁴ Cs	6,00E+02
¹³⁷ Cs	5,00E+02
¹³³ Ba	4,00E+02
¹⁴⁴ Ce	2,00E+03
²²³ Ra	3,00E+02
²²⁷ Th	5,00E+02
²³⁴ U	2,60E+00
²³⁵ U	4,00E+00
²³⁸ U	2,80E+00
²³⁸ Pu	6,00E+00
^{239,240} Pu	4,00E+00
²⁴¹ Am	1,50E+00
²⁴⁴ Cm	1,20E+00

Radionuklide (Halden)	Highest DL [Bq/m ³]
H-3	3,00E+05
Cr-51	1,50E+03
Mn-54	9,50E+01
Fe-59	4,00E+02
Co-58	2,00E+02
Co-60	1,10E+02
Zn-65	8,00E+01
Sr-90	1,00E+00
Nb-95	1,25E+02
Zr-95	1,80E+02
Zr-97	1,43E+04
Ru-103	1,30E+02
Ru-106	2,50E+02
Cd-109	4,30E+02
Ag-110m	7,50E+01
Sb-122	2,00E+01
Sb-124	3,50E+01
I-131	2,40E+02
Cs-134	1,00E+02
Cs-137	3,00E+02
Ce-141	4,00E+01
Ce-144	2,50E+02
Eu-154	3,00E+01
Hf-175	6,00E+01
Hf-181	7,50E+01

Table 8

- (1) The value indicated corresponds to the sum of individually assessed nuclides except tritium.
- (2) Additionally reporting required at discharges of H-3 above 2 TBq in one month.
Additionally reporting required at discharges of Gross-β above 0,3E-03 TBq in one month.
- (3) All three Danish research reactors have been taken out of operation and the process of decommissioning has started. As a consequence the discharge limits and the reporting obligations set in the Operational limits and Conditions have been revised. The annual discharges reported are now exclusively from the Waste Management Plant.
- (4) France informs that the column entitled "other radionuclides" corresponds to the sum of monthly liquid discharges 2011 (PF+PA+Ni63, Fe55, Sr90, Tc99).
- (5) Shut down in 1977.
- (6) Shut down in 1986.
- (7) Shut down in 2005.
- (8) Shut down in 1990.
- (9) Shut down in 2003.

- (10) Shut down in 1994.
- (11) Other radionuclides for José Cabrera: Fe-55, Co-60, Ni-63, Sr-90, Cs-137.
- (12) A central interim storage facility including a waste treatment plant (ZWILAG) was put in operation in Switzerland. First year of reporting of discharges from this facility is 2005. Since 2010 only operational waste from the nuclear power stations and the research and development facility Paul Scherrer Institute is treated.
- (13) Trawsfynydd shut down in 1993, reactors decommissioned.
- (14) Total Beta is calculated in the same way as in Table 5

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