Radiological Protection

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Occupational Exposures at Nuclear Power Plants

Twenty-fifth Annual Report of the ISOE Programme, 2015

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Radiological Protection

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NEA/ISOE(2017)20

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 33 countries: Argentina, Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Korea, Romania, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission and the International Atomic Energy Agency also take part in the work of the Agency.

The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;
– to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

FOREWORD

Throughout the world, occupational exposures at nuclear power plants have steadily decreased since the early 1990s. Regulatory pressures, technological advances, improved plant designs and operational procedures, ALARA culture and experience exchange have contributed to this downward trend. However, with the continued ageing and possible life extensions of nuclear power plants worldwide, ongoing economic pressures, regulatory, social and political evolutions, and the potential for new nuclear builds, the task of ensuring that occupational exposures are as low as reasonably achievable (ALARA), and taking into account economic and social factors, continues to present challenges to radiation protection professionals.

Since 1992, the Information System on Occupational Exposure (ISOE), jointly sponsored by the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA), has provided a forum for radiological protection professionals from nuclear power utilities and national regulatory authorities worldwide to discuss, promote and co-ordinate international co-operative undertakings for the radiological protection of workers at nuclear power plants. The objective of ISOE is to improve the management of occupational exposures at nuclear power plants by exchanging broad and regularly updated information, data and experience on methods to optimise occupational radiation protection.

As a technical exchange initiative, the ISOE Programme includes a global occupational exposure data collection and analysis programme, culminating in the world's largest occupational exposure database for nuclear power plants, and an information network for sharing dose reduction information and experience. Since its launch, the ISOE participants have used this system of databases and communications networks to exchange occupational exposure data and information for dose trend analyses, technique comparisons, and cost-benefit, as well as other analyses, promoting the application of the ALARA principle in local radiological protection programmes.

The Twenty-Fifth Annual Report of the ISOE Programme presents the status of the ISOE programme for the year of 2015.

"... the exchange and analysis of information and data on ALARA experience, dose-reduction techniques, and individual and collective radiation doses to the personnel of nuclear installations and to the employees of contractors are essential to implement effective dose management programmes and to apply the ALARA principle." (ISOE Terms and Conditions, 2012-2015).

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EXECUTIVE SUMMARY

Since 1992, the Information System on Occupational Exposure (ISOE) has supported the optimisation of worker radiological protection in nuclear power plants through a worldwide information and experience exchange network for radiation protection professionals at nuclear power plants and national regulatory authorities, and through the publication of relevant technical resources for ALARA management. This 25th Annual Report of the ISOE Programme presents the status of the ISOE programme for the calendar year 2015.

ISOE is jointly sponsored by the OECD/NEA and IAEA, and its membership is open to nuclear electricity utilities and radiation protection regulatory authorities worldwide who accept the programme's Terms and Conditions. The current ISOE Terms and Conditions for the period 2012-2015 came into force on 1 January 2012. As of 31 December 2015, the ISOE programme included 75 Participating Utilities in 29[1] countries (349 operating units; 57 shutdown units), as well as the regulatory authorities in 24 countries. The ISOE database includes occupational exposure information for over 400 operating units in 29 countries, covering about 84% of the world's operating commercial power reactors. Four ISOE Technical Centres (Europe, North America, Asia and IAEA) manage the programme's day-to-day technical operations.

Based on the occupational exposure data supplied by ISOE members for operating power reactors, the 2015 average annual collective doses per reactor and 3-year rolling averages per reactor (2013-2015) were:

	2015 average annual collective dose (person·Sv/reactor)	**3-year rolling average for 2013-2015 (person·Sv/reactor)**
Pressurised water reactors (PWR)	0.48	0.49
Pressurised water reactors (VVER)	0.45	0.44
Boiling water reactors (BWR)	0.95	0.85
Pressurised heavy water reactors (PHWR/CANDU)	0.76	0.78

In addition to information from operating reactors, the ISOE database contains dose data from 101 reactors which are shut down or in some stage of decommissioning. As these reactor units are generally of different type and size, and at different phases of their decommissioning programmes, it is difficult to identify clear dose trends. However, work continued in 2015 to improve the data collection for such reactors in order to facilitate better benchmarking. Details on occupational dose trends for operating reactors, and reactors undergoing decommissioning are provided in Section 2 of the report.

While ISOE is well known for its occupational exposure data and analyses, the programme's strength comes from its objective to share such information broadly amongst its participants. In 2015, the ISOE Network website (www.isoe-network.net) continued to provide the ISOE membership with a comprehensive web-based information and experience exchange portal on dose reduction and ISOE ALARA resources.

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[1] Dose info and principal events of 2015 are not presented for Belarus and United Arab Emirates which do not have NPPs in operation (or decommissioning).

The annual ISOE ALARA Symposia on occupational exposure management at nuclear power plants continued to provide an important forum for ISOE participants and for vendors to exchange practical information and experience on occupational exposure issues. The technical centres continued to host international / regional symposia, which in 2015 included the ISOE North-American ALARA Symposium organised by the North American Technical Centre in Fort Lauderdale (USA) on 12-14 January; the ISOE International ALARA Symposium organised by the IAEA Technical Centre in Rio de Janeiro (Brazil) on 26-27 May; and the ISOE Asian Symposium organised by the Asian Technical Centre in Tokyo (Japan) on 9-10 September. Regional and international symposia provide a global forum to promote the exchange of ideas and management approaches for maintaining occupational radiation exposures as low as reasonably achievable.

Of importance is the support that the technical centres supply in response to special requests for rapid technical feedback and in the organisation of voluntary site benchmarking visits for dose reduction information exchange between ISOE regions. The combination of ISOE symposia and technical visits provides a means for radiation protection professionals to meet, share information and build links between ISOE regions to develop a global approach to occupational exposure management.

The ISOE Working Group on Data Analysis (WGDA) continued its activities in support of the technical analysis of the ISOE data and experience, focusing largely on the integrity and consistency of the ISOE database.

The ISOE Working Group on Radiological Protection Aspects of Decommissioning Activities at Nuclear Power Plants (WGDECOM) became a formal working group and began its activities to develop a process within the ISOE programme to better share operational Radiation Protection (RP) data and experience for Nuclear Power Plants (NPPs) in some stage of decommissioning, or in preparation for decommissioning.

The ISOE Expert Group on Severe Accident Management (EG-SAM) published its final report early in 2015 which is now available through the OECD iLibrary and ISOE Network website under the title, “Occupational Radiation Protection in Severe Accident Management (EG-SAM) Report”.

Principal events in the ISOE participating countries are summarised in Section 3 of this report.

1. STATUS OF PARTICIPATION IN THE INFORMATION SYSTEM ON OCCUPATIONAL EXPOSURE (ISOE)

Since 1992, ISOE has supported the optimisation of worker radiological protection in nuclear power plants through a worldwide information and experience exchange network for radiation protection professionals from utilities and national regulatory authorities, and through the publication of relevant technical resources for ALARA management. The ISOE programme includes a global occupational exposure data collection and analysis programme, culminating in the world's largest database on occupational exposures at nuclear power plants, and a communications network for sharing dose reduction information and experience. Since the launch of ISOE, participants have used these resources to exchange occupational exposure data and information for dose trend analyses, technique comparisons, and cost-benefit and other analyses promoting the application of the ALARA principle in local radiation protection programmes, and the sharing of experience globally.

ISOE Participants include nuclear electricity utilities (public and private), national regulatory authorities (or institutions representing them) and ISOE Technical Centres who have agreed to participate in the operation of ISOE under its Terms and Conditions (2012-2015). Four ISOE Technical Centres (Asia, Europe, North America and IAEA) manage the day-to-day technical operations in support of the membership in the four ISOE regions (see Annex 3 for country-technical centre affiliation). The objective of ISOE is to make available to the Participants:

- broad and regularly updated information on methods to improve the protection of workers and on occupational exposure in nuclear power plants; and
- a mechanism for dissemination of information on these issues, including evaluation and analysis of the data assembled, as a contribution to the optimisation of radiation protection.

Based on feedback received by the ISOE Secretariat as of December 2015, the ISOE programme included: 75 Participating Utilities[2]in 29 countries, covering 349 operating units and 57 shutdown units, and the Regulatory Authorities in 24 countries. Table 1 summarises total participation by country, type of reactor and reactor status as of December 2015. A complete list of reactors, utilities and authorities officially participating in ISOE at the time of publication of this report is provided in Annex 1.

In addition to exposure data provided annually by Participating Utilities, Participating Authorities may also contribute with official national data in cases where some of their licensees are not ISOE members. The ISOE database thus includes occupational exposure data and information of 473 reactor units in 29 countries (372 operating; 101 in cold-shutdown or some stage of decommissioning), covering about 84% of the world's operating commercial power reactors. The ISOE database is made available to all ISOE members, according to their status as a participating utility or authority, through the ISOE Network website.

[2] Represents the number of leading utilities; in some cases, plants are owned/operated by multiple enterprises.

Table 1. The Official ISOE Participants and the ISOE Database (as of December 2015)

Note: The list of the Official ISOE Participants at the time of the publication of this report is provided in Annex 1.

Operating reactors: ISOE Participants

Country	PWR	VVER	BWR	PHWR	GCR	LWGR	Total
Armenia	–	1	–	–	–	–	1
Belgium	7	–	–	–	–	–	7
Brazil	2	–	–	–	–	–	2
Bulgaria	–	2	–	–	–	–	2
Canada	–	–	–	19	–	–	19
China	7	2	–	–	–	–	9
Czech Republic	-	6	–	–	–	–	6
Finland	-	2	2	–	–	–	4
France	58	–	–	–	–	–	58
Germany	7	–	2	–	–	–	9
Hungary	–	4	–	–	–	–	4
Japan	24	–	24	–	–	–	48
Korea	20	–	–	4	–	–	24
Mexico	–	–	2	–	–	–	2
Netherlands	1	–	–	–	–	–	1
Pakistan	2	–	–	1	–	–	3
Romania	–	–	–	2	–	–	2
Russia	–	17	–	–	–	–	17
Slovak Republic	–	4	–	–	–	–	4
Slovenia	1	–	–	–	–	–	1
South Africa	2	–	–	–	–	–	2
Spain	6	–	1	–	–	–	7
Sweden	3	–	7	–	–	–	10
Switzerland	3	–	2	–	–	–	5
Ukraine	–	15	–	–	–	–	15
United Kingdom	1	–	–	–	–	–	1
United States	57	–	29	–	–	–	86
Total	**201**	**53**	**69**	**26**	**–**	–	**349**

Operating reactors: Not participating in ISOE, but included in the ISOE database

Country	PWR/VVER	BWR	PHWR	GCR	LWGR	Total
Russia	1	–	–	–	–	1
United Kingdom	–	–	–	14	–	14
United States	3	5	–	–	–	8
Total	**4**	**5**	–	**14**	–	**23**

Total number of operating reactors included in the ISOE database

	PWR/VVER	BWR	PHWR	GCR	LWGR	Total
Total	**258**	**74**	**26**	**14**	–	**372**

Table 1. The Official ISOE Participants and the ISOE Database (as of December 2015) (Cont'd)

Definitively shutdown reactors: ISOE Participants							
Country	**PWR/ VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Bulgaria	4	–	–	–	–	–	4
Canada	–	–	3	–	–	–	3
France	1	–	–	6	–	–	7
Germany	4	4	–	–	–	–	8
Italy	1	2	–	1	–	–	4
Japan	–	8	–	1	–	1	10
Lithuania	–	–	–	–	2	–	2
Russia	2	–	–	–	–	–	2
Spain	1	1	–	1	–	–	3
Sweden	–	2	–	–	–	–	2
United States	8	4	–	1	–	1	14
Total	**21**	**21**	**3**	**10**	**2**	**2**	**59**
Definitively shutdown reactors: Not participating in ISOE but included in the ISOE database							
Country	**PWR/ VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Canada	–	–	3	–	–	–	3
Germany	3	1	–	2	–	–	6
Netherlands	–	1	–	–	–	–	1
Spain	–	–	–	–	–	–	0
Ukraine	–	–	–	–	3	–	3
United Kingdom	–	–	–	20	–	–	20
United States	6	2	–	1	–	–	9
Total	**9**	**4**	**3**	**23**	**3**	**–**	**42**
Total number of definitively shutdown reactors included in the ISOE database							
	PWR/ VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Total	**30**	**25**	**6**	**33**	**5**	**2**	**101**

Total number of reactors included in the ISOE database							
	PWR/ VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Total	**288**	**99**	**32**	**47**	**5**	**2**	**473**

Number of **Participating Countries**	**29**
Number of **Participating Utilities**[3]	**69**
Number of **Participating Authorities**[4]	**26**

3. Represents the number of lead utilities; in some cases, plants are owned/operated by multiple enterprises.
4. Three countries participate with two authorities.

2. OCCUPATIONAL EXPOSURE TRENDS

A key element of the ISOE is the tracking of occupational exposure trends from nuclear power facilities worldwide for benchmarking, comparative analysis, and experience exchanges amongst the ISOE members. This information is maintained in the ISOE Occupational Exposure Database which contains annual occupational exposure data supplied by Participating Utilities. The current ISOE database includes the following data types:

- Dosimetric information from commercial NPPs in operation, shut down or in some stage of decommissioning, including:
  - annual collective dose for normal operation,
  - maintenance/refuelling outage,
  - unplanned outage periods, and
  - annual collective dose for certain tasks and worker categories.

The two following data types (known previously as ISOE2 and ISOE3) had been collected in previous years. The data are available for historical consideration to Utilities on the ISOE Network website in the RP Library.

- Plant-specific information relevant to dose reduction, such as materials, water chemistry, start-up/shutdown procedures, cobalt reduction programme, etc. (ISOE2);
- Radiation protection related information for specific operations, jobs, procedures, equipment or tasks (radiological lessons learned), such as:
  - effective dose reduction,
  - effective decontamination, and
  - implementation of work management principles (ISOE3).

Using the ISOE database, ISOE members can perform various benchmarking and trend analyses by country, by reactor type, or by other criteria such as sister-unit grouping. The summary below provides highlights of the general trends in occupational doses at nuclear power plants.

2.1 Occupational exposure trends: Operating reactors

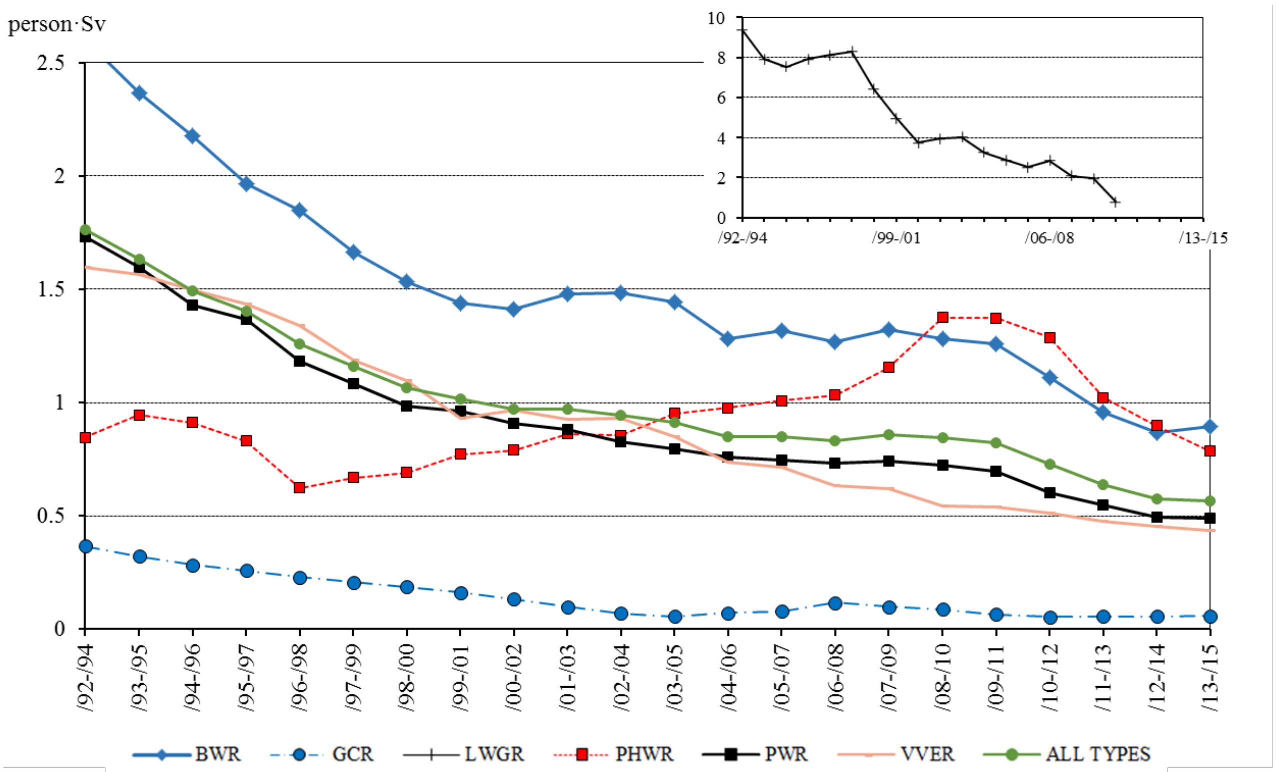
a) Global trends by reactor type

Figures 1 shows the trend in 3-year rolling average collective dose per reactor, by reactor type, for 1992-2015. In spite of some yearly variations, the clear downward dose trend in most reactors has continued, with the exception of PHWRs, which have shown a slight increasing trend since the lows achieved in the 1996-1998 time period.

PHWRs have shown a increasing trend in 3-year rolling average collective dose from 1996-98 to 2009-11, as seen in Figure 1. This can be partially explained by aging of a large number of operating PHWR reactors contributing data to ISOE database. When the trend toward higher does began in 1996-98 3-year rolling average collective dose, the average age of PHWRs in operation was 15 years, with the oldest in the fleet having been in operation for 27 years (Pickering 1) and the newest for only 1 year (Wolsong 2). Between 1998 and 2015, only 3 additional, newly commissioned PHWR reactors began reporting into ISOE. The preparation for and decommissioning of Gentilly 2 since its shutdown in 2012, as well as Pickering 2 and 3 moving to safe storage since 2010, appear to have made contributions to the reduction of collective dose among the PHWRs. The remaining fleet of operational PHWR reactors are ageing, which continues a trend towards requirements for increased maintenance, and therefore increased dose. Source term reduction efforts and other ALARA initiatives have been introduced to counteract the trend towards increased dose and since 2011 the PHWR average collective dose per reactor has begun to trend downward again. See the Country Reports for Canada, Korea, Pakistan, and Romania for more details on this type of reactor.

Average annual collective dose per reactor by country and reactor type for the period of 2013-2015 and 3 year rolling average annual collective dose per reactor, by country and reactor type for the period of 2011-2013 to 2013-2015 are given in table 2 and 3 respectively. These results are based primarily on data reported and recorded in the ISOE database during 2015, supplemented by the individual country reports (Section 3) as required. Figure 2 to 5 provide information on average collective dose per reactor by country for PWR, VVER, BWR and PHWR reactors. In all figures, the "number of units" refers to the number of reactor units for which data has been reported for 2015.

Figure 1. 3-year rolling average collective dose per reactor for all operating reactors included in ISOE by reactor type, 1992-2015 (person·Sv/reactor)



b) Average annual collective dose trends by country

Table 2 provides information on average annual collective dose per reactor by country and reactor type for the last three years. Most countries have maintained a relatively stable average collective dose over this period, allowing for some annual fluctuation which normally accompanies periodic tasks, with a few exceptions.

Among the PWR units, there have been slight increases in the average annual collective dose trends in South Africa and Belgium; mostly related to maintenance activities. Decreases were noted in China, Germany, and Slovenia; where planned upgrades were completed, reducing occupational exposures during normal operations. Hungary's VVERs also completed planned upgrades, resulting in lower exposures.

Mexico's two BWR units have reported higher collective doses per reactor for the last two years. The main sources of higher collective doses than other BWR units is attributed to equipment reliability issues and refuelling outages. Specifically, the Country Report notes an increase of radioactive source term following the application and noble metals and hydrogen since 2006, which was applied to prevent the stress corrosion and cracking of reactor internals.

Figures 2 to 5 show this tabular data from Table 2 in a bar-chart format, for 2015 only, ranked from highest to lowest average dose. Please note that due to the complex parameters driving the collective doses and the varieties of the contributing plants, these figures do not allow derivation of any conclusions on the quality of radiation protection performance in the countries addressed.

Table 2. **Average annual collective dose per reactor, by country and reactor type, 2013-2015 (person·Sv/reactor)**

	PWR			VVER			BWR		
	2013	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Armenia				0.73	1.01	0.89			
Belgium	0.19	0.25	0.32						
Brazil	0.48	0.34	0.33						
Bulgaria				0.23	0.30	0.45			
Canada									
China	0.86	0.46	0.52	0.23	0.25	0.26			
Czech Republic				0.12	0.11	0.14			
Finland				0.27	0.42	0.26	0.32	0.32	0.40
France	0.79	0.72	0.71						
Germany	0.29	0.15	0.15				1.09	1.16	1.11
Hungary				0.50	0.39	0.33			
Japan	0.23	0.23	0.19				0.20	0.19	0.22
Korea, Republic of	0.53	0.36	0.36						
Mexico							0.67	5.91	4.83
Netherlands	0.83	0.23	0.22						
Pakistan	0.53	0.60	0.59						
Romania									
Russia				0.52	0.62	0.56			
Slovak Republic				0.13	0.14	0.18			
Slovenia	1.35	0.11	0.79						
South Africa	0.30	0.28	1.09						
Spain	0.39	0.39	0.38				2.25	0.29	2.47
Sweden	0.52	0.72	0.68				0.71	0.94	0.83
Switzerland	0.35	0.26	0.57				1.11	1.23	1.23
Ukraine				0.53	0.48	0.55			
United Kingdom	0.39	0.37	0.05						
United States	0.36	0.51	0.45				1.27	1.09	1.23
Average	**0.50**	**0.49**	**0.48**	**0.42**	**0.44**	**0.45**	**0.84**	**0.89**	**0.95**

Note: Data provided directly from country report, rather than calculated from the ISOE database: UK - GCR: 2010 – 2015. Japan - BWR: 2011 – 2015 doses do not include Fukushima Daiichi Units 1-6.

	PHWR			GCR		
	2013	**2014**	**2015**	**2013**	**2014**	**2015**
Canada	0.85	0.90	0.83			
Korea, Republic of	0.49	0.37	0.43			
Pakistan	1.68	2.01	1.84			
Romania	0.25	0.30	0.19			
United Kingdom				0.03	0.08	0.07
Average	**0.78**	**0.81**	**0.76**	**0.03**	**0.07**	**0.07**

	2013	**2014**	**2015**
Global Average	0.51	0.54	0.54

Figure 2. 2015 PWR average collective dose per reactor by country (person·Sv/reactor)

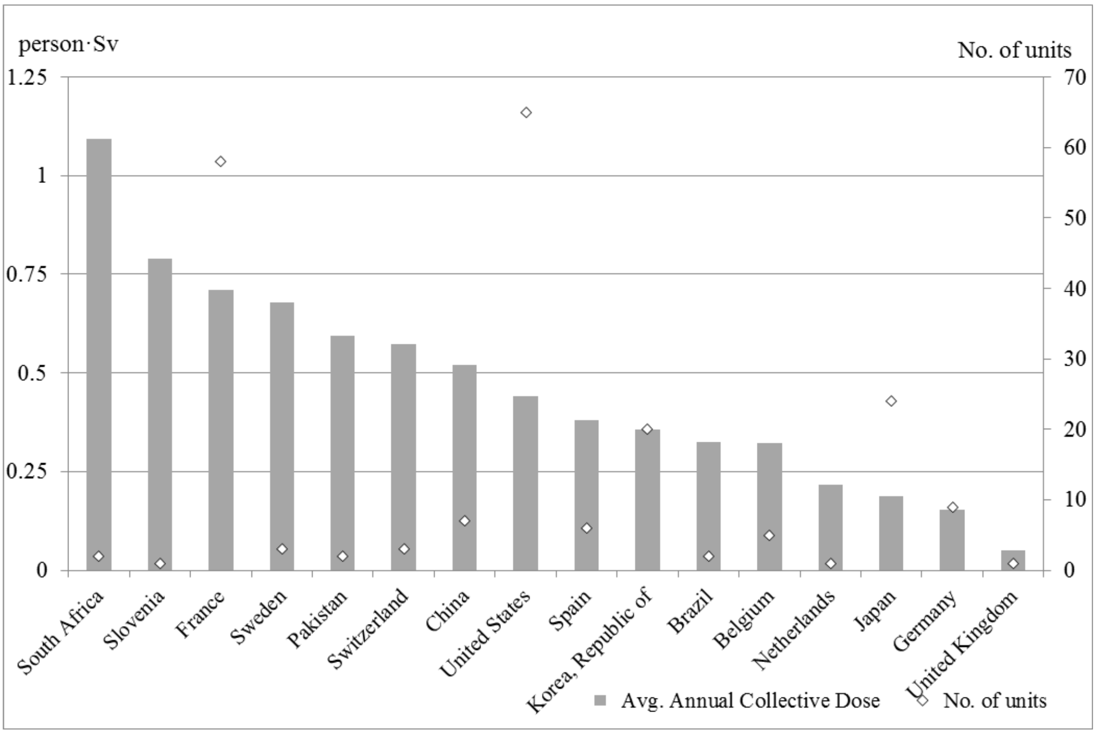


Figure 3. 2015 VVER average collective dose per reactor by country (person·Sv/reactor)

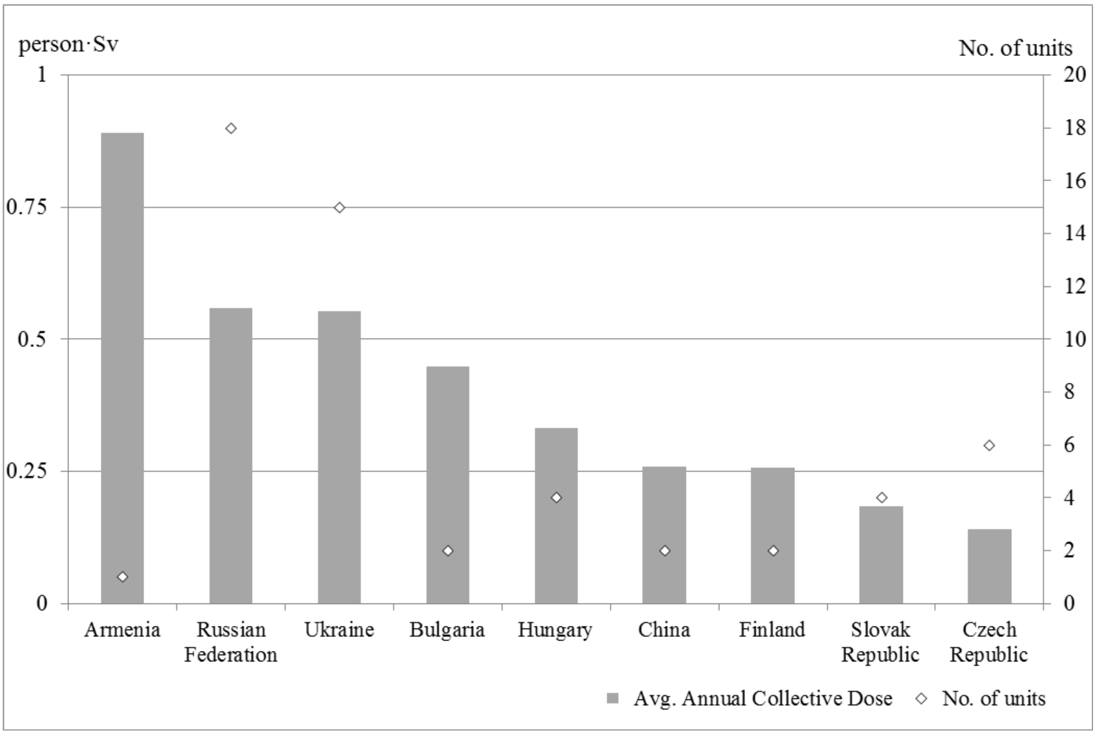
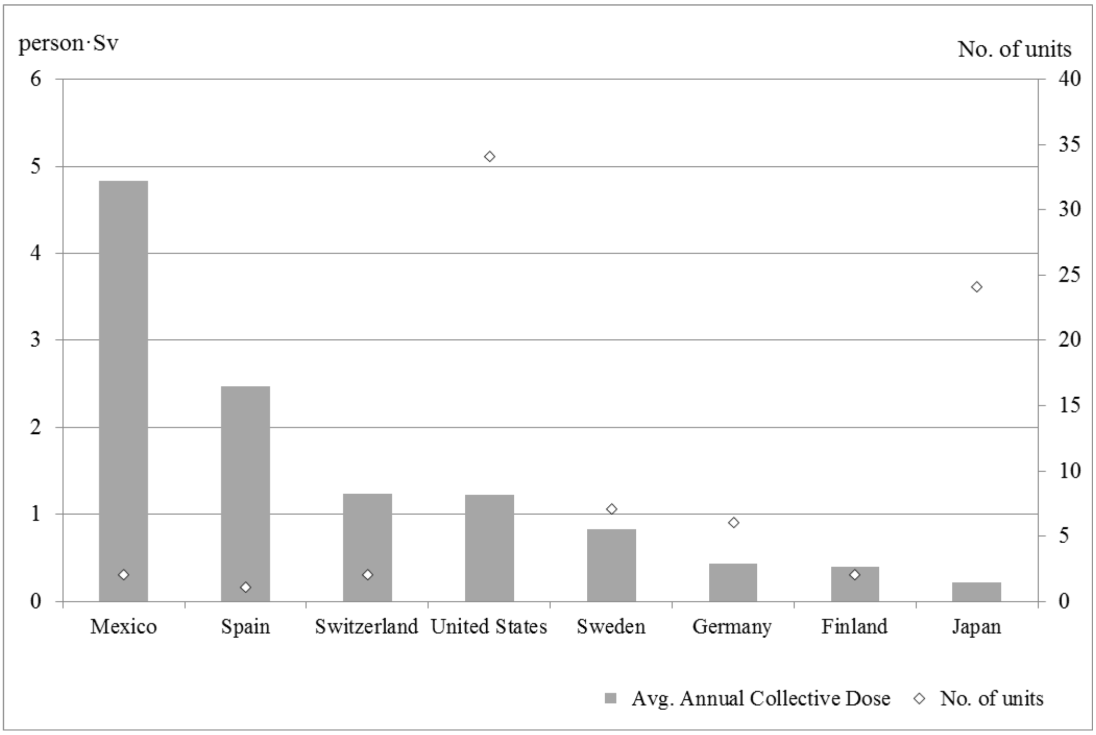
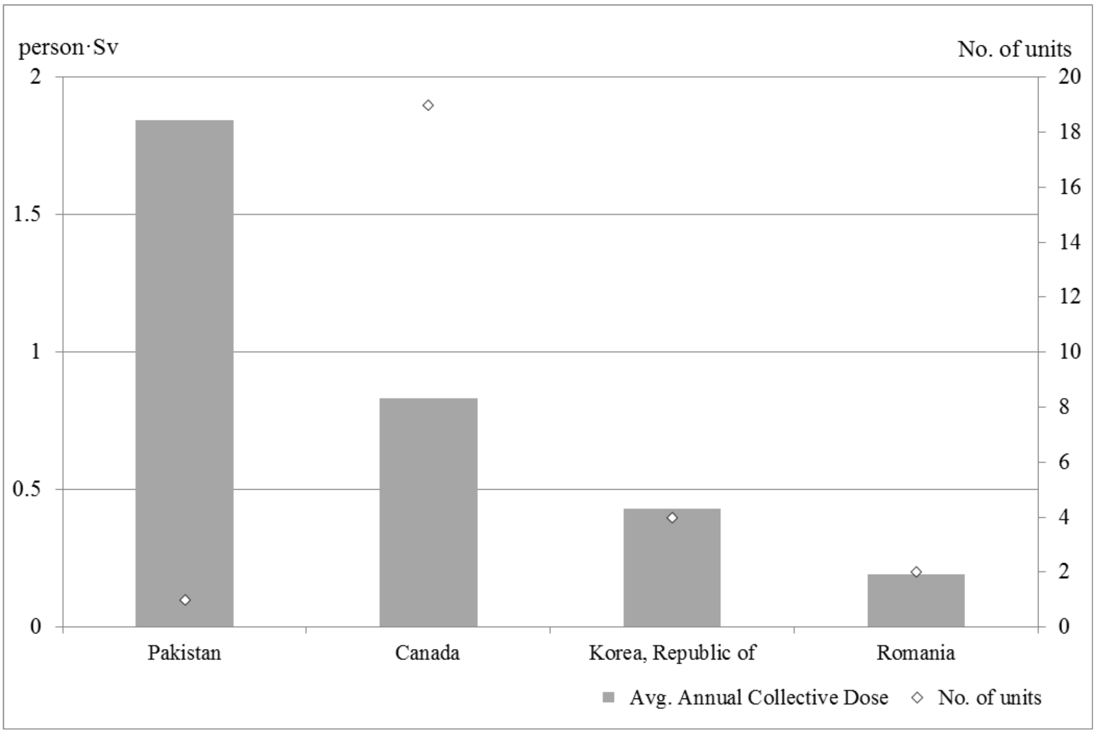


Figure 4. 2015 BWR average collective dose per reactor by country (person ·Sv/reactor)



Note: BWR dose in 2015 for Japan does not include Fukushima Daiichi Units 1-6.

Figure 5. 2015 PHWR average collective dose per reactor by country (person ·Sv/reactor)



c) 3-year rolling average collective dose trends by country

Table 3 provides information on 3-year rolling average annual collective dose per reactor, by country and reactor type for the period of 2011-2013 to 2013-2015. Figures 6-14 present the 3 -year rolling average annual collective dose at operational units from 1999 to 2012 in different countries by taking into account the reactor types, including PWR, VVER, BWR and PHWR.

Table 3. **3-year rolling average annual collective dose per reactor, by country and reactor type, 2011-2013 to 2013-2015 (person·Sv/reactor)**

	PWR			**VVER**			**BWR**		
	/11-/13	**/12-/14**	**/13-/15**	**/11-/13**	**/12-/14**	**/13-/15**	**/11-/13**	**/12-/14**	**/13-/15**
Armenia				0.96	0.88	0.87			
Belgium	0.30	0.26	0.26						
Brazil	0.31	0.30	0.38						
Bulgaria				0.23	0.23	0.32			
Canada									
China	0.61	0.59	0.61	0.23	0.24	0.25			
Czech Republic				0.12	0.12	0.13			
Finland				0.49	0.51	0.32	0.39	0.33	0.35
France	0.73	0.73	0.74						
Germany	0.32	0.23	0.22				0.92	1.11	1.12
Hungary				0.51	0.45	0.41			
Japan	0.46	0.21	0.22				0.51	0.23	0.21
Korea, Republic of	0.50	0.44	0.42						
Mexico							1.93	3.62	3.81
Netherlands	0.48	0.46	0.43						
Pakistan	0.28	0.40	0.57						
Romania									
Russia				0.60	0.58	0.56			
Slovak Republic				0.15	0.15	0.15			
Slovenia	0.77	0.78	0.75						
South Africa	0.54	0.45	0.56						
Spain	0.45	0.42	0.39				1.50	0.93	1.67
Sweden	0.83	0.59	0.64				0.82	0.77	0.83
Switzerland	0.38	0.35	0.39				1.23	1.28	1.19
Ukraine				0.57	0.53	0.52			
United Kingdom	0.32	0.26	0.27						
United States	0.52	0.49	0.44				1.27	1.16	1.19
Average	**0.55**	**0.50**	**0.49**	**0.48**	**0.45**	**0.44**	**0.96**	**0.87**	**0.89**

	PHWR			**GCR**			**LWGR**		
	/11-/13	**/12-/14**	**/13-/15**	**/11-/13**	**/12-/14**	**/13-/15**	**/11-/13**	**/12-/14**	**/13-/15**
Canada	1.12	1.00	0.86						
Korea, Republic of	0.55	0.50	0.43						
Pakistan	2.33	1.67	1.85						
Romania	0.30	0.34	0.25						
United Kingdom				0.06	0.06	0.06			
Average	**1.02**	**0.90**	**0.78**	**0.06**	**0.06**	**0.06**	-	-	-

	/11-/13	**/12-/14**	**/13-/15**
Global Average	**0.61**	**0.55**	**0.53**

Note: calculated from the ISOE database, supplemented by data provided directly by country (See Notes, Table 2).

The following discussion provides a brief overview of the results and trends observed in the four ISOE regions. However, it is noted that due to the various power plant designs and the complex parameters influencing collective doses, these analyses and figures do not support any conclusions with regard to the quality of radiation protection performance in the countries addressed. More detailed discussion and analyses of dose trends in individual countries are provided in Section 3.

European Region

In 2015, the average annual collective dose per reactor for all PWRs increased slightly compared to in 2014 going from 0.58 man·Sv to 0.60 man·Sv for PWRs (mainly due to Swiss and Belgian results) and decreased slightly for VVERs from 0.43 to 0.40 man·Sv (mainly due to Finnish and Russian results). The average collective dose for all BWRs also increased slightly compared to the year before, with a value of 0.99 man·Sv in 2015 compared to 0.88 man·Sv in 2014, mainly due to the Spanish results. Among the reasons which can explain such increases, it can be noted that year 2015 was marked by the following situations in the main countries affected:

- ↑Switzerland: outages performed for all units, with major projects at NPP Beznau,
- ↑Belgium: unplanned outages at 2 units, extensive outages for 3 units, replacement of vessel heads on 2 units,
- ↓Finland: short refuelling outages at 3 of 4 units, implementation of RI-ISI programme for pipe-inspections,
- ↓Russia: major repair outage at 5 units, decrease in total number and duration of planned outages from previous year,
- ↓Spain: 40-50 day outages at 5 of 6 units, 1 outage lasted 117 days, 1 reactor vessel head replacement, 1 unplanned outage to change damaged elements.

The 3-year rolling average annual collective dose, which provides a better representation of the general trend in dose, shows a stability of PWR average, a decrease for VVERs, and an increase for BWRs.

For further information on the evolution of collective doses in different countries, please see the ***ISOE European Technical Centre - Information Sheet No. 60***, available on the ISOE Network website.

Asian Region

In the Asian region, the 2013-2015 3-year rolling average annual collective dose showed a steady trend for the Japanese BWRs, PWRs, and Korean PWRs after a decrease in the 2011-2013. A decreasing trend was observed for the Korean PHWRs 3-year rolling average annual collective dose since the 2012-2014 period. In the ISOE database, Japan BWR dose data from 2011-2015 exclude Fukushima Daiichi Units 1-6, in order to make comparisons without the influence of the emergency response confounding the analyses.

The average annual collective doses per reactor for the Japanese BWRs and PWRs were 2.60 man·Sv and 0.18 man·Sv respectively. The PWR collective dose per reactor for 2015 slightly decreased from the previous year by 0.05 man·Sv. In fiscal year 2015, only 3 Japanese PWRs operated.

For the year 2015, 25 NPPs were in operation; 21 PWR units (Shin Kori #3 is under commissioning) and 4 PHWR units. The trend on the number of units is shown in Figure 1. The average collective dose per unit for the year 2015 was 354.46 man·mSv/unit; 310.52 man·mSv/unit (PWR) and 585.15 man·mSv/unit (PHWR).

For further information on dosimetry in Japan and Korea, please see the ***ISOE Asian Technical Centre - Information Sheets No. 43 and No. 44***, available on the ISOE Network website.

North American Region

In the North American region, the North American Technical Center provided technical radiological engineering and ALARA planning support to the North American ISOE utility and regulator members in 2015. Significant occupational dose challenges due to nuclear plant modernisation initiatives, major component failures and unit refurbishments are described by country below:

Canada:

Bruce Power A - Outage work scope accounted for 92% of the total annual dose for Bruce A. Planned outage work scope included fuel inspection, boiler work, condenser repair, feeder repair, feeder replacement, Grayloc refurbishment and feeder replacement.

Bruce Power B – Outage activities accounted for approximately 81% of the total collective dose. Planned outage work scope included feeder inspections in Unit 6 and a vacuum building inspection. Routine opertations accounted for approximately 19% of the total station collective dose.

Darlington Units 1-4 – Darlington Units 1-4 had routine operations dose of 0.329 person-Sv. The total outage dose was 2.312 person-Sv. The internal dose was 0.485 person-Sv. The external dose was 2.155 person-Sv which resulted in an average collective dose 0.660 person-Sv/unit.

Pickering – Outage activities accounted for approximately 87% of the collective dose. Routine operations accounted for approximately 13% of the toal collective dose. Internal dose accounted for approximately 15% of the total collective dose. This decrease was attributed to the scope and type of work performed.

Point Lepreau – Fully operational with a total of 58 outage days. Outage activities accounted for approximately 35% of the total collective dose. Internal dose accounted for approximately 20% of the toal collective dose, which is a slight increase over the previous year. This increased dose contribution from tritium was due in part to a leaking fitting on the primary heat transport system.

Gentilly-2 – There was a decrease in the collective doses at Gentilly-2 because the majority of radiological work activities with the transition from an operational unit to a safe storage state occurred in 2014. The 2015 collective dose is only attributed to the safe storage transition activities.

Mexico: Shortfalls and failures in equipment reliabilities such as steam leaks, reator water cleanup system pump failures, and radwaste treatment system failures. Reactor water chemical instability induced in turn but the application of noble metals and hydrogen since 2006 to prevent the stress corrosion cracking of reactor internals. The main problem associated with the high collective dose at Laguna Verde NPS is the continued increase of the radioactive source term (insoluble Cobalt deposited in the internal surfaces of piping, valves, and equipment in contact with the reactor water coolant.

USA: The total collective dose for the 99 reactors in 2015 was 70 185.15 person mSv, a decrease of 1.5% from the 2014 total collective dose of 71 244.6 person mSv from 99 operating reactors. The resulting average collective dose per reactor for USA LWR was 708.94 person mSv/unit or a 4.6% decrease from 2014 (742.13 person mSv/reactor unit). Two individuals received between 20-30 mSv at a US PWR site in 2015. Most US BWR units are on 24-month refuelling cycles. US BWRs have faced occupational dose challenges due to high CRUD levels on piping, and power up-rates modifications in 2015. Four US PWRs continued their transistions to decommissioning status.

For more detailed information each countries activities, please see the corresponding Country Reports in Section 3.

Figure 6. 3-Year rolling average collective dose by country from 2002 to 2015 for PWRs (1)

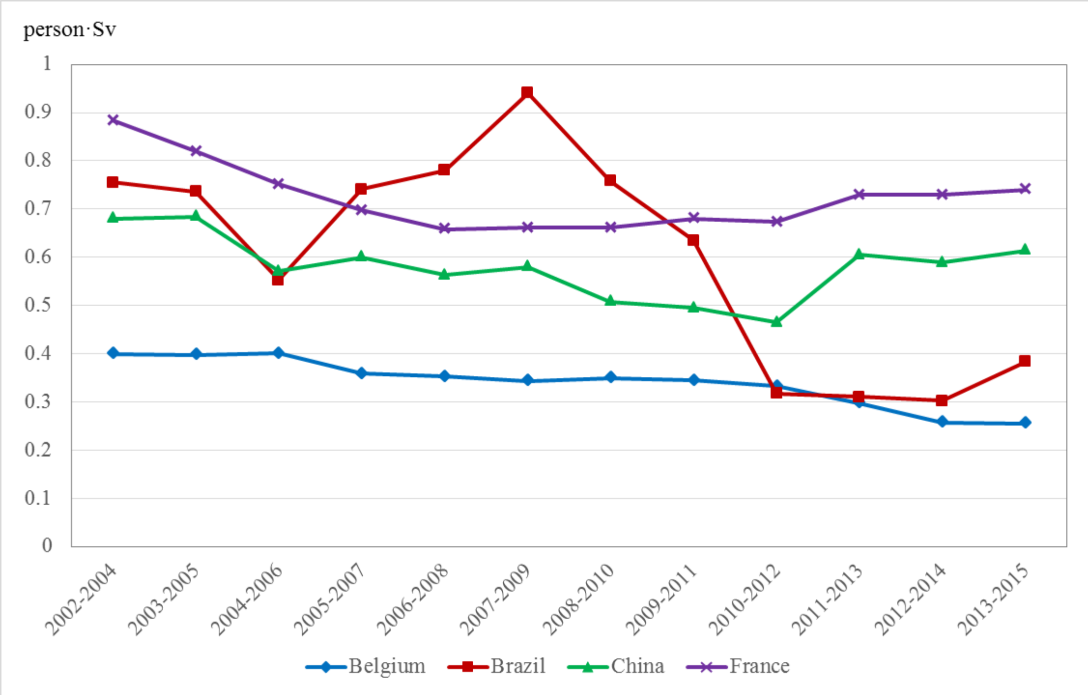


Figure 7. 3-Year rolling average collective dose by country from 2002 to 2015 for PWRs (2)

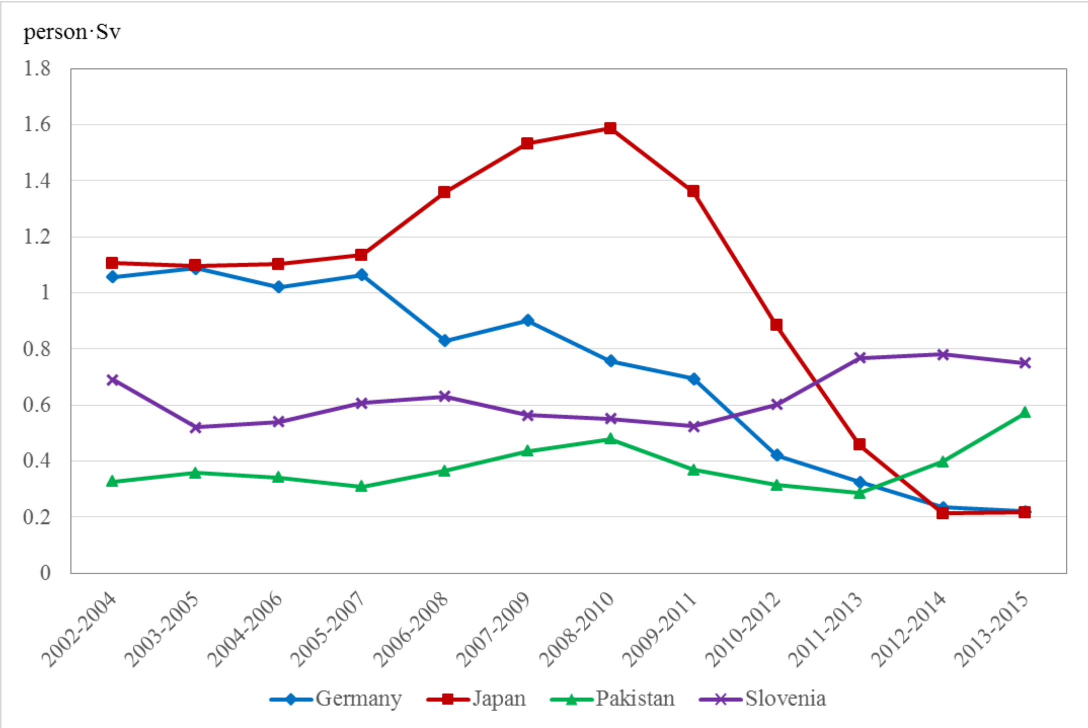


Figure 8. 3-Year rolling average collective dose by country from 2002 to 2015 for PWRs (3)

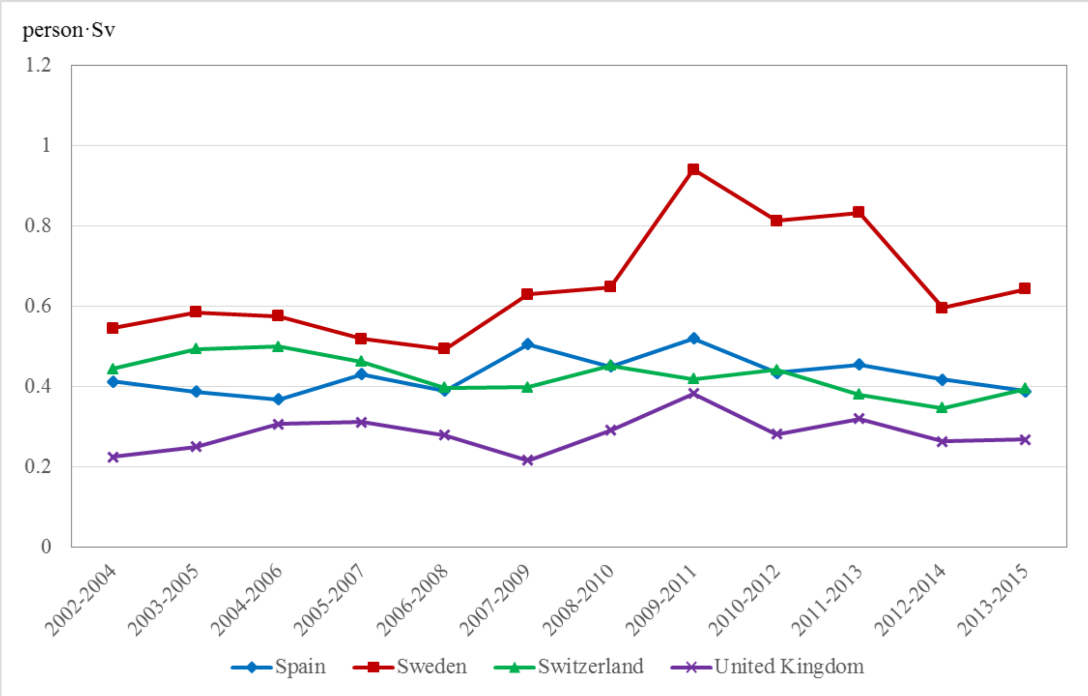


Figure 9. 3-Year rolling average collective dose by country from 2002 to 2015 for PWRs (4)

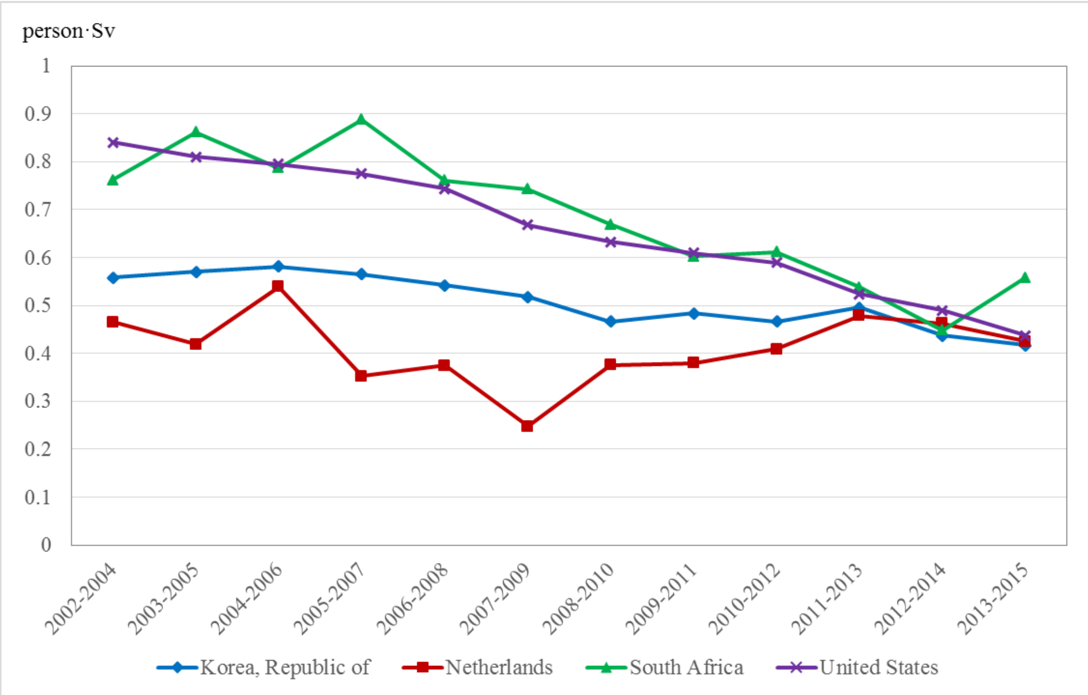


Figure 10. 3-Year rolling average collective dose by country from 2002 to 2015 for VVERs (1)

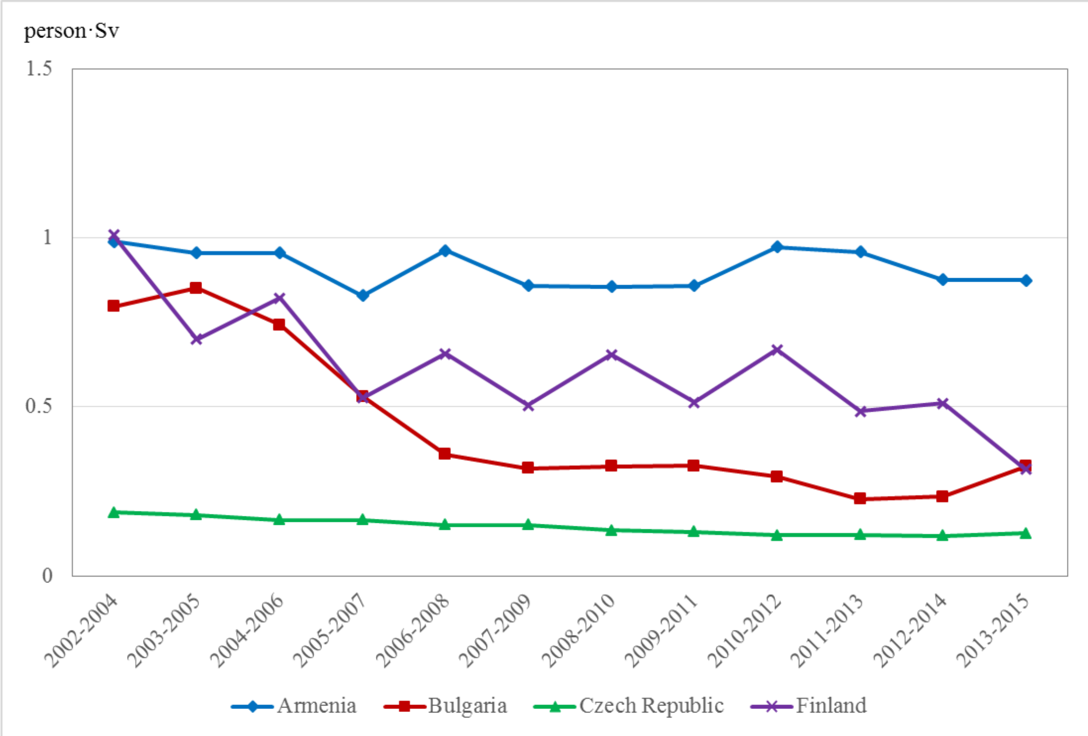


Figure 11. 3-Year rolling average collective dose by country from 2002 to 2015 for VVERs (2)

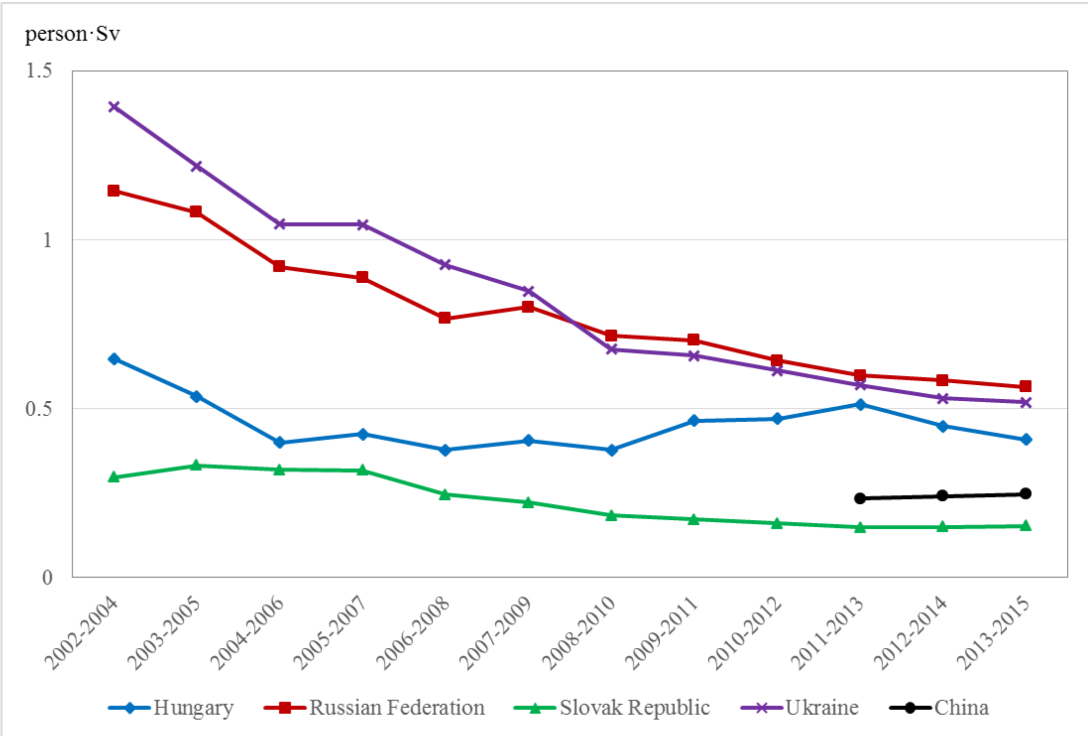


Figure 12. 3-Year rolling average collective dose by country from 2002 to 2015 for BWRs (1)

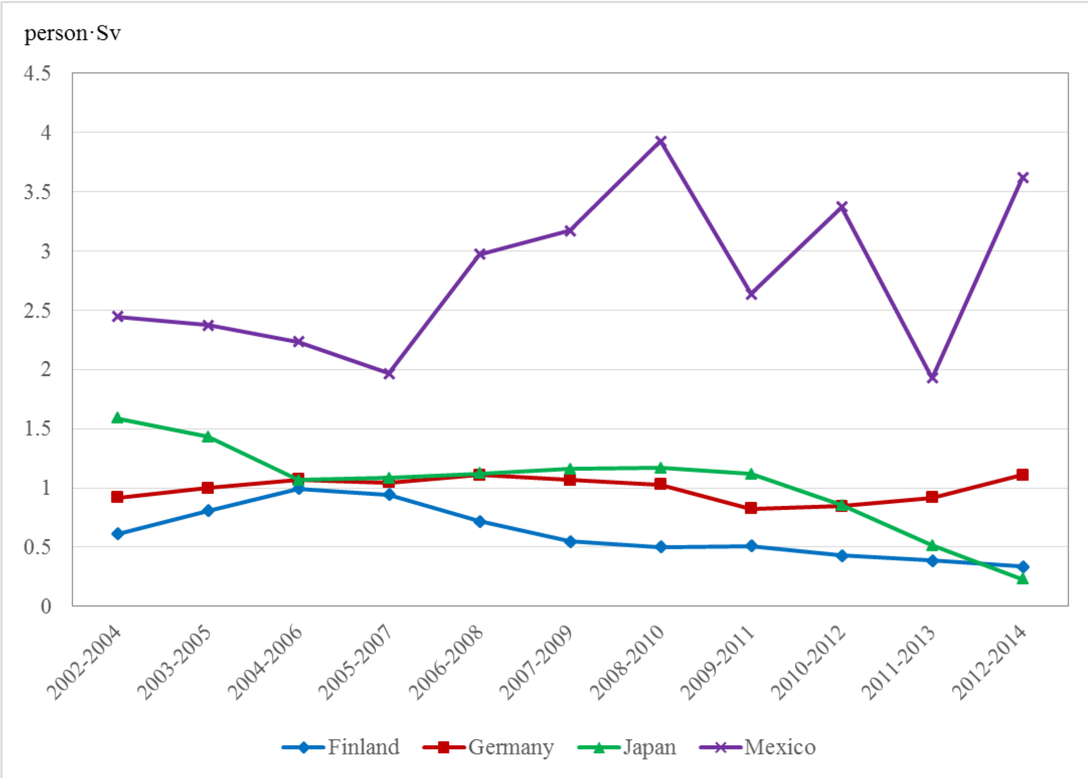


Figure 13. 3-Year rolling average collective dose by country from 2002 to 2015 for BWRs (2)

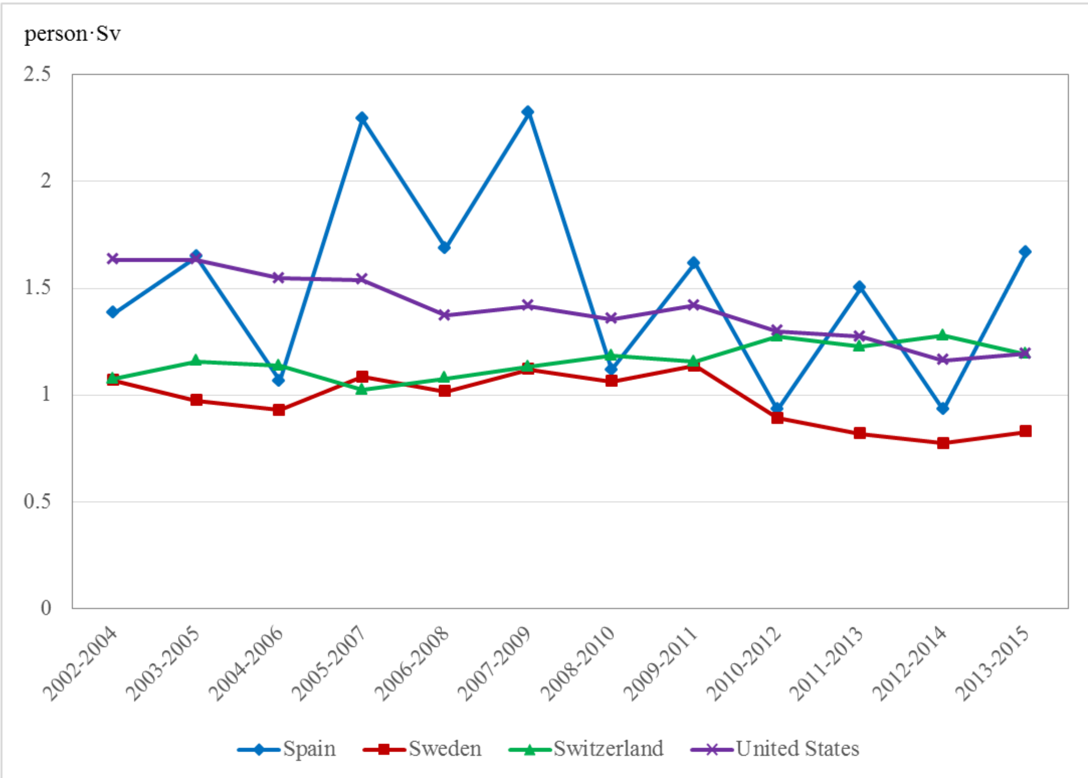
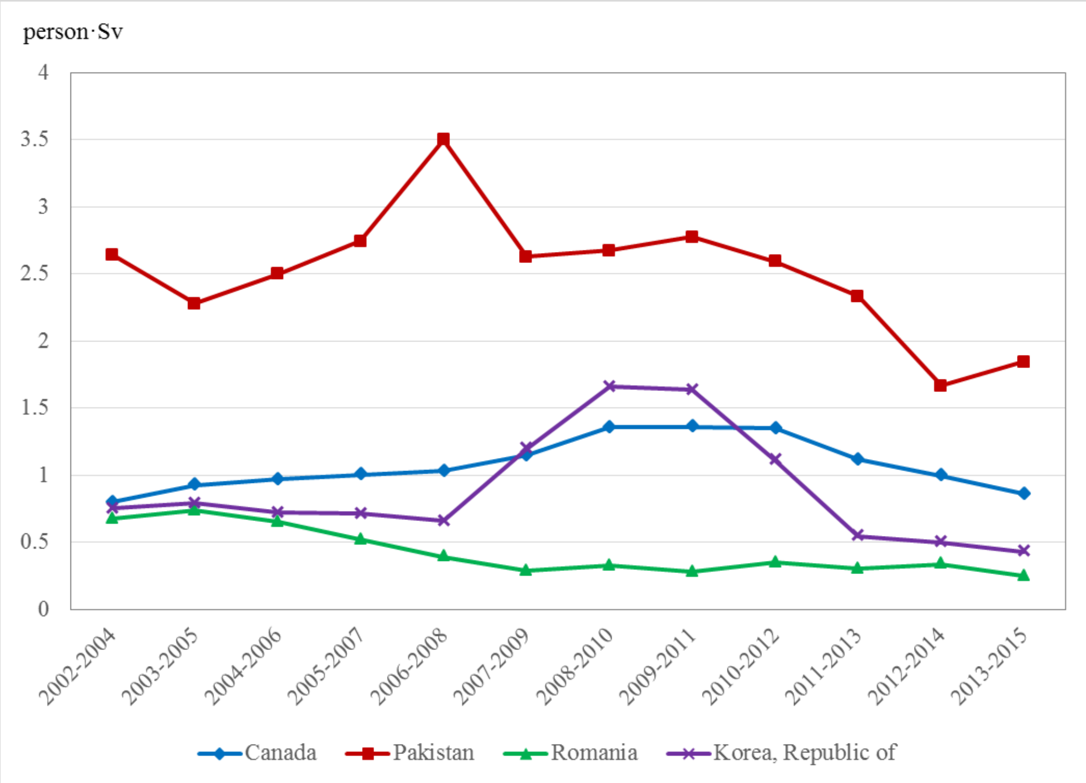


Figure 14. 3-Year rolling average collective dose by country from 2002 to 2015 for PHWRs



See Country Report for Canada for more details on units in SAFSTOR, whose exposures are included with operational PHWRs.

2.2 Occupational exposure trends: Definitely shutdown reactors

In addition to information from operating reactors, the ISOE database contains dose data from 109 reactors which are shut-down or in some stage of decommissioning. This section provides a summary of the dose trends for those reactors reported during the 2013-2015 period. These reactor units are generally of different type and size, at different phases of their decommissioning programmes, and supply data at various levels of detail. For these reasons, and because these figures are based on a limited number of shutdown reactors, definitive conclusions cannot be drawn. One example of this difficulty is in the PWR group in Table 4. Spain's average annual dose is markedly higher than other countries. This is due to the fact that the only shut-down PWR unit in Spain is undergoing active dismantling, whereas shut-down units from other countries units are in less dose-intensive phases of decommissioning or even in latency period. Under the ISOE Working Group on Data Analysis, work continued in 2015 aimed at improving data collection for shut-down and decommissioned reactors in order to facilitate better benchmarking.

Table 4 provides average annual collective doses per unit for definitely shutdown reactors by country and reactor type for 2013-2015, based on data recorded in the ISOE database, supplemented by the individual country reports (Section 3) as required. Figures 15-18 present the average annual collective dose by country for definitely shutdown reactors for 2011-2015 periods by reactor type (PWR, VVER, BWR and GCR). In all figures, the "number of units" refers to the number of units for which data has been reported for the year in question.

Table 4. Number of units and average annual dose per reactor by country and reactor type for definitely shutdown reactors, 2013-2015 (person·mSv/reactor)

		2013		2014		2015	
		No.	**Dose**	**No.**	**Dose**	**No.**	**Dose**
PWR	France	1	189.3	1	88.8	1	73.3
	Germany	7	139.7	7	76.0	7	84.0
	Italy	1	5.2	1	7.3	1	17.8
	Spain	1	468.9	1	591.3	1	438.4
	United States	12	47.3	10	83.4	12	121.5
	Average	*22*	*100.4*	*20*	*131.7*	*22*	*110.6*
VVER	Bulgaria	4	3.3	4	1.8	4	5.5
	Russian Federation	2	49.6	2	44.7	2	69.4
	Average	*6*	*18.7*	*6*	*16.1*	*6*	*26.8*
BWR	Germany	5	80.2	5	61.9	5	73.0
	Italy	2	34.2	2	17.4	2	40.0
	Japan*	2	64.2	2	40.6	2	64.3
	Netherlands	1	0.0	1	0.0	1	0.0
	Spain**	1	31.2	1	102.0	1	119.9
	Sweden	2	3.5	2	3.9	2	8.4
	United States	5	55.7	3	60.6	5	111.1
	Average	*18*	*50.8*	*16*	*44.8*	*18*	*70.3*
GCR	France	6	8.2	6	23.3	6	20.0
	Germany	1	0.0	1	0.0	1	0.0
	Italy	1	2.2	1	7.7	1	0.4
	Japan	1	10.0	1	0.0	1	0.0
	Spain	1	0.0	1	0.0	1	0.0
	United Kingdom	19	57.3	19	52.0	20	90.2
	Average	*29*	*39.7*	*29*	*39.2*	*30*	*64.1*
CANDU	Canada	3	17.3	3	36.3	4	1.8
LWGR	Lithuania	2	304.8	2	304.4	2	342.7
LWCHWR	Japan	1	134.1	1	29.8	1	45.8

* without Fukushima Daiichi NPP
** Spain's BWR was in cessation phase during this period.

Figure 15. Average annual collective dose by country from 2011 to 2015 for PWRs

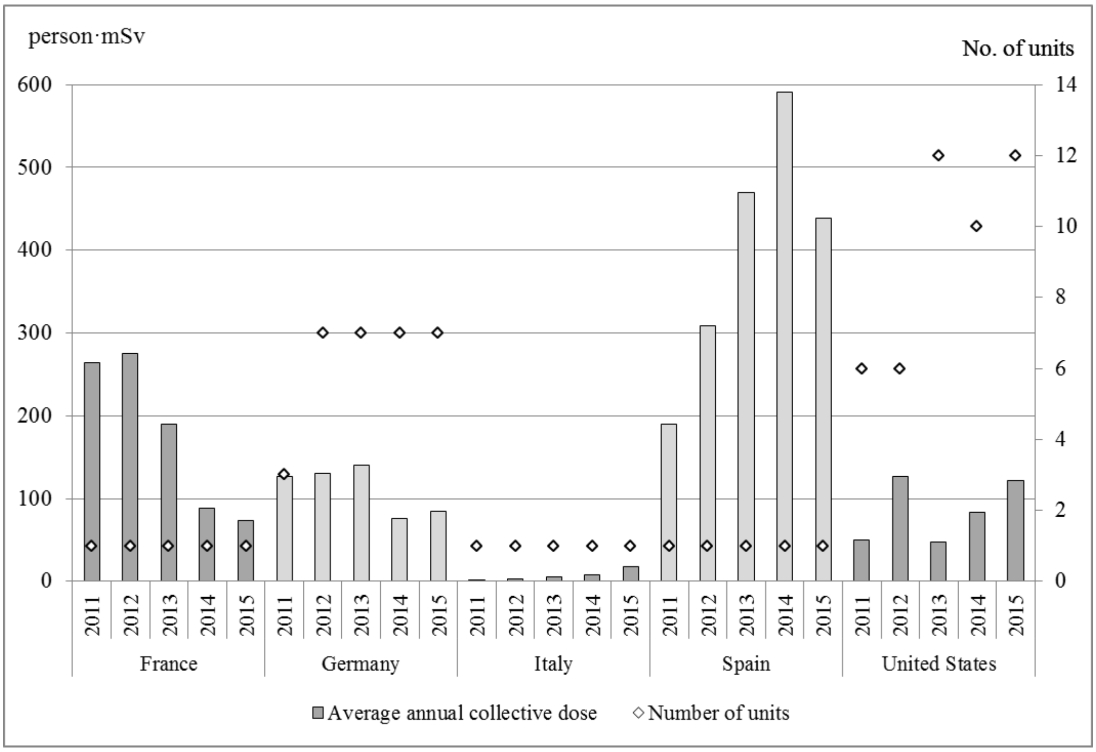


Figure 16. Average annual collective dose by country from 2011 to 2015 for VVERs

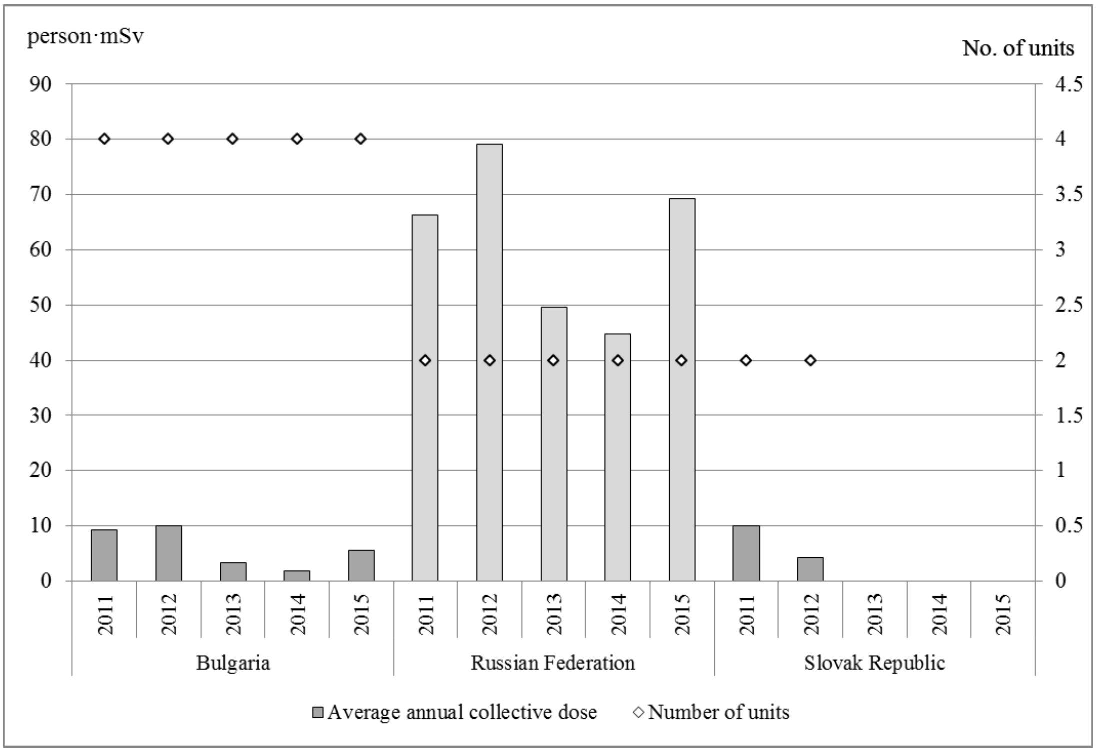


Figure 17. Average annual collective dose by country from 2011 to 2015 for BWRs

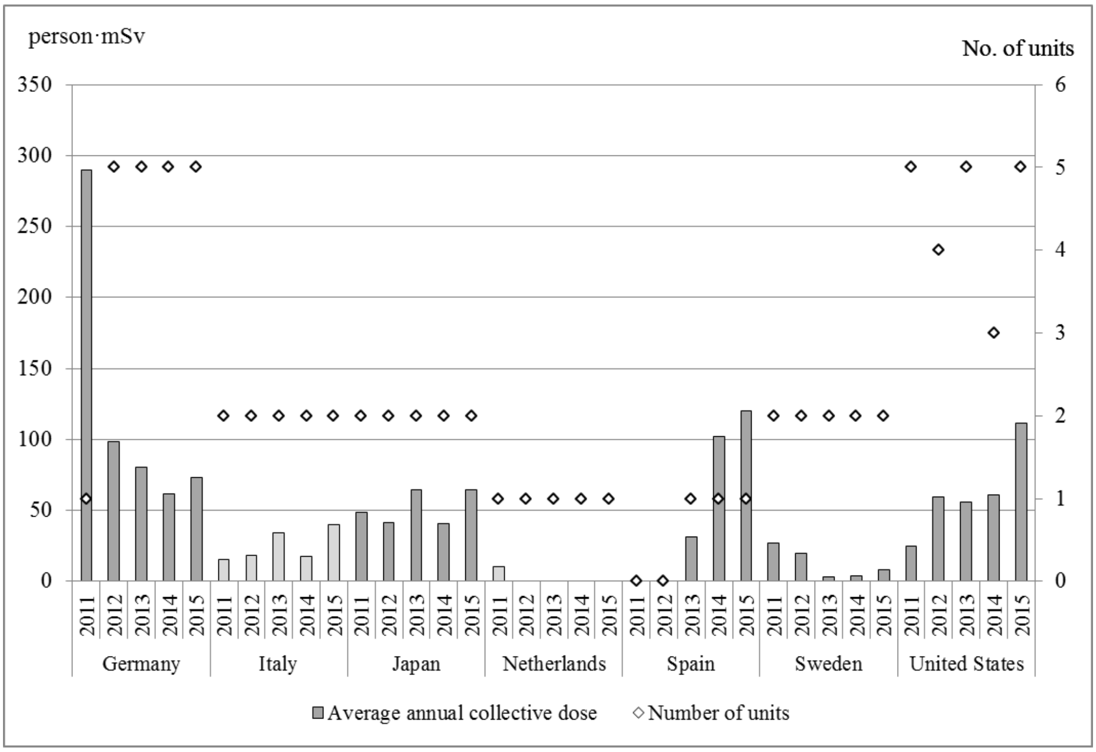
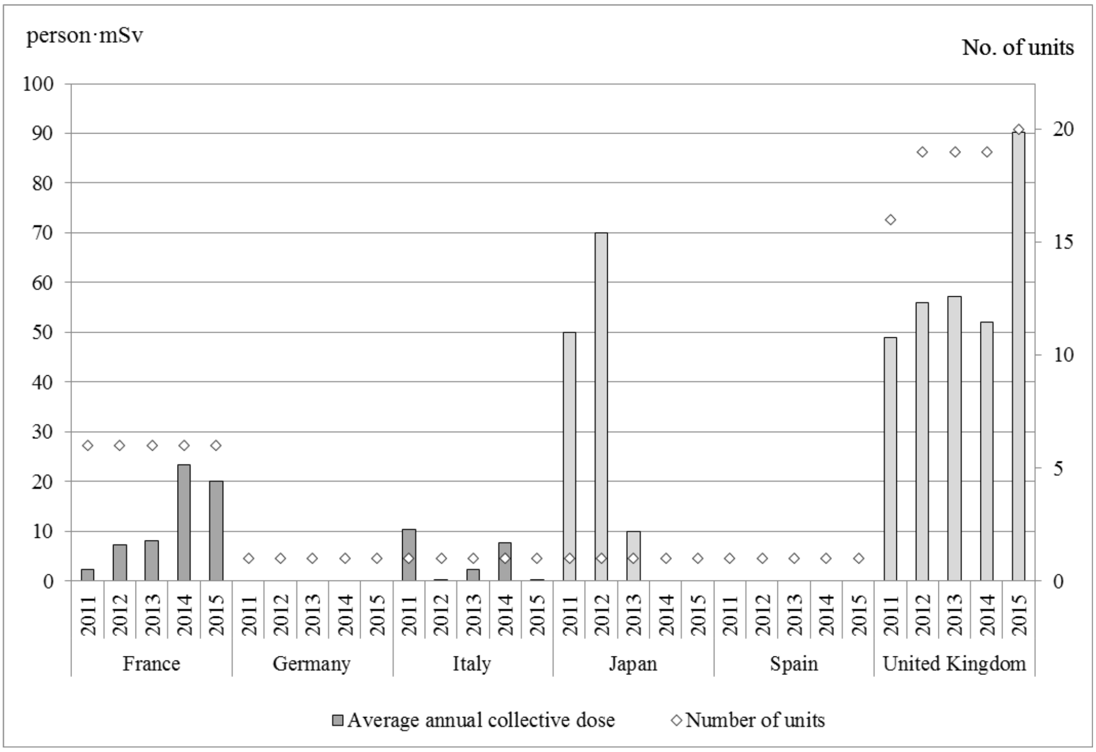


Figure 18. Average annual collective dose by country from 2011 to 2015 for GCRs



3. PRINCIPAL EVENTS IN PARTICIPATING COUNTRIES

As with any summary data, the information presented in Section 2: Occupational Dose Studies, Trends, and Feedback provides only a general overview of average numerical results from the year 2015. Such information serves to identify broad trends and helps to highlight specific areas where further study might reveal relevant experiences or lessons. However, to help to enhance this numerical data, this section provides a short list of important events which took place in ISOE participating countries during 2015 and which may have influenced the occupational exposure trends. These are presented as reported by the individual countries[1]. It is noted that the national reports contained in this section may include dose data arising from a mix of operational and/or official dosimetry systems.

1. Due to various national reporting approaches, dose units used by each country have not been standardised. Each country report following has reported the collective dose unit in the units customary to the legal frameworks of the country. For the purposes of dose comparisons, the gender-neutral version of the collective dose unit should be considered equivalent: person-mSv / unit ≅ man-mSv / unit.

ARMENIA

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	1	890
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv/unit]**
VVER	1	*No separate data is available*

2) Principal events of the year 2015

Summary of national dosimetric trends

For the year 2015, the dosimetric trend at the Armenian NPP was decreased, and that was the result of good planning of the work in the controlled area, such as work with spent fuel removal and transportation, work with activated material in reactor equipment, non-destructive testing of pipes and effective planning of other controlled-area work during the outage, including decontamination work and the work with radioactive wastes.

The maximum individual dose was 17.3 mSv.

The collective dose for outside workers was 17 man•mSv. The value for outside worker dose is very small, because the facility operator has its own repair workers.

The collective dose for repair and outage was planned in terms of dose constraints, and the real doses constituted 79% of planned doses.

- *Events influencing dosimetric trends*

  No significant events were registered for the impact on dosimetric trends.

- *Number and duration of outages*

  For 2015, one outage with a 85 (full refuelling) day duration was performed.

- *New plants on line/plants shut down*

  The new plant construction is on schedule. Siting considerations are currently ongoing and first preliminary results have been submitted to the Armenian Nuclear Regulatory Authority. The new safety improvement approaches in relation to the Fukushima-daiichi accident were considered in plant design regulatory requirements and site evaluation. The new regulations on site and design requirements were approved by the Government of Armenia and the requirements will be laid out in the bases for new design features.

- *Major evolutions*

  The “Dose reduction program including ALARA culture implementation” for 2015 was established, and improvement of the old radiation control system is almost finished. The new radiation control pass system is already in operation.

- *Component or system replacements*

  During the outage in 2015, no components or systems were replaced. In the frame of Life Time Extension (LTE) of the ANPP, modernization of some safety systems and components, including systems for radiation control and management, are foreseen.

- *Safety-related issues*

  Some safety related issues still exist due to medium activity radioactive waste treatment and storage activities. The preparation of a National Strategy for radioactive waste management in Armenia has been finished, and the NS is currently in approval stage at the Government. Major improvements in radioactive waste management are being implemented in the frame of LTE..

- *Unexpected events*
- For the year 2015, no unexpected events were registered.

- *New/experimental dose-reduction programmes*

  No new/experimental dose-reduction programmes were applied for the year 2015.

- *Organisational evolutions*

  Use of dose planning and the dose constraint approach for the reduction of individual doses of staff remain the main tools for ALARA implementation.

For 2016

- *Issues of concern*

  In 2016, the modification and modernization of some safety systems are being implemented due to the LTE and modernization program.

- *Technical plans for major work*

  1. Modernization of the Radiation Control System for airborne and liquid releases.
  2. Modernization and safety improvement measures for some safety systems (which are included in the LTE program).

- *Regulatory plans for major work*

  Review of Inspections procedures and special-work-related new Check list preparation for inspections at ANPP, to control compliance with license conditions, regulatory requirements and follow-up actions.

To review the safety assessment report (SAR) for LTE in terms of radiation protection of workers and the public, and the safety of radioactive waste management, submitted by ANPP in their reports, and preparation of follow up action.

BELGIUM

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	7	320

2) Principal events of the year 2015

- *Events influencing dosimetric trends*

a) Unplanned shutdown for Doel 3 / Tihange 2 because of indications (hydrogen flakes) in the reactor vessel lasted until the end of 2015, after the Belgian Safety Authority gave the authorization to restart on November 17th, 2015.
b) As in 2014, concrete conditioning of the radioactive waste at Doel remains stopped, after the discovery of an unexpected alkali-silicate reaction. Licensing of the new process is in progress.
c) More extensive plant outages for Doel 1 & 2, from the perspective of long term operation (10 additional years), were authorized by the Belgian Government on Oct 9th, 2014.
d) Doel 4 and Tihange 3 outages with replacement of the vessel heads.
e) LTO stop Tihange 1: included a large amount of work for LTO (but without refuelling).
f) Detailed collective dosimetry (outage information):

2015	Doel 1	Doel 2	Doel 3	Doel 4	Tihange 1	Tihange 2	Tihange 3
Outage dates	1/3 - 31/12	2/5 - 18/5 23/10 - 25/12	1/1 - 21/12 25/12 - 31/12	28/8 - 17/10	20/6 - 15/9	7/9 - 16/10 18/11 - 14/12	24/3 - 10/5
Outage man·mSv	133.4	77.45 and 364.8	180.1	393.9	341.4	83.0	419.0
Total man·mSv	601.3		181.2	405.6	393.6	176.5	454.6

- *New/experimental dose-reduction programmes*

a) Not yet any observed impact from Zinc injection in the primary circuit of Doel 3.
b) Zinc injection will not be implemented at Tihange 2, unless a long term operation would be envisaged
c) Alternative initiatives taken to reduce the source term (ex. Ag110m issue)
d) Additional effort were made to minimize the "search" dose (dose accumulated while locating the equipment which requires maintenance)

- *Organisational evolutions*

a) Additional test phases of RCA access using the Doel protocol (protective overclothes and not an entire change of clothes) during the year 2015. Full test expected during the next outage of Tihange 3 in 2016
b) Progressive replacement of the personal electronic dosimeters at Doel, to be completed by mid-2016.

- *Regulatory requirements*

  National safety authority kicked off the project to revise the base regulation for protection against ionising radiations, following the publication of the Euratom BSS. This project is on-going.

BRAZIL

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	2	651.232 (Angra 1: 389.322 Angra 2: 261.91)

2) Principal events of the year 2015

- *Events influencing dosimetric trends*

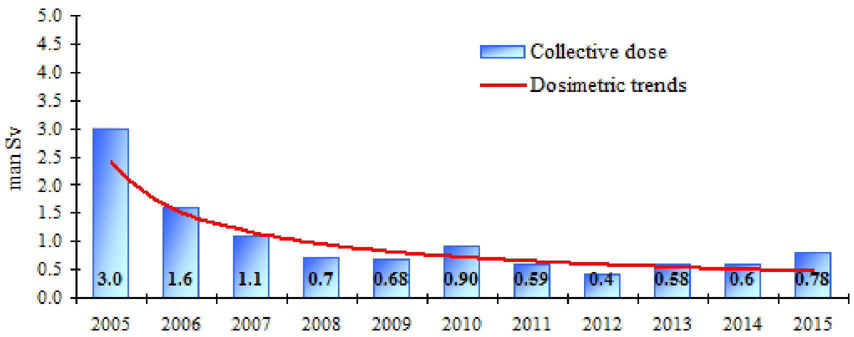
Outages information: Angra 1 - Days of planned outage: 59
Angra 2 - Days of planned outage: 30

BULGARIA

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER-1000	2	377
REACTORS IN COLD SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER-440	4	5.5

2) Principal events of the year 2015



Unit No.	Outage duration, days	Outage information
Unit 5	39	Refuelling and maintenance activities
Unit 6	54	Refuelling and maintenance activities

– *Events influencing dosimetric trends*

About 60% of the exposure of the workers in 2015 was due to implementation of two big projects – thermal power increase and life time extension of units 5&6. In this connection, a lot of modernization and refurbishment activities were performed on the unit systems in the RCA. Examples include the following:

- modernization of the steam generator separation system, planned in two stages – for unit 5 the first stage was finished on all SG, for unit 6 the second stage was finished on SG1 and SG4;
- modernization of the first circuit temperature measurement system;
- increased amount of radiographic inspection activities;
- thermal insulation replacement;
- systems and components inspection, etc.

CANADA

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
CANDU	19	830
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
CANDU	3	7*

* Gentilly-2 is the only shutdown reactor which reports occupational dose separate from operating reactor units or other licensed activities. The two other shutdown reactors, Pickering Units 2 and 3, are not reported separately and so are not included in this dose.

2) Principal events in ISOE participating countries

For 2015 National dosimetric trends:

- 15.84 Person-Sv for 19 operating units in 2015;
- Average annual dose per unit 0.83 person-Sv in 2015.

The total collective effective doses and the average collective dose per unit at operating Canadian nuclear plants decreased slightly in 2015 (approximately 7%) from 2014. However, the trends remain steady since 2013. The decrease in occupational dose reflects the type of scope of work being performed and values are noted to be less than when refurbishment activities were ongoing at Pt. Lepreau and Bruce Power Units 1, 2.

The average calculated dose for 2015 includes nineteen (19) units. The dose associated with activities performed at two units in safe storage (Pickering Units 2 and 3) is negligible and is not reported separately, but instead is included under the operational Pickering Units. Gentilly-2 transitioned from an operational site to safe storage in 2013.

The implementation of ALARA initiatives at Canadian Nuclear Power Plants (NPPs) and improved work planning and control, continue to contribute to the reductions in the annual Canadian collective dose. Distribution of annual effective doses to workers at Canadian NPPs showed that approximately 86 percent of the workers received an annual effective dose below 1 mSv.

In 2015, approximately 87% of the collective dose was due to outage activities, and most of the radiation dose received by workers came from external exposure. Approximately 11 % of the dose received was from internal exposure, with tritium being the main contributor to the internal dose of exposed workers.

3) Principal Events in Canada

Bruce Power A

In 2015, all four units were operational at Bruce A Nuclear Generating Station. Bruce A, Units 1-4 had 160 outage days in 2015. Outage work scope accounted for 92 percent of the total annual dose for Bruce A. Planned outage work scope included fuel inspection, boiler work, condenser repair, feeder repair, feeder replacement, Grayloc refurbishment and feeder replacement.

Routine operations accounted for approximately 8% of the total collective dose. Internal dose was approximately 5 percent of the total Bruce A collective dose. The 2015 internal dose was slightly lower than the 7% recorded in 2014. Internal dose ALARA initiatives in 2015 included reducing primary water heat transport leak rates and repairing vault vapour recovery dries.

Bruce A, Units 1-4 routine operations dose for 2015 was 0.376 person-Sv and the maintenance outage dose was 4.394 person-Sv (one planned outage and forced outages). The internal dose for Bruce A Units 1-4 was 0.260 person-Sv and the external dose was 4.510 person-Sv. The total collective dose for Bruce A Units 1-4 was 4.771 person-Sv which resulted in an average collective dose 1.193 person-Sv/unit.

Bruce Power B

Bruce B, Units 5-8 were operational in 2015 with a total of 110 outage days. Outage activities accounted for approximately 81% of the total collective dose. Planned outage work scope included feeder inspections in Unit 6 and a vacuum building inspection. Routine operations accounted for approximately 19 percent of the total station collective dose.

Bruce B, Units 5-8 routine operations dose was 0.505 person-Sv. The outage dose was 2.147 person-Sv in 2015. The internal dose was 0.155 person-Sv. The external dose was 2.498 person-Sv. The total dose was 2.652 person-Sv which resulted in an average collective dose 0.663 person-Sv/unit.

Darlington Units 1-4

In 2015, all four units were operational at Darlington Nuclear Generating Station with a total of 101 outage days. Outage activities accounted for approximately 88% of the total collective dose at Darlington. This is slightly higher than 2014 and reflect the scope and type of outage work scope. Planned outage work scope included feeder and boiler inspections in Unit 3 and a vacuum building inspection. Routine operations accounted for approximately 12 percent of the total collective dose.

Internal dose accounted for approximately 18% of the total collective dose, a slight increase from the internal dose of 15 percent reported in 2014. This increase can be attributed partly to increased airborne tritium levels in containment combined with a higher number of personnel making containment entries.

Darlington Units 1-4 had routine operations dose of 0.329 person-Sv. The total outage dose was 2.31 person-Sv. The internal dose for 2015 was 0.485 person-Sv. The external dose was 2.155 person-Sv which resulted in an average collective dose 0.660 person-Sv/unit.

Pickering Nuclear

In 2015, Pickering Nuclear Generating Station had six units in operation (Units 1, 4, 5-8), with a total of approximately 416 days outage days. Units 2 and 3 continued to remain in a safe storage state.

Outage activities accounted for approximately 87% of the collective dose at Pickering Nuclear Generating Station. Routine operations accounted for approximately 13% of the total collective dose.

Internal dose accounted for approximately 15% of the total collective dose, a slight decrease from the internal dose rate of 17% percent reported in 2014. This decrease can be attributed to the scope and type of work performed.

The routine collective dose for operational units was 0.747 person-Sv in 2015.

The outage dose for the operational units was 4.802 person-Sv. The internal dose was 0.821 person-Sv. The external dose was 4.728 person-Sv. The total dose was 5.549 person-Sv which resulted in an average of collective dose 0.925 person-Sv/unit.

The dose associated with radiological activities performed at Pickering Units 2 & 3 (in safe storage since 2010) is negligible when compared to collective dose of the operational units. Therefore, this dose is not reported separately but instead included under operational Pickering Units.

Point Lepreau

Point Lepreau is a single unit CANDU station. In 2015, Point Lepreau was fully operational with a total of 58 outage days. Outage activities accounted for approximately 35% of the total collective dose at Pt. Lepreau.

Internal dose accounted for approximately 20% of the total collective dose, which is a slight increase over 2014 (when internal dose was 15%). This increased dos contribution from tritium was due in part to a leaking fitting on the primary heat transport system. This fitting is scheduled for repair during a planned outage in the spring of 2016.

The routine collective dose for operational activities was 0.144 person-Sv in 2015.

The internal dose was 0.044 person-Sv. The external dose was 0.176 person-Sv. The total dose was 0.220 person-Sv.

Gentilly-2

Gentilly-2 is a single unit CANDU station. In 2015, Gentilly-2 continued transition from operation to safe storage state. The reactor was shut down in December 28, 2012.

There was a decrease in the collective doses at Gentilly-2 because the majority of radiological work activities with the transition from an operational unit to a safe storage state occurred in 2014. The 2015 station collective dose is only attributed to safe storage transition activities. Internal dose was approximately 41 percent of the total station collective dose. While this is an increase from 2014 (when the internal dose was 35 percent), the magnitude of the internal dose is largely attributable to it being a relative fraction of the very small total collective dose.

The internal collective dose in 2015 was 0.003 person-Sv. The external dose was 0.004 person-Sv. The total site collective dose in 2015 was 0.007 person-Sv.

4) Major 2015 Highlights

- *Regulatory Update*

  The implementation of radiation protection programs at Canadian Nuclear Power Plants (NPPs) met all applicable regulatory requirements and doses to workers and members of the public were maintained below regulatory dose limits.

- *Safety-related issues*

  No safety-related issues were identified in 2015.

- *Decommissioning Issues*

  Gentilly-2 continued to transition to safe storage in 2015.

- *New Plants under construction/plants shutdown*

  No Units under construction in 2015.
  No Units were shut down in 2015.

5) Conclusions

The 2015 average collective dose per operating unit for the Canadian fleet was 0.83 person-Sv/unit, nearly achieving the CANDU WANO dose target of 0.80 person-Sv/unit. The refurbishment activities executed in 3 of the 19 operational from 2010-2012 are showing solid benefits by providing improved unit reliability/nuclear safety and dose reduction at Bruce A, Units 1,2 and Pt. Lepreau.

The collective dose for all operating Canadian plant 2011-2015 was 15.84 person Sv. The collective dose from routine operations was 2.10 person mSv and the collective dose from outages was approximately 13.74 person Sv. Outages accounted for approximately 87% of the total collective dose. Internal dose contributed approximately 11% of the total collective dose with tritium the main dose contributor.

The implementation of initiatives to keep doses ALARA including improved shielding, source term reduction activities, use of CZT 3D isotopic mapping systems and improved work planning continue to reduce the collective dose per unit.

CHINA

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	23	395
VVER	2	260
PHWR	2	402
All types	27	385

2) Principal events of the year 2015

– *Events influencing dosimetric trends*

In 2015, there were no radiological events threatening the safety of people and the environment at the operational nuclear power plants. The monitoring index over the year showed that the integrity of three safety barriers was in sound status.

- For the operational nuclear power plants, the dose information in the table above is summarized for the 27 reactors operating before the end of 2015. In those reactors, refuelling outages were performed for 15 of 23 PWR units, 1 of 2 PHWR units, and 2 of 2 VVER units in 2015.
- Eight new PWR units (Fangjiashan 1-2, Hongyanhe 3, Ningde 3, Fuqing 1-2 and Yangjiang 1-2) began to operate in 2015.

– *New/experimental dose-reduction programmes*

In the operation of nuclear power plants, annual collective dose is mainly from outages. The ALARA programme is well implemented during the design and operation of all nuclear power plants. The average annual collective dose per unit varied slightly in comparison with the year 2014, and stayed at a low level.

– *Regulatory requirements*

- In 2015, the Environmental and Resource Protection Committee of the National People’s Congress completed the draft Nuclear Safety Act of the People's Republic of China by the study and development of related specific subjects.
- In 2015, all operational nuclear power plants completed improvement actions according to “General technical requirements of improvement actions for nuclear power plants after the Fukushima accident” issued in 2012.
- In 2015, the “Thirteenth five-year plan and 2025 perspective plan on nuclear safety and prevention & Control of Radioactive pollution” (Draft) was issued.

3) Report from Authority

NNSA Annual Report in 2015 (Chinese) has been drafted and will be published soon.

CZECH REPUBLIC

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	6	140

2) Principal events of the year 2015

- *Events influencing dosimetric trends*

  The main contributions to the collective dose were 5 planned outages.

NPP, Unit	Outage information	CED [man.mSv]
Temelin, Unit 1	64 days, standard maintenance outage with refuelling	46
Temelin, Unit 2	104 days, standard maintenance outage with refuelling	114
Dukovany, Unit 1	124 days, prolonged maintenance outage with refuelling, weld radiography and LTO (long-term operation) process	352
Dukovany, Unit 2	34 days, standard maintenance outage with refuelling	55
Dukovany, Unit 3	19 days, standard maintenance outage with refuelling	70

  CED increased in 2015 in comparison with the previous year mainly due to the LTO process and radiography of Primary and Secondary pipe welds during the outage of Unit 1 at Dukovany NPP.

  There was one radiation event at Temelin 2 in the year 2015 – Primary-to-Secondary Steam Generator leakage. This event had no impact on the general public. Reconstruction of a leaky pipe in a SG and subsequent repairs caused an increase of CED at Temelin 2.

  Very low values of outage and total effective doses represent results of a good primary chemistry water regime, well organised radiation protection structure and strict implementation of ALARA principles during the activities related to the work with high radiation risk. All CED values are based on electronic personal dosimeter readings.

- *New/experimental dose-reduction programmes*

  There were no new/experimental dose reduction programmes.

- *Organisational evolutions*

  In 2015 activities continued for two working groups (WG) established by the RP department in 2013:

  - Personal Contamination Events reduction WG, which aims for overall improvement of personnel perception of PCEs and ultimate reduction of the number of PCEs; and
  - Radiation Work Permit WG which is focused on the revision of the RWP system, classification of RCA areas and EPD alarm settings.

- *Regulatory requirements*

  The Post-Fukushima National Action Plan is being implemented progressively at Temelin NPP and Dukovany NPP.

  The LTO process was under way at Dukovany 1. Regulatory requirements are being implemented progressively.

3) Report from Authority

The State Office for Nuclear Safety (SUJB) carried out 48 inspections of radiation protection at nuclear facilities and contractors in 2015. Serious shortcomings were not identified.

At the end of the year, SUJB issued the license for operation of the workplace where radiation activities are performed, comprising the four units of Dukovany NPP and the Spent fuel storage facility Dukovany, for the next ten years.

Work on the “new” Atomic Act has been completed and preparation of implementing regulations was on-going. Requirements of the new Euratom BSS directive have been implemented.

FINLAND

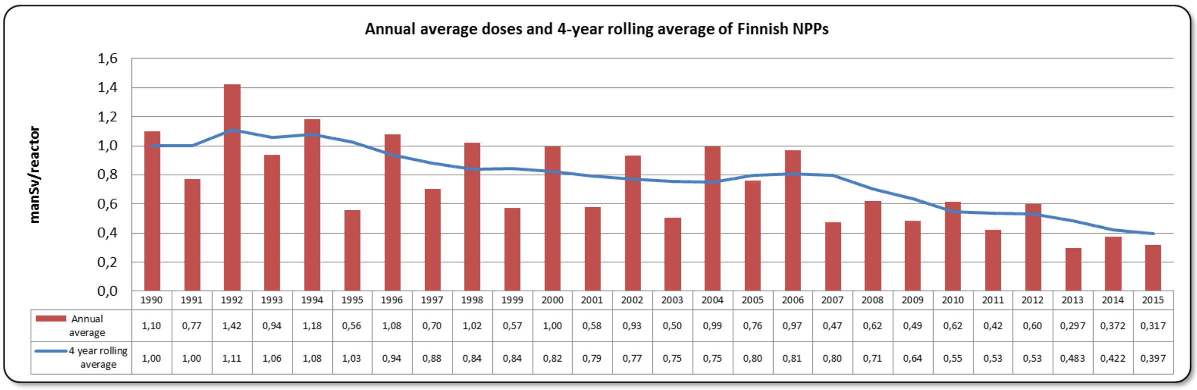
1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	2	258.43
BWR	2	376.24
All types	4	317.34

2) Principal events of the year 2015

Summary of national dosimetric trends

The annual collective dose strongly depends on the length and type of annual outages. The 2015 collective dose (1.269 man·Sv) of Finnish NPPs was the second lowest in the operating history, mainly due to short refuelling outages at three of four reactors. In the long run the 4-year-rolling average of collective doses shows a decreasing trend since the early 1990's.



Olkiluoto

The annual outage of 2015 at Olkiluoto Unit 2 was a maintenance outage. The duration of the outage was about 17 days. In addition to refuelling, some maintenance activities were carried out, including the replacement of low-voltage switchgear in two subsystems, mixing point change for the feed-water system and reactor cooling system and several other modification and maintenance jobs. Apart from TVO's own personnel, just over 800 subcontractor employees were involved in the OL2 outage. The collective outage dose was 0.438 man·Sv.

The refuelling outage at Olkiluoto Unit 1 took about 10 days including refuelling, maintenance and repair work, and some tests. The most significant maintenance work was the mixing point change for the feed-water system and the reactor cooling system. Just over 450 subcontractor employees were involved in the OL1 outage. The collective dose of the short refuelling outage was 0.176 man·Sv.

The maximum personal outage dose was 4.7 mSv.

On both units the Risk-Informed In-Service Inspection (RI-ISI) approach has been implemented on ASME piping inspection programs. The RI-ISI program is expected to reduce dose in the future.

Loviisa

On both units the 2015 outages were short refuelling outages, with durations of some 21 and 17 days. The outage collective doses were among the lowest in plant operating history: 0.238 and 0.223 man·Sv respectively. Main contributors to collective dose accumulation were reactor related tasks (disassembly, assembly), cleaning/decontamination and auxiliary work such as radiation protection, insulation and scaffolding. On both units new level measurement piping was installed to the steam generators as part of plant instrumentation renewal.

Source term reduction: After 5 years of studies, testing and approval, one antimony-free mechanical seal was installed in one of Loviisa 1's six primary coolant pumps in 2012. During the 2013 outage, this seal was inspected and approved. Following that approval, all seals on both units were replaced during outages in 2013 and 2014. The seal replacement project has resulted in a decrease of radioactive antimony and thus reduced dose rates in the vicinity of primary components.

3) Report from Authority

On November 12th, 2015, the Finnish Government granted a construction license for the Olkiluoto Spent Nuclear Fuel encapsulation and disposal facility. STUK gave its safety assessment on the construction license application in February 2015.

The Nuclear Energy Act was revised to broaden STUK's legal mandate to issue binding regulations and licence conditions. This is one of the recommendations from the IRRS mission to Finland in 2012. The IRRS follow-up was carried out in June 2015. STUK will publish the new binding regulations concerning nuclear safety, security, emergency preparedness and waste management in the beginning of 2016.

The implementation of the new regulatory guides (YVL Guides) was carried out for the operating NPPs during 2015. For Olkiluoto Unit 3, the implementation decisions will be made in conjunction with the operating license application review.

One new unit entered into the construction license phase at the end of June 2015 (the Fennovoima Hanhikivi Unit 1).

In other sectors of the nuclear cycle, a research reactor will be decommissioned.

FRANCE

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	58	710
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	88.8
GCR	6	23.3
GCHWR	1	11.4
SFR	1	3.4

2) Principal events of the year 2015

For 2015, the average collective dose of the French nuclear fleet (58 PWR) is 0.71 man·Sv/unit (as compared to the 2015 annual EDF objective of 0.79 man·Sv/unit). The average collective dose for the 900 MWe 3-loop reactors (900 MWe – 34 reactors) is 0.86 man·Sv/unit and the average collective dose for the 4-loop reactors (1300 MWe and 1450 MWe – 24 reactors) is 0.50 man·Sv/unit.

Type and number of outages

Type	**Number**
ASR – short outage	22
VP – standard outage	21
VD – ten-year outage	4
No outage	10
Forced outage	1

Specific activities

Type	**Number**
SGR	1 – not finished in 2015 (Paluel 2)
RVHR	0

The outage collective dose represents 81% of the total collective dose. The collective dose received when the reactor is operating represents 19% of the total collective dose. The collective dose due to neutron is 0.247 man·Sv; 78% of which (0.192 man·Sv) is due to spent fuel transport.

Individual doses

In 2015, no worker received an individual dose higher than 16 mSv in 12 rolling months on the EDF fleet. 76% of the exposed workers received a cumulative dose lower than 1 mSv, and 99.5% of the exposed workers received less than 10 mSv.

The main 2015 events with a dosimetric impact are the following:

- Blayais 3 SGR:
  The SGR (steam generator replacement) of unit 3 set a new record for the lowest dose received for a SGR, with 455 man·mSv. This was a long outage as it lasted from April 25th, 2014 to September 5th, 2015.
- Seismic resistance following a global safety event on the fleet:
  Biologic shielding whose seismic resistance was not proved has been removed. These removals impact the radiological conditions of areas in the nuclear auxiliary building and also for field and radiological protection inspections.
- Decontamination:
  For 4-loop reactors (1,300 MWe), decontamination and cleaning of Solid Waste Treatment System tank and Liquid Waste Treatment system evaporator before inspections.
- Radiography inspection with Selenium:
  Paluel, Flamanville, Cattenom and Nogent have been using Selenium-75 for radiographic inspections. These first experimentations allowed radiographic inspection to occur concurrent with (at the same time as) other activities in the turbine building, so time savings were achieved for the outage schedule.

3-loop reactors – 900 MWe

In 2015, Bugey 2, Fessenheim 1 and Gravelines 6 had no outage. Fessenheim 1 had a forced outage for 4 days for an occupational exposure of 5 man·mSv.
The 3-loop reactors outage program was composed of 14 short outages, 13 standard outages, and 3 ten-year outages. One Steam Generator Replacement was performed on Blayais 3.
Two outages of the 2014 program ended in 2015: the third ten-year outage and steam generator replacement at Blayais 3 for 0.391 man·Sv and a short outage at Cruas 2 (collective dose in 2015: 0 man·Sv for 5 days).
One outage of 2015 was not finished at the end of the year: Bugey 5 (end of the standard outage for a planned occupational exposure of 0.133 man·Sv).

The lowest collective doses for the various outage types and specific activities were:

- Short outage: 0.123 man·Sv at Chinon B4
- Standard outage: 0.609 man·Sv at Chinon B3
- Ten-year outage: 1.696 man·Sv at Cruas 1
- SGR: 0.455 man·Sv at Blayais 3.

4-loop reactors – 1,300 MWe and 1,450 MWe

In 2015, 8 units had no outage. There were 2 forced outages: Cattenom 4 (11 man·mSv) and Nogent 2 (42 man·mSv).

The 4-loop reactors outage program was composed of 8 short outages, 8 standard outages and 1 ten-year outage.

The lowest collective doses for the various outage types were:

- Short outage: 0.149 man·Sv at Cattenom 3
- Standard outage: 0.493 man·Sv at Nogent 2.

Main radiation protection significant events (ESR)

In 2015, 3 events were classified at the INES scale.

- Gravelines NPP (rated level 1 at the INES scale)
  1 ESR on Unit 5: skin dose higher than one quarter of the annual limit when checking padlocking on reactor cavity and spent fuel pit cooling and treatment system.
- Nogent NPP (rated level 1 at the INES scale)
  1 ESR on Unit 1: skin dose higher than one quarter of the annual limit on waste treatment.
- Blayais NPP (rated level 2 at the INES scale)
  1 ESR on Unit 4: skin dose higher than the annual limit.
  Contamination on the chin by a particle of Co-60 of activity estimated at 504 kBq during the preparation of the requalification of the CVCS regenerative heat exchanger.

2016 goals

For 2016, the collective dose objective for the French nuclear fleet is set at 0.80 man·Sv/unit.

For the individual dose, one of the objectives is to reduce by 10% in 3 years, the individual dose of the most exposed workers. The other objectives are the following:

- Less than 5 workers with a dose > 14 mSv;
- Less than 300 workers with a dose > 10 mSv.

Future activities in 2016

Collective dose: continuation of the activities initiated since 2012.

- Implementation of the action plan on radiography inspection;
- Source Term management (oxygenation and purification during shutdown, management and removal of hotspots);
- Chemical decontamination of the most contaminated circuits;
- Optimization of biologic shielding (using CADOR software);
- Organizational preparation of the RMS, deployment of the fleet planned from 2016 to 2018.

49 outages are planned for 2016 with 22 short outages, 22 standard outages and 5 ten-year outages, including a ten-year outage on 3-loop reactor combined with a SGR and the end of the one started at Paluel 2 in 2015 (lead unit). For 2016 hydrotests on RHRS circuits are expected: Blayais, Cruas, Dampierre, Tricastin, Gravelines, Cattenom, Penly and Paluel, and supplementary controls and activities (due to post-Fukushima, "Grand carénage" and ASN demands).

3) Report from Authority

In 2015, ASN carried out 28 radiation protection inspections. In 2015, asn focused particular attention on compliance with the prescriptions for occupational radiation protection during work in controlled zones and this was checked in most of the npps operated by EDF.

The collective dose on all the reactors fell slightly in 2015 by comparison with 2014. The average dose received by the workers for one hour of work in a controlled zone has been falling since 2013. ASN considers that the radiation protection situation of the NPPs in 2015 could be improved on a certain number of points:

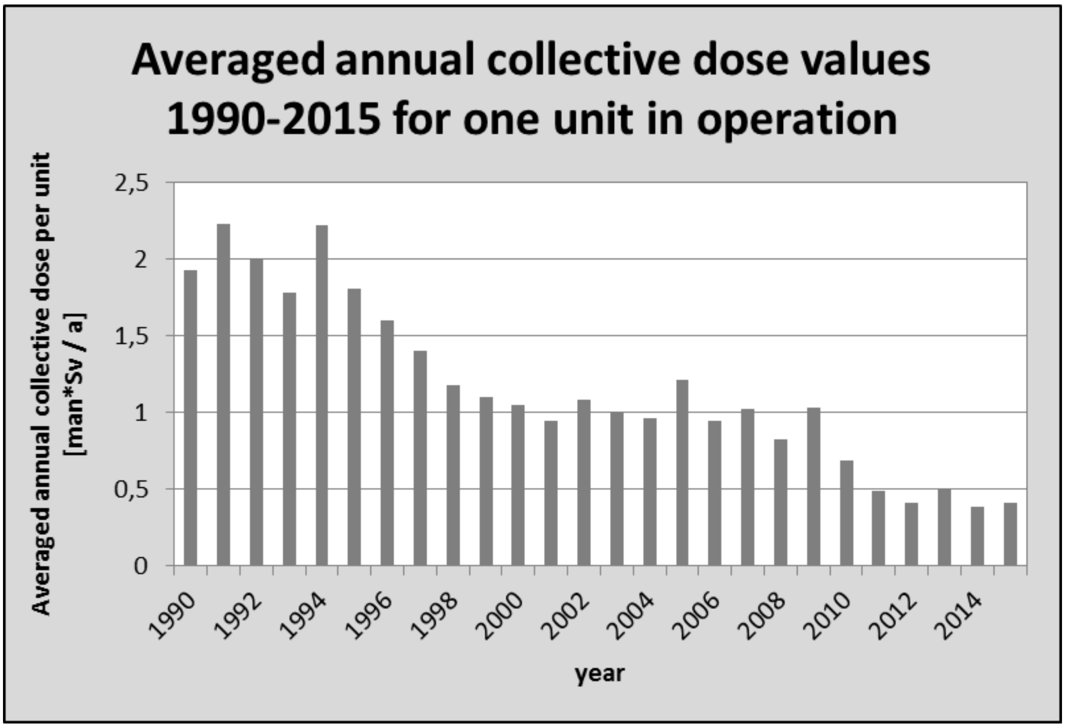
The management of industrial radiography worksites could be improved. ASN in particular observed two events in which the signs barring entry to operations areas were ignored. Progress is expected in the preparation of the worksites, more specifically the involvement of all stakeholders and the quality of the installation visits carried out when preparing these worksites.

- Management of contamination dispersal inside the reactor building is still insufficient, owing to inadequate worksite containment or contamination level signage errors. ASN repeatedly observed non-compliance with instructions for contamination checks on personnel exiting worksites, the lack of contamination inspection devices or devices that are unserviceable. In addition, on several sites, the inspectors found a lack of radiation protection culture on the part of certain workers.
- These inadequacies can contribute to delaying the detection of bodily contamination of the workers :
  - With regard to exposure monitoring, ASN has observed numerous events relating to the failure of workers to wear individual dosimeters. Improvements were however observed in terms of the optimisation of exposed worker classification and improvements in remote-dosimetry.
  - EDF has taken steps to reinforce control of personnel access to limited stay areas, although further improvements are still required. ASN observes inadequacies in the identification and signposting of these areas.

GERMANY

1) Dose information for the year 2015

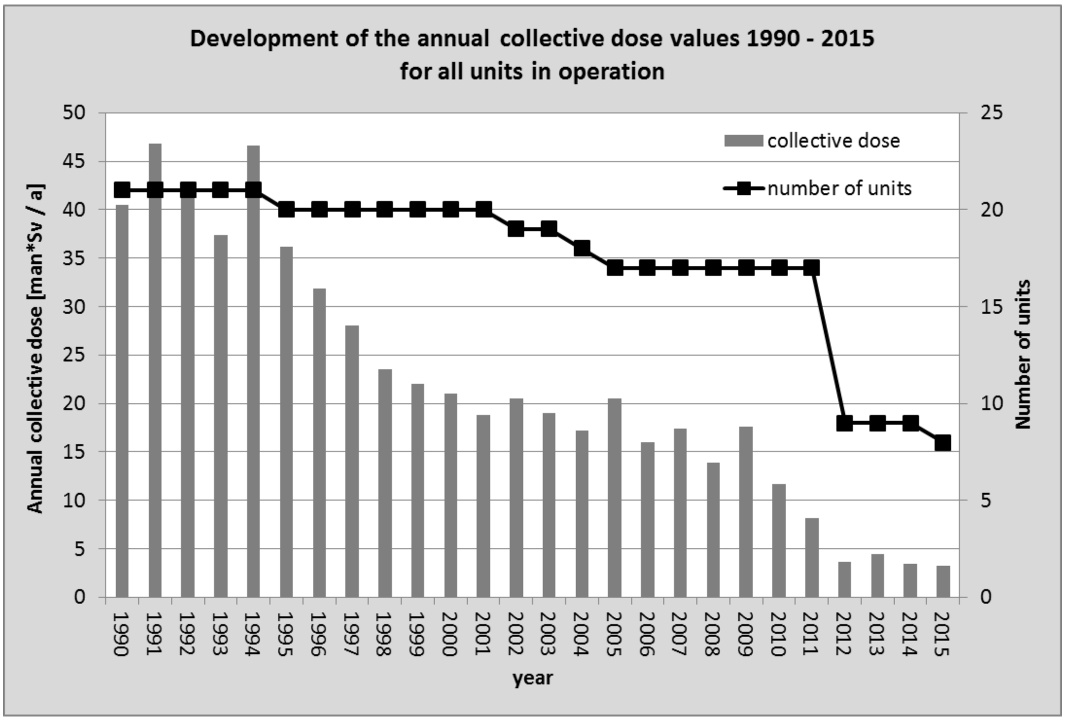
ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	6	169
BWR	2	1,114
All types	8	360
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	7	84
BWR	4	91
All types	11	86



Summary of national dosimetric trends

Due to the political decisions after the Fukushima accident in 2011, eight nuclear power plants (Unterweser, Biblis A, Biblis B, Neckarwestheim 1, Philippsburg 1, Krümmel, Brunsbüttel and Isar 1) were permanently shut down in the middle of the year 2011. The nuclear power plant Grafenrheinfeld was shut down on June 27th, 2015. The remaining eight nuclear power plants will be finally shut down in a stepwise process until 2022, due to the amendment of the Atomic Energy Act of July 2011; one plant each by the end of 2017 and 2019 and another three at the end of 2021 and of 2022.

In 2015, the average annual collective dose per unit in operation was 0.40 man·Sv which is comparable to the value of 0.38 man·Sv in the year 2014. The trend in the average annual collective dose from 1990 to 2015 is presented in the figure above. For the plants in decommissioning, the value of the average annual collective dose is even lower, at 0.09 man·Sv.



HUNGARY

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	4	441 (with electronic dosimeters) 436 (with TLDs)

2) Principal events of the year 2015

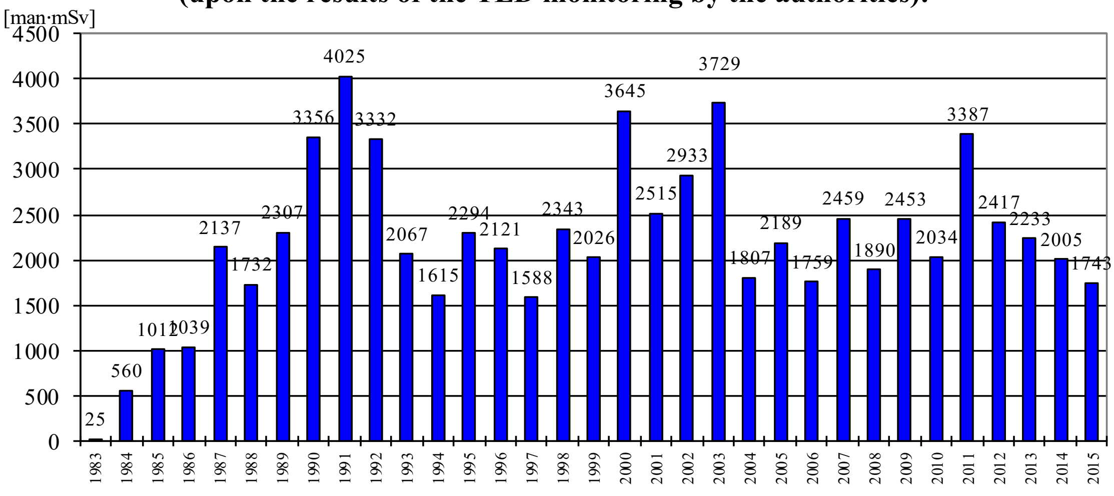
Summary of national dosimetric trends

Using the results of operational dosimetry the collective radiation exposure was 1,765 man·mSv for 2015 at Paks NPP (1,330 man·mSv with dosimetry work permit and 435 man·mSv without dosimetry work permit). The highest individual radiation exposure was 9.2 mSv, which was well below the dose limit of 50 mSv/year, and our dose constraint of 20 mSv/year.

The collective dose decreased in comparison to the previous year. The lower collective exposures were mainly ascribed to the exposure-reduction investment activities which resulted in higher doses ending in 2014.

The electronic dosimetry data correspond well with TLD data in 2015.

Development of the annual collective dose values at Paks Nuclear Power Plant (upon the results of the TLD monitoring by the authorities):



- *Events influencing dosimetric trends*

  There was one general overhaul (long maintenance outage) in 2015. The collective dose of the outage was 639 man mSv at Unit 1.
- *Number and duration of outages*

  The durations of outages were 65 days at Unit 1, 26 days at Unit 2, 29 days at Unit 3, and 24 days at Unit 4.

ITALY

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	17.82 (1 unit - Trino NPP)
BWR	2	80.04 (1 unit Caorso NPP [2.96 man·mSv] + 1 unit Garigliano NPP [77.08 man·mSv])
GCR	1	61.02 (1 unit - Latina NPP)

JAPAN

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit·year]**
PWR	24	188
BWR	24	223
All types	48	205
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit·year]**
BWR	8	9.724
GCR	1	0
LWCHWR	1	46

2) Principal events of the year 2015

- *Outline of national dosimetric trend*

  The average annual collective dose for shutdown BWRs decreased from 13.081 man·mSv/unit in the previous year (2014) to 9.724 man·mSv/unit in 2015. The average annual collective dose excluding Fukushima-daiichi NPP for this year was 44 man·mSv/unit, and that of Fukushima-daiichi NPP was 12.943 man·mSv/unit.

  The average annual collective dose of operating reactors was almost at the same level as for 2014. This is because almost all of the nuclear reactors have been shut down for a long time after the accident at Fukushima-daiichi NPP.

- *Operating status of nuclear power plants*

In FY 2015, only three PWRs operated.

From April 1st to August 13th, 2015 : no unit operated
From August 14th to October 20th, 2015 : 1 unit (Sendai unit 1)
From October 21st, 2015 to January 31st, 2016 : 2 units (Sendai unit 1, 2)
From February 1st to March 9th, 2016 : 3 units (Sendai unit 1, 2, Takahama 3)
From March 10th to March 31st, 2016 : 2 units (Sendai unit 1, 2)

- *Exposure dose distribution of workers in Fukushima-daiichi NPP*

  Exposure dose distributions at Fukushima-daiichi NPP for cumulative dose until March 2016 and for dose during FY 2015 are shown below.

As of July 31,2016

Cumulative dose Classification (mSv)	Number of workers (March 2011 – March 2016)			Fiscal year 2015 (April 2015 – March 2016)		
	TEPCO	Contractor	Total	TEPCO	Contractor	Total
＞250	6	0	6	0	0	0
200 ～ 250	1	2	3	0	0	0
150 ～ 200	26	2	28	0	0	0
100 ～ 150	117	20	137	0	0	0
75 ～ 100	321	312	633	0	0	0
50 ～ 75	328	1801	2129	0	0	0
20 ～ 50	633	6515	7148	6	592	598
10 ～ 20	619	5794	6413	52	1947	1999
5 ～ 10	507	5439	5946	108	2247	2355
1 ～ 5	908	9618	10526	533	5114	5647
≦1	1246	12759	14005	998	6599	7597
Total	4712	42262	46974	1697	16499	18196
Max. (mSv)	678.80	238.42	678.80	24.00	43.20	43.20
Ave. (mSv)	22.43	11.76	12.83	1.85	4.52	4.27

* TEPCO uses the integrated value from the APD that is employed every time an individual enters the radiation controlled area of the facility. These data are sometimes replaced by monthly dose data measured by an integral dosimeter for the individual.
* There has been no significant internal radiation exposure reported since October 2011.
* Internal exposure doses may be revised when the reconfirmation is made.

– *Regulatory requirements*

The examination of the new safety standards began in July 2013. Three PWRs obtained approval in FY 2015.

3) Report from Authority

The IAEA conducted an Integrated Regulatory Review Service (IRRS) mission to NRA from January 11th to 22nd, 2016.

The mission report was sent from IAEA and received by NRA on 23 April 2016.

Good practices

• The Government of Japan has put in place a framework which established and supports NRA as a new effective independent and transparent regulatory body with increased powers.

• NRA made a prompt and effective incorporation of the lessons learnt from the TEPCO Fukushima-daiichi accident in the areas of natural hazards, severe accident management, emergency preparedness and backfitting of existing facilities, into the Japanese legal framework.

Recommendations and Suggestions concerning Radiation Protection

• The government should ensure that the Japanese regulatory authorities having responsibilities relevant to nuclear and radiation safety develop and implement an effective, collaborative process for the exchange of information regarding policies, authorisations, inspections and enforcement actions to provide coordinated and effective regulatory oversight that should also ensure a harmonized regulatory framework under their respective responsibilities.

• The Government should empower the regulatory body to establish requirements for authorization or approval processes for service providers for monitoring of occupational and public exposures, and environmental monitoring in general, and verify that these requirements are met by licensees.

• NRA should put greater priority and allocate more resources on its oversight of the implementation of radiation protection measures by licensees as well as its participation in the development of international standards in radiation protection and related research activities in collaboration with NIRS.

• NRA should establish requirements relating to consideration of decommissioning during all life stages of nuclear and radiation facilities and criteria for the release of sites at the end of decommissioning.

• NRA and other authorities having jurisdiction for radiation sources should develop a single set of requirements and guidance for EPR in relation to radiation sources including requirements related to emergency plans, arrangements for timely notification and response, and quality assurance programme using graded approach.

• NRA should consider strengthening its plans and procedures to consistently respond to emergencies related to radiation sources.

Response to issues concerning Radiation Protection in FY 2016

• NRA will create a proposal for detailed system design of regulatory requirements to licensees of radioisotopes which include development of an emergency response system, theft prevention measures (security), safety culture and quality assurance, etc.

• Based on the above proposal, NRA will revise the regulations.

• To strengthen the inspection system for radioisotopes, NRA considers the improvement of training programmes for inspectors with sufficient capacity for the new field of inspection and requirements for an increase in manpower.

• NRA considers establishment of a mechanism to identify, collect, and evaluate up-to-date knowledge of radiation protection.

• Based on domestic and international trends, NRA considers a framework for improvement of quality assurance in the monitoring of occupational exposure, etc.

KOREA, REPUBLIC OF

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	21	310.52
PHWR	4	585.15
All types	25	354.46

2) Principal events of the year 2015

– *Summary of national dosimetric trends*

For the year 2015, 25 NPPs were in operation; 21 PWR units (Shin Kori #3 is under commissioning) and 4 PHWR units. The average collective dose per unit in 2015 was 354.46 man·mSv. The dominant contributors of the collective dose in 2015 were the works carried out during the outages, resulting in 86.6 % of the total collective dose. 14,926 people were engaged in radiation works and the total collective dose was 8,861.58 man·mSv.

– *Number and duration of outages*

Overhauls were performed at 16 PWRs and 3 PHWRs. The total duration for the outages was 1,074 days for PWRs and 277 days for PHWRs. Total outage duration was increased by compared to that in 2014.

– *Component replacements*

- Reactor Vessel Head was replaced at Hanbit 4 from August 2015 to November 2015 during the outage, resulting in 40.05 man·mSv.
- Steam generator tubes were maintained at Hanul 4 in 2015, resulting in 78.57 man·mSv.

– *Unexpected events/incidents*

None

- *New reactors on line in 2015*

  - Shin Wolsong Unit 2 starts commercial Operation (2015/7/24).
  - Shin Kori #3 is under commissioning. (Reactor Fuels are loaded.)

- *New dose-reduction programmes*

A trial application of zinc injection to reduce source term has been applied to Hanul 1 from 2010, and as a result of this attempt, there was about 30% ~ 40% decrease of radiation exposure rate at RCS pipings and steam generator chambers. KHNP is planning to extend zinc injection to other reactors. Zinc injection is scheduled to be applied to 4 NPPs (Hanbit 3, 4/ Hanul 3,4) from 2017, and 4 NPPs (Kori 2, Hanul 2, Hanbit 5, 6) from 2018.

LITHUANIA

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
LWGR	2	342.09

2) Principal events of the year 2015

- *Events influencing dosimetric trends*

  In 2015, the occupational doses at the Ignalina NPP (INPP) were maintained as low as possible, taking into account all economic, social and technological conditions: 631 man·mSv in 2011, 587 man·mSv in 2012, 655 man·mSv in 2013, 638 man·mSv in 2014, and 684 man·mSv (62% of planned dose) in 2015. The collective dose for INPP personnel was 619.9 man·mSv (65% of planned dose), and for contractor personnel – 64.3 man·mSv (40% of planned dose). The external dosimetry system used was Thermoluminescence dosimeters (TLD).

  The 20 mSv individual dose limit was not exceeded. The highest individual effective dose for INPP staff was 9.37 mSv, and for contractor personnel – 7.13 mSv. The average effective individual dose for INPP staff was 0.36 mSv, and for contractor personnel – 0.06 mSv.

  The main works that contributed to the collective dose during technical service and decommissioning of Units 1 and 2 at the INPP were fuel handling; repairing of the hot cell; modernization and maintenance works at the spent fuel storage pool hall, reactor hall and reactor auxiliary buildings; waste and liquid waste handling; radiological monitoring of workplaces and radiological investigations; and isolation of the main circulation circuit.

  In 2015, no component or system replacements were performed. In 2015, there were no unexpected events.

- *New/experimental dose-reduction programmes*

  The doses were reduced by employing up-to-date principles of organization of work, by doing extensive work on modernization of plant equipment, and by using automated systems and continuously implementing programs of introducing ALARA principle during work activities. The evaluation and upgrading of the level of safety culture, extension and support to the effectiveness of the quality improvement system are very important.

- *Organisational evolutions*

Year 2015 was very important to decommissioning of INPP. During the year, significant progress was made in implementation of the major decommissioning projects. Results of great importance to the safe decommissioning of INPP were achieved.

Cold trials of the new Spent Nuclear Fuel Storage Facility were successfully completed and functionality of the building, installed systems and equipment was demonstrated. An issue on safety justification of spent nuclear fuel casks was resolved. Cold trials of the Solid Radioactive Waste Handling and Storage Facility were started.

At the end of 2015, the State Nuclear Power Safety Inspectorate issued a license for construction and operation of a Landfill Facility for Short-lived Very Low Level Waste.

The progress of key decommissioning projects was evaluated by the contributing countries and European Commission as positive. The progress of decommissioning projects was presented to the delegations of the embassies of Denmark, Canada, Germany, France, Spain, the Netherlands and Japan.

In 2015, the dismantling works continued, with about 8.6 thousand tonnes of equipment dismantled that year.

The second stage of the enterprise structural change was completed at the end of the year. The dismantling planning and control functions were separated from the dismantling implementation process.

The positive practice of cooperation with IAEA was maintained in 2015. An International Workshop on Development of Specific Decontamination Techniques for RBMK Reactors Dismantling and Removal of Radioactive Material was organized at the INPP, where the experts of different countries shared their experience.

The priority activities of INPP are nuclear and radiation safety, transparency and effectiveness of the activity, responsibility of staff and high professional quality of workers, and social responsibility.

3) Report from Authority

In 2015, VATESI carried out radiation protection inspections at Ignalina NPP in accordance with an approved inspection plan. Assessments were made regarding how radiation protection requirements were fulfilled in the following areas and activities: clearance of radioactive materials, monitoring of occupational exposure and radiation protection during dismantling and decontamination works of turbine hall equipment of Unit 1. Inspections results showed that Ignalina NPP activities were carried out in accordance with the established radiation protection requirements.

In 2016, VATESI will continue supervision and control of nuclear safety of decommissioning of INPP, management of radioactive waste, including the construction and operation of new nuclear facilities, as well as the radiation protection of these activities and facilities. To enhance the level of radiation protection during decommissioning of the INPP, VATESI will continue to review radiation protection requirements established in legal documents. It is planned to approve amended requirements on occupational radiation protection at nuclear facilities by the end of 2016.

MEXICO

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	2	4833,51

2) Principal events of the year 2015

Summary of national dosimetric trends

The nuclear reactors existing in Mexico are two BWR/GE units at the Laguna Verde Nuclear Power Station located in Laguna Verde, State of Veracruz, Mexico.

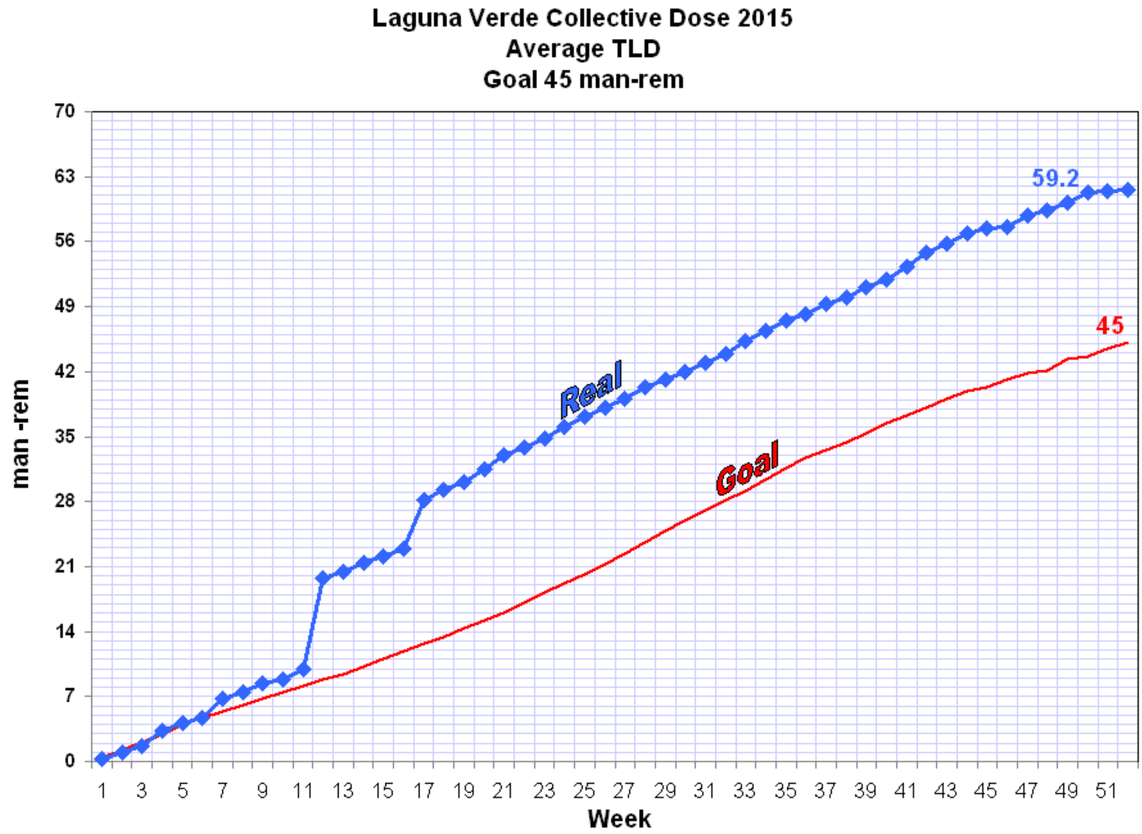
Laguna Verde's historical collective dose both on line and during refuelling outages is higher than the BWRs average. On line collective dose is high because of shortfalls or failures in equipment reliability. Some examples are steam leaks, reactor water cleanup system pump failures, and radwaste treatment systems failures. Refuelling outage collective dose is high mainly because the radioactive source term (Co-60) caused high radiation areas.

There was the LV's Vice President's strong commitment to keep collective dose ALARA.

2015 collective dose was the lowest for on line (normal) operation. For unit 1 it was 0.59175 man·Sv and unit 2, 0.5585 man·Sv; no matter , Laguna Verde staff recognizes these values are high when compared with those of other BWRs.

- *Events influencing dosimetric trends*
    a) Increase of radioactive source term: this factor was originated by the reactor water chemical instability induced in turn by the application of noble metals and hydrogen since 2006 to prevent the stress corrosion cracking of reactor internals. This factor is still strongly influencing dose rates at the plant and specifically in the drywell during refuelling outages.

    Since 2011, LV's Chemistry Manager has taken the responsibility for hydrogen injection, iron control in feed water and any other condition that can result in a chemical instability inside the reactor vessel. Laguna Verde's VP has appointed a Source Term Control and Reduction Project Manager (STPM), supported by the Radiological Protection Manager (RPM) and the Chemistry Manager (CM).



On Line 2015 Collective Dose Graph

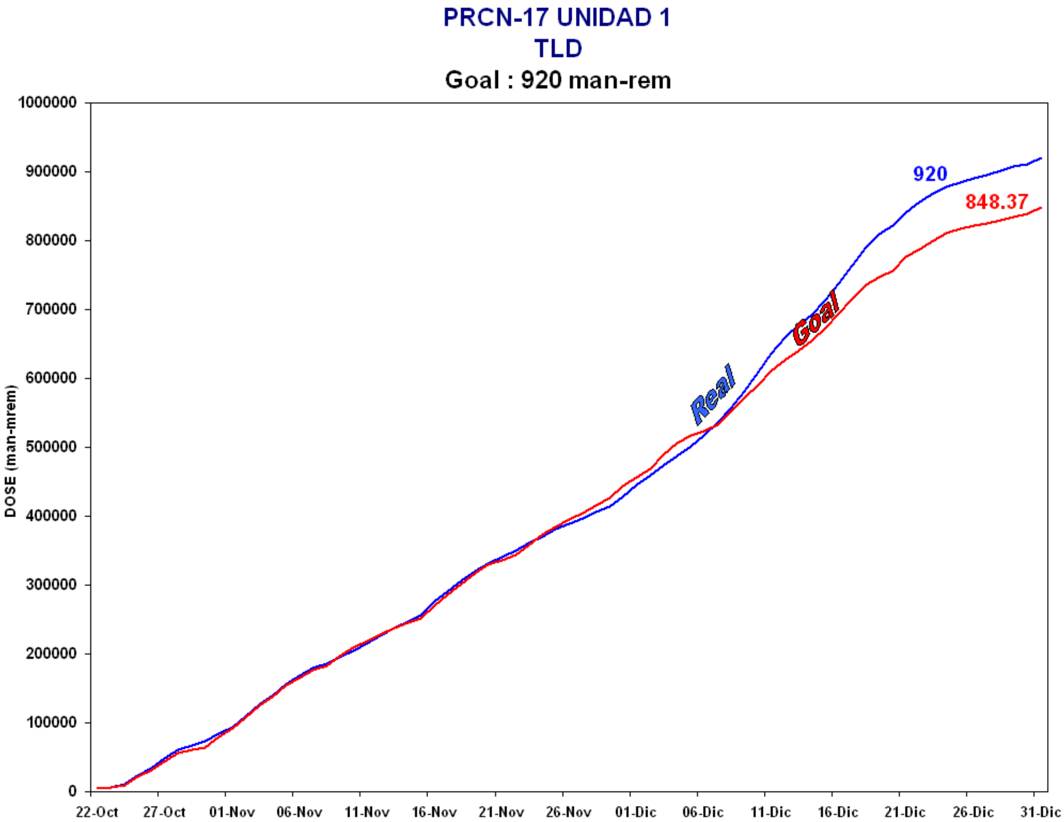
45 man-rem = 450 man-mSv

– *Number and duration of outages*

2015: 17 RFO U1 (from October 22nd 2015 to December 31th 2015) Collective dose 8.4837 man·Sv.

Forced outages:
U1:
From June 29th 2015 to July 01th 2015 in Unit 1, collective dose 0.00524 man·Sv.

U2:
From May 19th 2015 to May 24th 2015 in Unit 2, collective dose 0.01441 man·Sv.
From May 12th 2015 to May 15th 2015 in Unit 2, collective dose 0.01519 man·Sv.



– *New plants on line / plants shutdown*

None

– *Major evolutions*

None

– *Component or system replacements*

None

– *Safety-related issues*

None

– *Unexpected events*

None

– *New/experimental dose-reduction programmes*

The main problem associated with the high collective dose at Laguna Verde NPS is the continued increase of the radioactive source term (insoluble Cobalt deposited in internal surfaces of piping, valves and equipment in contact with the reactor water coolant).

Control and optimisation of reactor water chemistry plays a fundamental role in the control and eventual retraction of the source term. The main strategies / actions aiming at such purpose are:

- Chemical decontamination of recirculation loops during refuelling outages: to be applied until all of the other reactor water chemistry parameters become stabilized and optimised, in order to avoid a recontamination next cycle after the decontamination; On Line Noble Metal Chemistry (OLNC);
- Cobalt selective removal resins continuously applied to reactor water;
- Continuous application of Zinc to the reactor water;
- Control of Iron concentration in feed water;
- Reactor Water Cleanup System (RWCU) continuous operation;
- Fuel Pool Cooling and Cleanup System (FPCC) hydrolysing;
- Optimising continuity and availability of Hydrogen injection to the reactor;
- CRUD pumps with high flow (600 gpm) during the outages (2014);
- Portable demineralizer during the outages (2014);
- RWCU system modifications to improve its efficiency.

– *Organisational evolutions*

None

For 2016

Issues of concern in 2016

Two refuelling outages - 18 RFO Unit 1 and 15 RFO Unit 2.

Technical plans for major work in 2016

Work on the above-mentioned strategies for radioactive source term reduction.

Regulatory plans for major work in 2016

No comments.

THE NETHERLANDS

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	Collective dose = 217.2 man·mSv; average individual = 0.29 mSv
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	1	0

2) Principal events of the year 2015

- *Events influencing dosimetric trends*

  Outage duration was 29 days. No specific high dose jobs.

1.

PAKISTAN

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PHWR	1	1,843.83
PWR	2	593.705
All types	3	1,010.41

2) Principal events of the year 2015

- *Events influencing dosimetric trends*
  - PHWR 12 outages, 133 days
  - PWR (Chashma -1) 3 outages, 122 days
  - PWR (Chashma -2) 3 outages, 37.67 days

- *Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitely shutdown*

  Moderator Heat Exchangers Tube Leak (for PHWR).

ROMANIA

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
CANDU	2	194

2) Principal events in the year 2015

Summary of national dosimetric trends

Occupational exposure at Cernavoda NPP (2000-2015)			
Year	**Internal effective dose [man·mSv]**	**External effective dose [man·mSv]**	**Total effective dose [man·mSv]**
2000	110.81	355.39	466.2
2001	141.42	433.44	574.86
2002	206.43	344.04	550.48
2003	298.02	520.27	818.28
2004	398.26	258.45	656.71
2005	389.3	342.29	731.59
2006	302.27	258.79	561.06
2007	83.34	187.49	270.83
2008 (2 units)	209.3	479.34	688.6
2009 (2 units)	67.6	417.7	485.3
2010 (2 units)	210.3	577	787.3
2011 (2 units)	56	337	393
2012 (2 units)	250.8	667.1	917.9
2013 (2 units)	92.3	416.8	509.1
2014 (2 units)	160.3	432	592.3
2015 (2 units)	36.4	351.7	388.1.3

– *Events influencing dosimetric trends*

Normal operation of the plant (U1 & U2)

At the end of 2015:

- there are 90 employees with annual individual doses exceeding 1 mSv; 5 with individual doses exceeding 5 mSv; none with individual dose over 10 mSv (unplanned exposure) and none with individual dose over 15 mSv;
- the maximum individual dose for 2015 is 6.632 mSv;
- the contribution of internal dose due to tritium intake is 9.4%.

An aggressive policy to reduce tritium exposure has been applied since 2005, including strict control of D_2O leaks, providing dryers' availability, and optimization of personnel access in R/B. Radiation Work Permits require workers to use adequate respiratory protection both in normal operation and outages. By implementing a Tritium in Air Monitoring System, the number of routine and investigation activities for tritium monitoring was reduced by 50%. As a result, collective internal dose was significantly reduced from 250.8 man·mSv in 2012 to 160.3 man·mSv in 2014, and from 92.3 man·mSv in 2013 to 36.4 man·mSv in 2015, which are the lowest collective internal doses in the CANDU fleet.

Planned Outage

A 23-day planned outage was done at Unit 2 between May 9th and June 1st, 2015. Activities with major contribution to the collective dose were as follows:

- Fuelling machine bridge components preventive maintenance;
- Feeder – yoke clearance measurements and correction;
- Inspection for tubing and supports damages in the feeder cabinets;
- Planned outage systematic inspections;
- Feeder thickness measurements, feeder clearance measurements, feeder-yoke measurements, elbow UT examination;
- Snubbers inspection, piping supports inspection.

Total collective dose at the end of the planned outage was 172.2 man mSv (154 man mSv external dose and 18.2 man mSv internal dose due to tritium intakes).

Finally this planned outage had a 44% contribution to the collective dose of 2015.

Planned Outages dose history

Year	Unit	Interval	External collective dose received man mSv	Internal collective dose (^3H intakes) received man mSv	Total collective dose received man mSv
2003	1	15.05 – 30.06	345	161	506
2004	1	28.08 – 30.09	153	179	332
2005	1	20.08 – 12.09	127	129	256
2006	1	09.09 – 04.10	103	107	210
2007	2	20 – 29.10	16	0	16
2008	1	10.05 – 03.07	187	111	298
2009	2	09.05 – 01.06	122	11	133
2010	1	08.05 – 01.06	319	95	414
2011	2	07.05 – 01.06	117.2	13	130.2
2012	1	04.05 – 11.06	396.9	177.7	574.6
2013	2	10.05 – 03.06	185.8	49.2	235
2014	1	09.05 – 06.06	229	81.4	310.4
2015	2	09.05 – 01.06	154	18.2	172.2

Unplanned outages

Unit 1 – March 27th – March 30th: Unit was orderly shut down for corrective maintenance on Liquid Zone Control circuit. (12.4 man mSv external dose).

Radiation protection-related issues

During 2014, the implementation of Radiation Monitoring System (RMS) at Cernavoda U1 was started. The system already exists in Unit 2. This project was finalized in 2015.

The purpose of this improvement was to connect the on-line radiation monitoring equipment to a computerized interface system that allows remote monitoring, limited remote control capability and maintaining an integrated short and long-term database.

RMS interface with the following systems is enabled: Fixed Gamma Area Monitoring, Fixed Contamination Monitoring, Portable Radiation Monitors, Fixed Tritium in Air Monitoring, Liquid Effluent Monitor, Gaseous Effluent Monitor and Post Accident Air Sampling and Monitoring.

The expectation is that the collective dose of the operating personnel will decrease (by avoiding entry into high radiation hazard areas) and radiation hazard control will be improved for the normal operation of the plant (where real time radiation hazard information will be available).

Issues of concern in 2015

The main concerns for 2015 were important works, with high radiological impact, performed during the Planned Outage of Unit 2.

For 2016

Issues of concern in 2016

The main concerns for 2016 are activities with high radiological impact, to be performed during the Planned Outage of Unit 1:

- Removal of magnetite deposits from the inside diameter surface of the steam generators' tubes;
- ECT inspection of Steam Generators;
- Fuelling machine bridge components preventive maintenance;
- Feeder – yoke clearance measurements and correction;
- Inspection for tubing and supports damage in the feeder cabinets;
- Planned outage systematic inspections;
- Feeder thickness measurements, feeder clearance measurements, feeder – yoke measurements, elbow UT examination;
- Snubbers inspection, piping supports inspection;
- Implementation of engineering changes.

RUSSIAN FEDERATION

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	18	559.6
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	2	69.3

2) Principal events of the year 2015

Collective doses

In 2015, the total effective annual collective dose of utility employees and contractors at eighteen operating VVER type reactors was 10,072.5 man·mSv. This value presents a 395 man·mSv (3.8%) decrease from the year 2014 total collective dose of 10,467.5 man·mSv.

Comparative analysis showed a considerable difference between average annual collective doses for the groups of VVER-440 MWe and VVER-1000 MWe operating reactors. In 2015, the results were as follows:

- 1,026.8 man·mSv/unit with respect to the group of six operating VVER-440 reactors (Kola 1-4, Novovoronezh 3-4);
- 448.2 man·mSv/unit with respect to the group of eleven operating VVER-1000 reactors (Balakovo 1-4, Kalinin 1-4, Rostov 1-2, Novovoronezh 5). Rostov 3 was not considered during this estimation. This reactor was put into commercial operation on 17 September 2015, and collective dose was 8.3 man·mSv through the end of 2015.

  Average annual collective dose for two reactors at the stage of decommissioning (Novovoronezh 1 of VVER-210 MWe and Novovoronezh 2 of VVER-365 MWe) was 69.3 man·mSv/unit as compared to 44.7 man·mSv/unit in 2014.

- *Events influencing dosimetric trends*

  In 2015, average annual collective doses for the group of VVER-440 reactors increased by 44.7% as compared to 2014. The main reason is the major repair outage and the considerable increase of collective dose to 1,677.1 man·mSv/unit at Novovoronezh 4.

  Average annual collective doses for the group of VVER-1000 reactors decreased by 20.6% as compared to 2014. As the result of 18 month fuel campaigns at all Russian units with VVER-1000 reactors (except Novovoronezh 5 NPP), there was no planned outage at three reactors (Balakovo 4, Kalinin 3 and 4) in 2015. Moreover, the planned outage at Balakovo 3, begun in 2014, was finished with a duration of 15 days in 2015. Planned outages were performed at all VVER-1000 units in 2014. Thus, the 2015 collective dose decrease was entirely determined by the decrease in the total number and duration of planned outages as compared to 2014.

Average annual collective dose for two reactors at the stage of decommissioning increased by 55.0% in 2015. The main reason is the increase of work on radioactive waste treatment.

Individual doses

In 2015, individual effective doses of utilities' employees and contractors did not exceed the control dose level of 18.0 mSv per year at any VVER-440 or VVER-1000 reactor.

The maximum recorded individual dose was 16.8 mSv. This dose was gradually received over the full year by a worker in the Novovoronezh NPP maintenance department during the repair of reactor component equipment at Units 3-5.

The maximum annual effective individual doses at other nuclear plants with VVER type reactors in 2015 were:

- Balakovo – 14.0 mSv;
- Kalinin – 11.3 mSv;
- Kola – 14.9 mSv;
- Rostov – 6.7 mSv.

Planned outage durations and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Balakovo 1	54	1,256.0
Balakovo 2	80	567.7
Balakovo 3	15 (completion of outage which was started in 2014)	84.6
Balakovo 4	No outage	--
Kalinin 1	33	584.7
Kalinin 2	34	474.7
Kalinin 3	No outage	--
Kalinin 4	No outage	--
Kola 1	50	483.4
Kola 2	49	300.8
Kola 3	57	1,138.9
Kola 4	49	619.3
Novovoronezh 3	31	730.7
Novovoronezh 4	70	1,523.0
Novovoronezh 5	67	940.4
Rostov 1	63	193.7
Rostov 2	45	157.0
Rostov 3	No outage	--

Unplanned outage durations and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Kalinin 2	8	67.2
Rostov 1	13	22.9
Rostov 2	5	10.1

New reactor on line

Rostov 3 with a VVER-1000 MWe type reactor (project V-320) was put into commercial operation on 17 September 2015.

Issues of concern in 2015

- New programme of radiation protection optimization at Concern Rosenergoatom NPPs for the period 2015 – 2019.
- Results of 2014 collective dose budget for all Russian nuclear power plants and projects for 2015.
- Putting into operation new automated equipment (AKIDK-401) at Kalinin NPP for dose control to the skin and lens of the eye.
- Complex of organizational and technical actions aimed at decreasing doses of utilities' employees and contractors: implementation of special protective clothes at Balakovo NPP, optimization of work for recharging of gamma flaw detectors at Kola NPP, use of new type manipulator for SG tube plugging at Rostov NPP.

SLOVAK REPUBLIC

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	4	163.414
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	2	Not included in ISOE
GCR	1	Not included in ISOE

2) Principal events of the year 2015

– *Events influencing dosimetric trends*

- Bohunice NPP (2 units): The total annual effective dose in Bohunice NPP in 2015, calculated from legal film dosimeters, was 398.298 man mSv (employees – 124.326 man mSv, outside workers – 273.972 man mSv). The maximum individual dose was 5.288 mSv (contractor). Without internal contamination. Without anomalies in radiation conditions.
- Mochovce NPP (2 units): The total annual effective dose in Mochovce NPP in 2015, evaluated from legal film dosimeters and E50, was 255.357 man mSv (employees – 87.753 man mSv, outside workers – 167.594 man mSv). The maximum individual dose was 2.62 mSv (contractor worker).

– *Outage information*

Bohunice NPP:

- Unit 3 – 46.4 day major maintenance outage. The collective exposure was 302.136 man mSv from electronic operational dosimetry
- Unit 4 – 19.8 day standard maintenance outage. The collective exposure was 117.286 man mSv from electronic operational dosimetry.

Mochovce NPP:

- Unit 1 – 27.25 day standard maintenance outage. The collective exposure was 143.314 man mSv from electronic operational dosimetry.
- Unit 2 – 19.3 day major maintenance outage. The collective exposure was 85.62 man·mSv from electronic operational dosimetry.

- *Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown*

  - Mochovce NPP –The computerised central radiological data system was finished.

- *Unexpected events/incidents*

  - Bohunice NPP – Unexpected exposure during the outage of Unit 3: during the removal of foreign material found in an internal part of the reactor, the contractor caught it in his hand for 18 sec. After the investigation, the assigned equivalent dose to the skin was 437 mSv and the equivalent dose to the extremity was 30 mSv. The contractor violated the RP rules – he performed work without approval of the RP dept., and he did not stop the work when he heard the warning signals of the EPD.

3) Report from Authority

- Licensing process of the NPP Mochovce, Units 3 and 4.
- Decommissioning of JAVYS NPP, inspection.
- Inspections of outages in all operated units.

SLOVENIA

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	790

2) Principal events of the year 2015

- *Events influencing dosimetric trends*
  - Refuelling outage duration of 36 days (April 11th – May 16th, 2015). Outage collective dose was 690 man·mSv.
  - A modification related to reactor vessel up-flow conversion was performed efficiently to prevent fuel failures due to cladding fretting in the upper core baffle region.
- *Regulatory requirements*

  Technical Plans (refer to Slovenian 7th Report on Nuclear Safety):

  Post Fukushima up-grade projects are going on. The first phase of the Safety Upgrade Programme (SUP) was completed in 2013 with installation of passive containment hydrogen recombiners and a passive post-accident filter system. The modifications for the second phase of the SUP, planned to be concluded in 2018 include: flood protection of the nuclear island, operation support centre reconstruction, pressurizer power operated valve bypass, spent fuel pool alternative cooling, alternate cooling of reactor coolant system (RCS) and containment, emergency control room, upgrade of bunkered building electrical power supply, and replacement and upgrade of critical instrumentation.

  The third phase of the SUP will comprise a bunkered building with additional sources of borated and clean water with injection systems for the reactor cooling system / containment and steam generators capable of assuring reactor cooling for at least 30 days. The third phase will be completed by the end of 2021.

  Spent fuel dry storage at the plant location is scheduled for implementation in the year 2020.

3) Report from Authority

Slovenian Nuclear Safety Administration (SNSA) and Slovenian Radiation Protection Administration (SRPA) are performing regulatory control and inspection surveillance of the Krško NPP operation.
In 2015 and 2016, both regulatory authorities are putting effort into legislative amendments and their implementation. At the end of 2015 the Slovenian Ionising Radiation Protection and Nuclear Safety Act was amended. Other under-lying legislative acts concerning radiation protection and nuclear safety will be changed accordingly.
At the same time, legislative changes will be made to implement the new EU BSS directive.

SOUTH AFRICA

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	2	1,028.158 (TLD)

2) Principal events of the year 2015

- *Events influencing dosimetric trends*
- *Number and duration of outages*

  Koeberg Nuclear Power Station Unit 1 Refuelling Outage

  The Koeberg Nuclear Power Station Unit 1 was operational and on-line since December 27th, 2013 and was shut down for a refuelling outage on February 5th, 2015. During the power reduction and depressurization phases, no increase in fission product activity was observed. This confirmed the absence of any fuel defects in the reactor core. All of the fuel assemblies were tested for leaks via a sipping process during fuel unloading. The Koeberg Nuclear Power Station Unit 1 refuelling outage was completed on May 28th, 2015. The refuelling outage ALARA dose target was set at 1,167 man mSv, and the collective dose for the refuelling outage was 949.406 man mSv. A total of 81,201 entries were made into the reactor building for executing work activities, which equates to 0.011 mSv per entry. The highest dose to an individual registered during the refuelling outage was 8.364 mSv.

  Koeberg Nuclear Power Station Unit 2 Refuelling Outage

  The Koeberg Nuclear Power Station Unit 2 was operational and on-line since May 13th, 2014 and was shut down for a refuelling outage on August 31st, 2015. During the power reduction and depressurization phases, no increase in fission product activity was observed. This confirmed the absence of any fuel defects in the reactor core. All of the fuel assemblies were tested for leaks via a sipping process during fuel unloading. The Koeberg Nuclear Power Station Unit 2 refuelling outage was completed on December 3rd, 2015. The refuelling outage ALARA dose target was set at 1,152 man mSv, and the collective dose for the refuelling outage was 1,106.552 man mSv. A total of 77,797 entries were made into the reactor building for executing work activities, which equates to 0.014 mSv per entry. The highest dose to an individual registered during the refuelling outage was 5.45 mSv.

- *Component or system replacements, Unexpected events/incidents, New reactors on line*

  During the refuelling outage on Unit 1, the lagging around the reactor vessel was replaced with new lagging. A total dose of 13.146 man mSv was accrued for the work versus a target of 15 man mSv.

During the refuelling outage on Unit 2, a modification was made to the fuel handling mast and in-line sipping instrumentation was fitted. A total dose of 12.726 man mSv was accrued for the work.

- *Unexpected events/incidents*

  One personal dose-meter alarmed while an individual was working on a primary system heat exchanger. The contact dose rate conditions on the component were found to be higher than anticipated.

SPAIN

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	6	430.25
BWR	1	2,466.80
All types	7	378.90
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	438.36
BWR	1	119.90
GCR	1	0

2) Principal events of the year 2015

PWR

Almaraz NPP

– *Events influencing dosimetric trends (Outage information (number and duration), Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown…)*

22nd outage of Almaraz Unit 2:

- Duration: 40 days
- Collective outage dose: 436.836 man·mSv
- Maximum individual outage dose: 2.952 mSv

- Replacement of Feed Water System pipes in 22nd outage of Unit 2
- Modification in vessel seal cones in 22nd outage of Unit 2
- Replacement of external nuclear instrumentation system and its associated wiring during 22nd outage of Unit 2.

- *New/experimental dose-reduction programmes*

- Degreasing of the cavity walls and floor with solvent during 22nd outage of Unit 2.

Ascó NPP

– *Events influencing dosimetric trends (Outage information (number and duration), Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown…)*

24th refuelling outage of Ascó 1:

- Duration: 42 days
- Collective outage dose: 498.73 man·mSv
- Maximum individual outage dose: 3.948 mSv
- Relevant activities from RP point of view performed during refuelling outage:
  - ✓ Reactor cavity injection design modification
  - ✓ H_2 Passive Autocatalytic Recombiners installation
  - ✓ Filtered reactor containment venting system installation

Trillo NPP

- *Events influencing dosimetric trends (Outage information (number and duration), Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown…)*

  - Outage duration: 31 days
  - Collective outage dose: 247.467 man·mSv
  - Maximum individual outage dose: 2.97 mSv.

- *Organisational evolutions*
  - New specialist who is undergoing training to be the future head of radiation protection.

Vandellós 2 NPP

- *Events influencing dosimetric trends (Outage information (number and duration), Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown…)*

One outage with 57 days duration and a collective dose of 784.32 man·mSv. During the outage, the reactor vessel head was replaced. The total operational dose due to the reactor vessel head replacement, including the required plant design modifications, was 119.842 man·mSv.

BWR

Santa María De Garoña NPP

- *Events influencing dosimetric trends (Outage information (number and duration), Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown…)*

Date	Event	Collective Dose (man·mSv)
February 17th - March 6th	Control rod drive (CRD) removal and maintenance	14.338
September 3rd - December 30th	Reconditioning of drums containing waste built-in MICROCEL	14.106

Cofrentes NPP

- *Events influencing dosimetric trends (Outage information (number and duration), Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown…)*

  Chemical decontamination of the reactor recirculation system (B33) and reactor water clean-up system (G33) lines in the 20th outage.

- *Number and duration of outages*
  - 20th outage
  - 48 days
  - There was 1 forced outage to change damaged fuel elements (11 days).

- *New/experimental dose-reduction programmes*

  - <u>Improvement of the protection wardrobe used in reactor cavity</u>
    Use of ventilated hoods for specific work with high risk of personal contamination, to improve the workers' conditions in the reactor cavity.

- Chemical decontamination
  Chemical decontamination of the reactor recirculation system (B33) and reactor water clean-up system (G33) lines in the 20th outage.

- Auxiliary filtering systems in reactor building spent fuel pools
  Increase in the capacity of the auxiliary filtering systems, by providing 4 TRINUKE pumps in the 20th outage.

- Use of remote equipment
  Use of suction robot in reactor building spent fuel pools and remote equipment for the replacement of internal valves of the recirculation system (B33).

- Remote dose control
  The remote dose control system was used for a multitude of work in the dry well, like CRDs change, LPRMs change, SRMs and IRMs revision, chemical decontamination, internal valves replacement of recirculation system (B33) and others.

- Time reduction in high radiation areas and job control from access
  IP type TV cameras were installed in different points of the dry well and auxiliary building steam tunnel allowing the radiological control and supervision of the work from low radiation areas. Additionally, time-lapse TV cameras were installed on the refuelling and turbine floors. Screens were used at the dry well entrance to be able to check the component locations from a low radiation area. Besides, this tool was in use during the job planning stage.

- Temporary and permanent shielding
  The site continued implementation of permanent shielding in different plant areas.

- Training in scale models
  Training was performed using scale models for the following jobs: recirculation system plugs installation, installation of gauges in the main steam pipes, LPRM extraction and cut, CRD change-out and cleaning of the PRM conduit.

- *Organisational evolutions*

Change of the head of PR's Service in January, 2016, going to Ms. Amparo García Martínez.

SWEDEN

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	3	679
BWR	7	835
All types		788
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	2	11

2) Principal events of the year 2015

Forsmark NPP
During 2015, a routine was implemented where the dose alarm on the EPD is set automatically according to the RWP (Radiation Work Permit). Expectation is that it will lower the majority of very low doses achieved during outages. Also during 2015, new RP training was introduced, including practical training in how to enter and act in the RCA. This training is mandatory for work in the RCA for all Swedish NPPs.

Forsmark 1: In the reactor systems, more extensive repair work on valves than anticipated led to a collective dose higher than expected during the outage. Also, replacement of cable entries to the containment led to higher doses than expected. Work on the travelling in-core probe system while the containment was pressurized led to unexpected spread of contamination. The outage lasted 41 days compared with a planned 35. An unplanned one week long stop occurred in the spring due to leakage in the reactor water cleaning system.

Forsmark 2: Extensive repair work in the reactor water cleaning system (the same problem that caused the unplanned stop at F1) led to slightly higher collective dose during the outage than planned and also led to a prolonged outage period. The dose rates in some reactor systems are still higher than before the system decontamination of 2012, and are still showing an upward trend. As at F1, work on the travelling in-core probe system led to unexpected spread of contamination, although not for the same reason as for F1. The outage lasted 27 days compared with a planned 15.

Forsmark 3: A one week forced stop due to replacement of leaking fuel occurred in the spring. When opening the reactor pressure vessel head, the iodine content in the air of the reactor hall was higher than expected and continued to be at a quite high level for some days. One person received internal contamination because of this.

The main modification during the planned outage was the exchange of the main generator. The performance of this job prolonged the outage from a planned 46 days to 142. But the dose due to this work was a minor part of the collective dose. More extensive repair work on valves in the reactor systems than anticipated (including more decontamination and scaffolding work) contributed to a higher collective dose than planned for the outage.

Barsebäck NPP
Evaluation of the choice of method for demolition – Work is continuing with the evaluation of various methods through studies and development projects as well as through the acquisition of international experience. The evaluation includes taking into account the principles of ALARA.

Business activity – System decontamination has meant that most areas in the reactor building have low dose rates. This means that the facilities are suitable for training and testing for the nuclear industry.

Ringhals NPP
As for previous years, the dose exposures in 2015 were dominated by large projects regarding modernization, life time extension and regulatory demands.

Source term control shows slightly decreasing trends in all reactors, but the source term investigations and trending concerning dose contributors such as Antimony, Silver and Cobalt continue.

Collective dose outcome in 2015 at Ringhals is 3.0 man-Sv, comparable with the annual doses in the previous three-year period.

During 2015, 10 individuals received doses ≥ 10 mSv. Almost everyone concerned received the dose during the work in the project RH/SP (alternative water supply) at Ringhals 2.

Based on experience from 2015, the RP department has taken a new approach for outage periods. The new approach, with new roles, starts in RA 2016 and means that Ringhals' own Radiation Protection staff will take over the operational management for RP work from the RP contractors on shift. The change is seen as very positive and will strengthen both the performance and safety culture.

The Radiation Protection Department has for several years been working on the follow-up of Contamination Events (CE) in exit monitors, both in the pre-monitors and in the final monitors. The measures taken have produced good results, and the trend since the more frequent monitoring started is downwards. Target goals at pre-monitors and in the final monitors, for 2016, have been lowered to 0.8 % respectively 0.3 % (1.0 % prior resp. 0.5 %).

Ringhals' release of radioactive substances is very low. Preliminarily, the radiation dose to the critical group calculated using the SSI (Authority)'s approved model from 2002, is 0.3 micro Sieverts in 2015. This is less than 1 / 200th part of the emission limit and far less than 1 / 1000th part of the radiation dose from the natural background.

The decision on the earlier final shut down of Ringhals 1 and 2 will need extra focus in certain areas, including expertise in radiation protection, available resources and not least the safety culture.

Oskarshamn NPP
In 2015 the radiation protection organization at OKG was pushing for "job rotation" for high dose work.

Effective system decontamination was conducted on the O2 plant for the project PLEX, and the reactor has been in outage from mid-2013 (so the source terms have decayed), which has had a positive impact on the dose outcome.

During the year, the focus has also been placed on FME (Foreign Material Exclusion) to optimize the conditions for clean systems. This has been accomplished through the creation of FME zones in the reactor hall and for large system rebuilds. Staff has been trained to establish a clear understanding of the importance of clean systems. To reinforce the importance and to have a direct responsibility, an FME-engineering services organisation was established.

A model for dose planning and department collective dose goals is under development.

On the basis of the decisions in 2015 to not restart the O2 reactor after completion of the upgrading project PLEX and to do the final shutdown of the O1 reactor by mid-2017, studies and analyses have been carried out concerning organization and the fact that OKG will need to manage both the production operation, service operation and decommissioning activities.

In 2015, there has also been a focus on development and improvements in the radiation protection area. As part of efforts to strengthen radiation protection support, radiation coaching services have been implemented.

Training activities have evolved, and the industry training Protection, Safety and Radiation Protection in practice was launched in January 2015 and has since then worked very well.

Measures have been taken, an information meeting has been held and workshops have been conducted with the intention of providing a better understanding of the requirements for the handling of radioactive sources.

Efforts have been made in 2015 regarding release of material as non-radioactive material, including the logistics of handling of materials. Internal follow-up supervision was directed against the ‘classification for release of material for free use’ activities at the end of the year, ahead of an official inspection in 2016.

OKG in 2015 remained under Authority (SSM) special supervision.

3) Report from Authority

The Swedish Radiation Safety Authority (SSM) is working on a draft of a new radiation protection law, and a complete set of radiation protection legislation framework, supporting the law. The regulations include nuclear safety, radiation protection, security and safeguards and will be completed in 2018.

SSM actively follows the planning of the decommissioning of the four reactors that close down in the 2016-2020 period, and performs its normal surveys of the operating nuclear reactors.

SWITZERLAND

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	3	573
BWR	2	1,234

2) Principal events of the year 2015

- *Events influencing dosimetric trends*

NPP Beznau
In 2015, long outages led to a collective dose in both units of 1,227 man mSv (around 2,000 persons). No incorporation was detected (detection threshold 1,000 Bq Co-60). The highest individual dose was 10.7 mSv. 52 persons had doses between 5 mSv and 10 mSv. 2 persons had doses > 10 mSv.

At Unit 1, the outage started on March 13th, and the following major projects were performed:

a) reactor vessel closure head replacement;
b) NDT inspection of reactor vessel;
c) NDT inspection of crossover legs;
d) replacement of containment ventilation cooler units;
e) integration of Emergency sealing water system;
f) integration of Emergency stand-alone power supply.

Because of findings in the reactor vessel, a sophisticated investigation and analysis of the backing material has to be performed. International expert groups were formed by AXPO and ENSI. Reconnection to the grid is planned for the end of 2016.

The Beta/Alpha Ratio of surface contamination at Unit 1 has been decreasing for the last couple of years. The ratio varies over several orders of magnitude. This new situation has been a challenge for the RP department.

Unit 2 has been in outage since August 13th. Reconnection to the grid occurred on December 23rd, as planned before. Unit 2 followed the same outage plan with the same projects as Unit 1.

In Unit 2 the reactor vessel showed no findings such as those on Unit 1.

NPP Gösgen
The outage led to a collective dose of 401 man mSv, with no incorporation, and 8.4 mSv as the maximum recorded annual individual dose. Zn-64 injection was started in 2005, leading to a reduction of the average dose rate of primary circuit components of about 62 %. The reduction in one single year is around 7 %.

NPP Leibstadt

The 2015, outage dose of 1,189 man·mSv was within a reasonable range of the dose goal (1,150 man·mSv). The slight overrun was mainly due to the failure of the reactor building crane, while the reactor pressure vessel head was hanging on it. The Soft Shutdown and optimized operations lowered the dose rate in the Residual Heat Removal System (RHR) as much as a factor of 2. There were two forced outages due to lube oil malfunctions in the turbine/generator area, with no impact to RP.

NPP Mühleberg
KKM had a "normal" outage leading to 710 man mSv as planned (no incorporation, max individual dose of 7.6 mSv) with the following special work: Dumping and cleaning of the suppression system (torus), Extensive NDT program in the drywell, and Integrated Leak Rate Testing of the drywell. This outage also included refitting of the crane in the reactor hall (4 years before planned shutdown for decommissioning).

3) Report from Authority

The Swiss Federal Nuclear Safety Inspectorate (ENSI) acknowledges as a general rule, that planning by the operators of nuclear facilities in the field of radiological protection is of a high standard so that the resulting collective doses generally closely match the projected values.

ENSI has identified an increasing public interest in data concerning radiation and has therefore introduced a number of new concepts. Typical of these is the online availability, since the start of 2015, of monthly nuclear power plant releases. There is also a new development concerning the data from the network for automatic measurement of dose rates in the vicinity of nuclear power plants (MADUK). It is now possible to view dose rates since 1994 averaged over periods of ten minutes, one hour and one day. A special chapter of this report deals with C-14 releases, which are regularly the subject of enquiries from interested parties.

UKRAINE

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	15	620

In 2015, the dose rate per unit was worse than in 2014. The common reason could be defined as increased duration and scope of radiation work when performing overhauls and planned repairs at ZNPP Units 2 and 5 and all RNPP Units (incl. an overhaul outage at Unit 4) as compared with the previous year. This degradation is also related to a significant scope of rehabilitation work performed to extend the life of SUNPP Unit 2 beyond its original design lifetime and involving a significant number of contracted personnel to perform these activities.

UNITED KINGDOM

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	50.91
GCR	14[(1)]	66.58
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
GCR	20[(2)]	90.2

Notes
(1) 14 Advanced Gas-Cooled Reactors
(2) 20 Magnox Reactors.

2) Principal events of the year 2015

The majority of Advanced Gas Reactors recorded low annual collective radiation exposures, in the range 20 – 40 man·mSv, with the exception of Hinkley Point and Hunterston who recorded collective radiation doses of approximately 340 man·mSv and 450 man·mSv respectively. The doses at the latter two reactor sites are dominated by inspections carried out inside the vessels, to support the long term safety case for operation.

Sizewell B, the only PWR in the United Kingdom, did not have an outage in 2015 so the collective radiation exposure for the year was low. The construction and commissioning of a Dry Fuel Store at Sizewell B continued. The Dry Fuel Store is intended to store all of the station's expected arising of spent fuel. The first irradiated fuel is expected to enter the storage building in the late autumn of 2016.

2015 marked the final year of operation of the last generating Magnox reactor (1st generation gas-cooled reactor) in the United Kingdom, with Wylfa entering in to decommissioning in December. Two further sites have been declared fuel free, meaning Wylfa will now be the only site in the defuelling phase of decommissioning. The rest of the Magnox sites are in Care and Maintenance preparations, Care and Maintenance being a passively safe and secure state where radiation levels are left to decay naturally. The first site is anticipated to enter this state in 2019.

There is a large amount of nuclear new build planned and proposed in the UK. EDF Energy plans to build twin EPRs at Hinkley Point and has proposed the same at Sizewell. Similarly, Horizon Nuclear Power plans to build twin GE-Hitachi Advanced Boiling Water Reactors at Wyfla Newydd and has proposed the same at Oldbury. Three Westinghouse AP1000 units are also proposed at Moorside by the Nu Generation consortium. These proposals are undergoing generic design assessment by the UK regulators. A final investment decision on Hinkley Point is expected from EDF Energy in 2016. EDF and Chinese General Nuclear have also agreed to advance plans for two Chinese design PWRs at Bradwell.

UNITED STATES

1) Dose information for the year 2015

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	65	440.499
BWR	34	1,222.139
All types	99	708.941
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	7	207.866
BWR	3	185.117

2) Principal events of the year 2015

Summary of national dosimetric trends

The USA PWR and BWR occupational dose averages for 2015 reflected a continued emphasis on dose reduction initiatives at the 99 operating commercial reactors. Four PWR units continued transition to the SAFSTOR/decommissioning phases. San Onofre Units 2&3 are scheduled to have an accelerated transition to decommissioning for the site. Crystal River and Kewaunee have moved into SAFSTOR for a 10–20 year period after the spent fuel pools are emptied and spent fuel is relocated to the dry cask storage pad.

Reactor Type	Number of Units	Total Collective Dose	Avg Dose per Reactor
PWR	65	28,632.42 person mSv	440.499 person mSv/unit
BWR	34	41,552.73 person mSv	1,222.139 person mSv/unit

The total collective dose for the 99 reactors in 2015 was 70,185.15 person mSv, a decrease of 1.5% from the 2014 total collective dose of 71,244.6 person mSv from 99 operating reactors. The resulting average collective dose per reactor for USA LWR was 708.94 person mSv/unit or a 4.6% decrease from 2014 (742.13 person mSv/reactor unit).

Two individuals received between 20–30 mSv at a US PWR site in 2015.

US PWRs
The total collective dose for US PWRs in 2015 was 28,632.42 person mSv for 65 operating PWR units. The 2015 PWR total collective dose was 14% lower than the 2014 US PWR total collective dose of 33,263.97 person mSv. The 2015 average collective dose per reactor was 440.499 person mSv/PWR unit. US PWR units are generally on 18-month refuelling cycles. The US PWR refuelling frequency can create fewer refuelling outages in certain years in the US, for example 2013, 2016 and 2019.

The US PWR sites that achieved annual site doses of under 100 person mSv in 2015 were:

- Callaway 32.8 person mSv
- Davis Besse 9.9 person mSv

US BWRs

The total collective dose for US BWRs in 2015 was 41,552.73 person mSv for 34 operating BWR units. The 2015 BWR total collective dose was 20 % higher than the 2014 US BWR total collective dose of 33,363.97 person mSv for 34 operating BWR units. The 2015 average collective dose per reactor was 1,222 person mSv/BWR unit.

Most US BWR units are on 24-month refuelling cycles. The highest 2015 annual US BWR site dose was 5,016.66 person mSv at LaSalle County 1, 2. US BWRs have faced occupational dose challenges due to high CRUD levels on piping, and power up-rates modifications in 2015.

– *New plants on line/plants shut down*

Watts Bar 2, a TVA Westinghouse Ice Condenser unit, commenced commercial operations in early 2016. Southern Company is continuing the construction of two new PWRs at the Vogtle site in Georgia. South Carolina Electric & Gas is constructing two new PWRs on the V. C. Summer site. Upon completion of these reactors, the US may be operating 104 reactors in the near future, if there are no additional permanent shutdowns at other US sites.

Zion Units 1 and 2 located on Lake Michigan north of Chicago started decommissioning in 2010. Energy Solutions is responsible for the decommissioning of the Zion site. Vermont Yankee, Kewaunee, San Onofre 2, 3 and Crystal River transitioned into the decommissioning phase during the period of 2013-2014.

Vermont Yankee Nuclear Power Station was a 1,912 MWt BWR which began operations in 1972. The reactor was permanently shut down on December 29th, 2014. The nuclear fuel was removed on January 12th, 2015. Entergy, site owner, has stated that all spent nuclear fuel will be placed in dry cask storage and the plant will be placed in SAFSTOR until the owner is ready to fully decommission the site. License termination is scheduled to take place by 2073.

The Kewaunee Power Station was a 1772 MWt PWR which began operations on June 16th, 1974. The reactor was permanently shut down on May 7th, 2013. The spent nuclear fuel was permanently removed from the reactor by May 14th, 2013, and was placed into dry cask storage by June 15th, 2017. The plant will be placed in SAFSTOR until the owner Dominion Energy is ready to fully decommission the site. License termination is scheduled to take place by 2073.

Other updates: Were successful in removing all the Inconel springs (GTCC) from the thimble plugs, and the springs are now stored in a small shielded container in Containment. Loaded all the irradiated hardware, excore detectors, and the RCCAs into the TN-RAM liner and shipped it to WCS in TX for burial on Oct 23rd, 2017. Have two of the smaller canal racks removed, bagged, and they will be shipped to Energy Solutions (Bear Creek facility in TN) next week. All the hold down bolts have already been removed from the larger racks, so are expecting to finish this job by the end of the year if we can ship 2 -3 racks per week.

The Crystal River Nuclear Plant, known as CR3, became operational on March 13, 1977, and produced on average 860 megawatts of generation between 1977 and 2009. CR3 shut down and entered a refueling/major component replacement outage on October 26, 2009 without restarting. Duke Energy announced the decision to retire the nuclear plant on Feb.

5, 2013, rather than pursue a first-of-its-kind repair to the plant's containment building. CR3 has chosen the SAFSTOR decommissioning option and is on track to be fully in the SAFSTOR status with minimal staff by mid-2019. Currently spent fuel is being moved to Dry Cask Storage on the Independent Spent Fuel Storage Installation(ISFSI) to be completed by January 2018. Clean out of all spent fuel pool non-fuel components including spent filters, irradiated hardware, and empty spent fuel cages begins in February 2018 to be completed by May 2018. Further abandonment of plant systems is ongoing with all power to the plant, all fire suppression systems, all internal radiation monitoring systems and spent fuel pool drained before entering SAFSTOR. Also, starting the process to reduce the CR3 FSAR Radiological Footprint of over 4300 acres to just what will be needed surrounding the plant with includes eliminating 4 coal plants, coal piles, ash piles and a gypsum plant from the footprint.

– *Major evolutions*

Four US PWRs continued their transition to decommissioning status. The 2015 (as compared to 2014) annual occupational doses for selected US units undergoing SAFESTOR or decommissioning are as follows:

Site	2014	2015
• Crystal River	6.96 person mSv	7.00 person mSv
• San Onofre 2, 3	13.69 person mSv	12.02 " "
• Kewaunee	19.64 person mSv	43.91 " "
• Humboldt Bay	123.81 person mSv	43.91 " "
• Zion 1, 2	787.30 person mSv	1,426.05 " "

- *Safety-related issues*
  Some US PWRs with over 40 years of operations performed full baffle bolt inspections on the vessel core barrel. Salem 1 replaced 190 baffle bolts and Indian Point 2 replaced 278 baffle bolts as emergent work scope during their scheduled refuelling outages
- *New/experimental dose-reduction programmes*

  Numerous RPMs are implementing the H3D CZT detector system developed by the University of Michigan which achieves 3D individual isotopic mapping of in-plant components and piping. The new ALARA tool has been found to be effective in verifying the adequacy of temporary shielding and in other RP applications.

Technical plans for major work in 2015

FLEX equipment and programs were fully implemented in 2015 at US licensees. Two regional FLEX Centres were established in Memphis, Tennessee and Phoenix, Arizona to serve the US sites in the unlikely event of a reactor accident. Each site maintains a smaller inventory of FLEX equipment in seismically qualified buildings.

PWRs continue to perform MSIP treatments (piping squeeze to relieve metallurgical stresses) on plant piping. Boric acid leak remediation is also an on-going emphasis at US PWRs.

Extensive source term reduction initiatives were initiated at the LaSalle County site (BWR) in 2015 to reduce CRUD in the BWR piping and reactor cavity.

US fleets and alliances are continuing to standardize RP procedures and policies across the fleets/alliances to improve efficiency of RP operations and minimize confusion of traveling RP techs.

Due to the significant increase in single unit nuclear sites in the US considering early transition to SAFSTOR/Decommissioning, US nuclear senior managers have initiated a program to improve the efficiencies of nuclear plant operations and achieve lower operating costs. Low natural gas prices and wind energy coming onto the US grid have created economic pressure on operating nuclear units at some US utilities. The New York State Legislature with the Governor’s support passed legislation to keep the Fitzpatrick and Ginna stations operating: giving credit of the renewable, carbon-free generation that nuclear units provide to the state.

Loading of spent fuel assemblies into dry casks continued in 2015. US BWRs continue to replace dryers in the upper reactor internals.

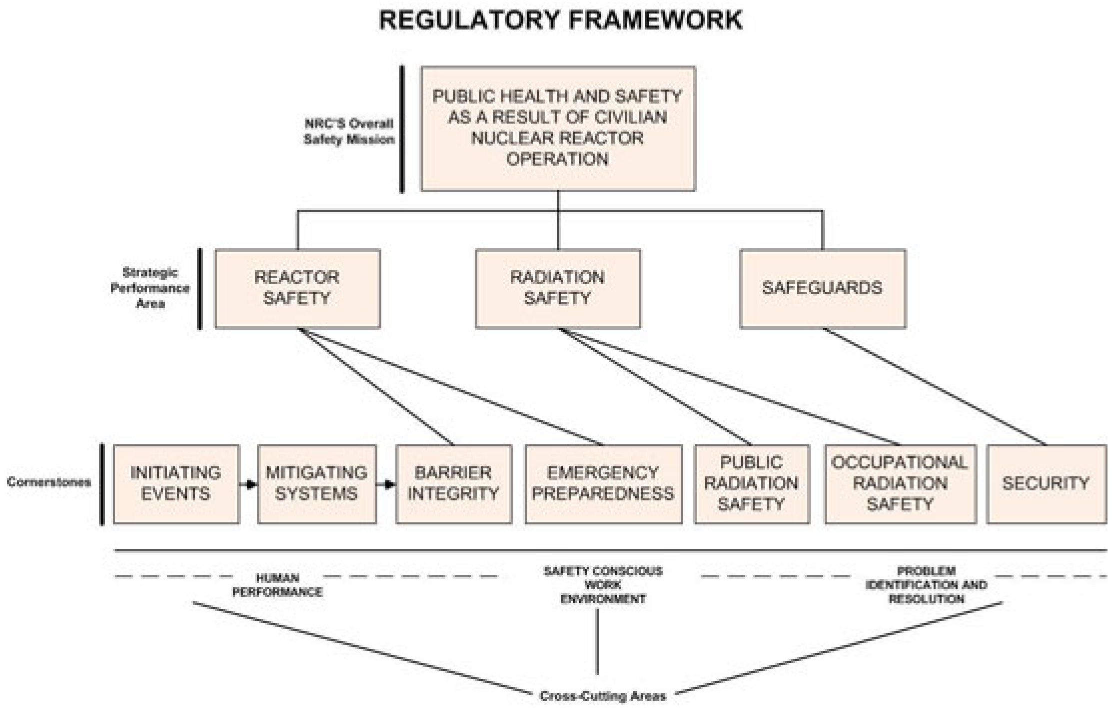
The Zion Units 1 &2 site removed most of the contaminated equipment in 2015. The turbine and containment building are undergoing demolition in 2016.

Regulatory plans for major work in 2015

NRC’s Reactor Oversight Program - Regulatory Framework

The U.S. Nuclear Regulatory Commission’s (NRC) regulatory framework for reactor oversight is shown in the diagram below. It is a risk-informed, tiered approach to ensuring plant safety. There are three key strategic performance areas: reactor safety, radiation safety, and safeguards. Within each strategic performance area are cornerstones that reflect the essential safety aspects of facility operation. Satisfactory licensee performance in the cornerstones provides reasonable assurance of safe facility operation and that the NRC's safety mission is being accomplished.

Within this framework, the NRC's operating reactor oversight process provides a means to collect information about licensee performance, assess the information for its safety significance, and provide for appropriate licensee and NRC response. The NRC evaluates plant performance by analysing two distinct inputs: inspection findings resulting from NRC's inspection program and performance indicators (PIs) reported by the licensees.



Occupational Radiation Safety Cornerstone and 2015 Results

Occupational Radiation Safety - The objective of this cornerstone is to ensure adequate protection of worker health and safety from exposure to radiation from radioactive material during routine civilian nuclear reactor operation. This exposure could come from poorly controlled or uncontrolled radiation areas or radioactive material that unnecessarily exposes workers. Licensees can maintain occupational worker protection by meeting applicable regulatory limits and ALARA guidelines.

Inspection Procedures – There are five attachments to the inspection procedure for the occupational radiation safety cornerstone:

IP 71124 Radiation Safety-Public and Occupational
IP 71124.01 Radiological Hazard Assessment and Exposure Controls
IP 71124.02 Occupational ALARA Planning and Controls
IP 71124.03 In-Plant Airborne Radioactivity Control and Mitigation
IP 71124.04 Occupational Dose Assessment
IP 71124.05 Radiation Monitoring Instrumentation

Occupational Exposure Control Effectiveness - The performance indicator for this cornerstone is the sum of the following:

- Technical specification high radiation area occurrences
- Very high radiation area occurrences

- Unintended exposure occurrences

Occupational Radiation Safety Indicator	**Thresholds** (White) Increased Regulatory Response Band	(Yellow) Required Regulatory Response Band	(Red) Unacceptable Performance Band
Occupational Exposure Control Effectiveness	> 2	> 5	N/A

Those units that do not cross the thresholds receive a green finding or no findings. The latest ROP Performance Indicator Findings can be found at http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/pi_summary.html.

Additional background information can be found on the Detailed ROP Description page at http://www.nrc.gov/reactors/operating/oversight/rop-description.html.

4. ISOE EXPERIENCE EXCHANGE ACTIVITIES

While ISOE is well known for its occupational exposure data and analyses, the programme's strength comes from its efforts to share such information broadly amongst its participants. The combination of ISOE symposia, ISOE Network and technical visits provides a means for radiation protection professionals to meet, share information and build links between ISOE regions to develop a global approach to occupational exposure management. This section provides information on the main information and experience exchange activities within ISOE during 2015.

4.1 ISOE ALARA Symposia

ISOE International ALARA Symposium

The 2015 ISOE International ALARA Symposium, organized by the IAEA TC with the support of ELECTRONUCLEAR in collaboration with the Institute of Radiation Protection and Dosimetry (IRD) and the Brazilian Radiological Protection Society, was held on 26-28 May 2015 in Rio de Janeiro/Brazil. In total, 70 participants from 13 member countries, two non-member countries, and international organizations attended, with representation from all ISOE TCs. Three distinguished papers were selected by the participating technical centres:

– *ALARA Planning and Controls According the Angra NPS ALARA Program*, W. Alves Ferreira, L. Teixeira Marcos, Angra NPP, Brazil

– *EDF Feedback on the Management and the Treatment of Ag-110m Contamination*, M. Benfarah, EDF SEPTEN, France

– *How R&D may help to improve RP performance at the decommissioning stage of nuclear power plant?,* G. Laurent (EDF CIDEN), L. Vaillant (CEPN), France

In connection with the symposium, the participants had the opportunity to participate in a technical visit to Angra NPP.

ISOE Regional ALARA Symposia

North-American Symposium

The 2015 ISOE North-American ALARA Symposium, organised by the NATC, was held 12-14 January 2015 in Fort Lauderdale/USA. In total, 135 participants from 7 counties attended. The symposium included a technical exhibition, an enrichment training course on source term measurements, and a regional RPM meeting with regulators. The *2014 World Class ALARA Performance Award* was presented to the Quad Cities Generating Station, with Dan Collins who presenting a paper on *Quad Cities Generating Station Dose Reduction Achievements*. Two distinguished papers were selected by the participating technical centres:

– *Suppression Pool Diving Dose Reductions at Limerick Generating Station*, T. Mscisz, Limerick NPP, USA

– *ALARA Aspects of DSC Campaign at Robinson,* S. Hall, Robinson NPP, USA

The ISOE WGDA meeting was organised on 11 January 2015 preceding the symposium.

Asian Symposium

The 2015 ISOE Asian ALARA Symposium, organised by the ATC and Nuclear Safety Research Association (NSRA) and co-sponsored by the IAEA and NEA, was held 9-11 September 2015 in Tokyo/Japan. The symposium included a technical tour to Japan Nuclear Fuel Limited (JNFL). Distinguished papers selected by the participating technical centres included:

– *Improvement of the labor environment at Fukushima Daiichi Nuclear Power Station*, Y. Nishida, Tokyo Electric Power Company, Japan
– *Development of IDIS (Integrated Drain Information System) for reducing radiation exposure,* D.-U. Kim, Shin-Kori NPP #2 (unit 3&4), South Korea

In connection with the symposium, the participants had the opportunity to participate in a technical visit to Japan Nuclear Fuel Limited (JNFL) NPP.

Proceedings and conclusions of the various Symposia are available on the ISOE Network.

4.2 The ISOE Website (www.isoe-network.net)

The ISOE Network is a comprehensive information exchange website on dose reduction and ALARA resources for ISOE participants, providing rapid and integrated access to ISOE resources through a simple web browser interface. The network, containing both public and members-only resources, provides participants with access to a broad and growing range of ALARA resources, including ISOE publications, reports and symposia proceedings, web forums for real-time communications amongst participants, members address books, and online access to the ISOE occupational exposure database.

ISOE Occupational Exposure Database

In order to increase user access to the data within ISOE, the ISOE occupational exposure database is accessible to ISOE participants through the ISOE Network.

It was decided, in 2011, to modify reactor statuses of the database. Only three statuses will be kept: two for operational reactors (pre-operational and operational) and one for shutdown reactors (decommissioning). For decommissioning reactors, three phases have been defined: permanently shutdown, safe storage and decommissioning activities.

Since 2005, the database statistical analysis module, known as MADRAS, has been available on the Network. Major categories of pre-defined analyses include:

- Benchmarking at unit level;
- Total annual collective dose;
- Average annual collective dose per reactor;
- Rolling average annual collective dose per reactor;
- Average annual collective dose per energy produced;
- Plant unit rankings;
- Quartile rankings;
- Total outage collective dose;
- Average outage collective dose per reactor;

- Job collective dose;
- Trends in the number of reactor units;
- Dose rates; and
- Miscellaneous queries.

Outputs from these analyses are presented in graphical and tabular format, and can be printed or saved locally by the user for further use or reference. Corrections of "bugs" and improvements to the user interface continued, and in 2015, there were two new analyses developed on MADRAS.

RP Library

The RP Library, one of the most used website features, provides ISOE members with a comprehensive catalogue of ISOE and ALARA resources to assist radiation protection professionals in the management of occupational exposures. The RP Library includes a broad range of general and technical ISOE publications, reports, presentations and proceedings. In 2015, the following types of documents were made available:

- Benchmarking reports,
- RP Experience reports,
- RP Management documents,
- Plant information related documents,
- Training documents,
- ISOE 2 questionnaires,
- ISOE 3 reports,
- RP Forum syntheses,
- Source-term management documents,
- Severe Accident Management documents,
- Cavity decontamination documents

RP Forum

In addition to the RP Library, registered ISOE users can access the RP Forum to submit a question, comment or other information relating to occupational radiation protection to other users of the Network. In addition to a common user group for all members, the forum contains a dedicated regulators group and a common utilities group. All questions and answers entered in the RP Forum are searchable using the website search engine, increasing the potential audience of any entered information.

4.3 ISOE Benchmarking Visits

To facilitate the direct exchange of radiation protection practice and experience, the ISOE programme supports voluntary site benchmarking visits amongst the Participating Utilities in the four technical centre regions. These visits are organized at the request of a utility with technical centre assistance. The intent of such visits is to identify good radiation protection practices at the host plant in order to share such information directly with the visiting plant. While both the request for and hosting of such visits under ISOE are voluntary on the utilities and the technical centres, post-visit reports are made available to the ISOE members (according to their status as utility or authority member) through the ISOE Network website in order to facilitate the broader distribution of this information within ISOE. Highlights of visits conducted during 2015 are summarized below.

Benchmarking visits organized by ETC

In 2015, two benchmarking visits were been organized by ETC for the French Utility EDF, using ISOE contacts, but no ISOE/ETC resources.

The first visit took place from 31 August – 4 September 2015 to Ringhals NPP/Sweden.

The main topics discussed were:

- Radiation Protection organisation,
- SGR,
- PZR replacement,
- Source term management.

The second visit took place from 4-5 November 2015 to Philippsburg NPP/Germany.

The main topics discussed were:

- Radiation Protection organisation,
- Training
- Radiation Protection performance indicators
- Optimisation process

Benchmarking visits organized by NATC

Listed below are the benchmarking visits conducted by the NATC.

- October 2015: Bruce Power benchmarked Radiological Controls at Candu Plants by RP managers from LaSalle, River Bend, and Cook to discuss worker dose reduction and operation experience, and to assist in planning the Bruce 3-8 refurbishments.
- July 2015: Palo Verde benchmarked Gravelines NPP/France and EDF Headquarters.
- March 2015: Tepco benchmarked Palo Verde for RP contamination control and dose controls. (report pending)
- January 2015: NATC's "Super Engineer" Programme visite LaSalle NPP. (report pending)

4.4 ISOE Management

ISOE Management and Programme Activities

As part of the overall operations of the ISOE programme, ongoing technical and management meetings were held throughout 2015, including:

ISOE Meetings	**Date**
ISOE Bureau	May 2015; Nov 2015
Working Group on Data Analysis (WGDA)	May 2015; Nov 2015
24th ISOE Management Board Meeting	Nov 2015
Working Group on Decommissioning (WGDECOM)	Jun 2015; Oct 2015

ISOE Management Board

The ISOE Management Board continued to focus on the management of the ISOE programme, reviewing the progress of the programme at its annual meeting in 2015 and approving the programme of work for 2016. The 2015 mid-year meeting of the ISOE Bureau focused on the status of the ISOE activities for 2015, the status of the renewal of the ISOE Terms and Conditions, and planning for the ISOE annual session 2015.

ISOE Working Group on Data Analysis (WGDA)

The Working Group on Data Analysis (WGDA) met in May and November 2015, continuing its focus on the integrity, completeness and timeliness of the ISOE database and options for improving ISOE data collection and analysis, including the implementation of new pre-defined MADRAS queries.

ISOE Working Group on Radiological Protection Aspects of Decommissioning Activities at Nuclear Power Plants (WGDECOM)

Following the decision of the ISOE Management Board in November 2014, the draft WGDECOM Terms of Reference were prepared by the NEA Secretariat and announced on 30 January 2015. The informal kick-off meeting of the WGDECOM was held on 29 May 2015 in Rio de Janeiro, Brazil and attended by four WGDECOM members (from Brazil, Canada, France and the Republic of Korea), ISOE Chair and Vice-Chair, WGDA Chair, 1 ETC representative, Joint NEA/IAEA Secretariat, and 1 observer (from the Republic of Korea).

The objective of the WGDECOM is to provide a forum for experts to develop a process within the ISOE programme to better share operational RP data and experience for NPPs in some stage of decommissioning, or in preparation for decommissioning. The working group will manage all identified work which has been proposed by the ISOE Management Board and will report regularly on the status of all such work to the ISOE programme.

In 2015, the WGDECOM also participated in a joint topical session with the International Co-operative Programme on Decommissioning (CPD). Following their first informal meeting in Brazil, the WGDECOM formally convened in June and October 2015, continuing their focus on RP aspects of decommissioning activities at NPPs.

Annex 1

STATUS OF ISOE PARTICIPATION UNDER THE RENEWED ISOE TERMS AND CONDITIONS (2012-2015)

Note: This annex provides the status of ISOE official participation as of 1 January 2016

Officially Participating Utilities: Operating reactors

Country	Utility[1]	Plant name	
Armenia, Republic of	Armenian Nuclear Power Plant (CJSC)	Medzamor 2	
Belgium	Electrabel (GDF- SUEZ)	Doel 1, 2, 3, 4	Tihange 1, 2, 3
Brazil	Electrobras Eletronuclear S.A.	Angra 1, 2	
Bulgaria	Kozloduy NPP Plc.	Kozloduy 5, 6	
Canada	Bruce Power	Bruce A1, A2, A3, A4	Bruce B5, B6, B7, B8
	New Brunswick Electric Power Commission	Point Lepreau	
	Ontario Power Generation	Darlington 1, 2, 3, 4 Pickering 1, 4	Pickering 5, 6,7, 8
China	Daya Bay Nuclear Power Operations and Management Co., Ltd.	Daya Bay 1, 2 Ling Ao 1, 2, 3, 4	
	CNNC Nuclear Power Operations Management Co., Ltd.	Qinshan 1	
	CNNP Jiangsu Nuclear Power Corporation	Tianwan 1, 2	
Czech Republic	ČEZ, a. s.	Dukovany 1, 2, 3, 4 Temelin 1, 2	
Finland	Fortum Power and Heat Oy	Loviisa 1, 2	
	Teollisuuden Voima Oyj (TVO)	Olkiluoto 1, 2	
France	Électricité de France (EDF)	Belleville 1, 2 Blayais 1, 2, 3, 4 Bugey 2, 3, 4, 5 Cattenom 1, 2, 3, 4 Chinon B1, B2, B3, B4 Chooz B1, B2 Civaux 1, 2 Cruas 1, 2, 3, 4 Dampierre 1, 2, 3, 4 Fessenheim 1, 2	Flamanville 1, 2 Golfech 1, 2 Gravelines 1, 2, 3, 4, 5, 6 Nogent 1, 2 Paluel 1, 2, 3, 4 Penly 1, 2 Saint-Alban 1, 2 Saint Laurent B1, B2 Tricastin 1, 2, 3, 4

[1] Where multiple owners and/or operators are involved, only Leading Undertakings are listed / En cas de plusieurs propriétaires et/ou exploitants, seuls les principaux sont mentionnés

Germany	E.ON Kernkraft GmbH	Brokdorf Grafenrheinfeld	Grohnde Isar 2
	EnBW Kernkraft GmbH	Philippsburg 2	Neckarwestheim 2
	RWE Power AG	Emsland	Gundremmingen B, C
Hungary	Magyar Villamos Művek Zrt	Paks 1, 2, 3, 4	
Japan	Chubu Electric Power Co., Inc.	Hamaoka 3, 4, 5	
	Chugoku Electric Power Co. Inc.	Shimane 1, 2	
	Hokkaido Electric Power Co. Inc.	Tomari 1, 2, 3	
	Hokuriku Electric Power Co.	Shika 1, 2	
	Japan Atomic Power Co.	Tokai 2	Tsuruga 1, 2
	Kansai Electric Power Co., Inc.	Mihama 1, 2, 3 Ohi 1, 2, 3, 4	Takahama 1, 2, 3, 4
	Kyushu Electric Power Co., Inc.	Genkai 1, 2, 3, 4	Sendai 1, 2
	Shikoku Electric Power Co., Inc.	Ikata 1, 2, 3	
	Tohoku Electric Power Co., Inc.	Higashidori 1	Onagawa 1, 2, 3
	Tokyo Electric Power Co.	Fukushima Daini 1, 2, 3, 4	Kashiwazaki Kariwa 1, 2, 3, 4, 5, 6, 7
Korea	Korean Hydro and Nuclear Power Co. Ltd. (KHNP)	Hanbit 1, 2, 3, 4, 5, 6 Hanul 1, 2, 3, 4, 5, 6 Kori 1, 2, 3, 4	Shin-Kori 1, 2 Shin-Wolsong 1, 2 Wolsong 1, 2, 3, 4
Mexico	Comision Federal de Electricidad	Laguna Verde 1, 2	
Netherlands	E.P.Z.	Borssele	
Pakistan	Pakistan Atomic Energy Commission (PAEC)	Chasnupp 1, 2	Kanupp
Romania	Societatea Nationala "Nuclearelectrica" S.A.	Cernavoda 1, 2	
Russian Federation	Rosenergoatom Concern OJSC	Balokovo 1, 2, 3, 4 Kalinin 1, 2, 3, 4 Kola 1, 2, 3, 4	Novovoronezh 3, 4, 5 Rostov 1, 2
Slovak Republic	Slovenské Electrárne A.S.	Bohunice 3, 4	Mochovce 1, 2
Slovenia	Nuklearna Elektrarna Krško	Krško 1	
South Africa	ESKOM	Koeberg 1, 2	
Spain	UNESA	Almaraz 1, 2 Ascó 1, 2 Cofrentes	Trillo 1 Vandellós 2
Sweden	Forsmarks Kraftgrupp AB (FKA)	Forsmark 1, 2, 3	
	OKG Aktiebolag (OKG)	Oskarshamn 1, 2, 3	
	Ringhals AB (RAB)	Ringhals 1, 2, 3, 4	
Switzerland	Axpo AG	Beznau 1, 2	
	BKW FMB Energie AG	Mühleberg	
	Kernkraftwerk Gösgen-Däniken AG	Gösgen	
	Kernkraftwerk Leibstadt AG	Leibstadt	
Ukraine	National Nuclear Energy Generating Company "Energoatom"	Khmelnitsky 1, 2 Rivne 1, 2, 3, 4	South Ukraine 1, 2, 3 Zaporizhzhya 1, 2, 3, 4, 5, 6
United Kingdom	EDF Energy	Sizewell B	

United States	American Electric Power Co.	D.C. Cook 1, 2	
	Arizona Public Service Co.	Palo Verde 1, 2, 3	
	Detroit Edison Co.	Fermi 2	
	Dominion Generation	North Anna 1, 2 Millstone 2, 3	Surry 1, 2
	Duke Energy Corp.	Brunswick 1, 2 Catawba 1, 2 Harris 1	McGuire 1, 2 Oconee 1, 2, 3 Robinson 2
	Energy Northwest	Columbia	
	Entergy Nuclear Operations, Inc.	Palisades	
	Exelon Generation Co., LLC	Braidwood 1, 2 Byron 1, 2 Calvert Cliffs 1, 2 Clinton 1 Dresden 2, 3 Fort Calhoun 1 Ginna 1 LaSalle County 1, 2	Limerick 1, 2 Nine Mile Point 1, 2 Oyster Creek 1 Peach Bottom 2, 3 Quad Cities 1, 2 Salem 1, 2 TMI 1
	First Energy Nuclear Operating Co. (FENOC)	Beaver Valley 1, 2 Davis Besse 1	Perry 1
	Luminant Generation Company, Llc.	Comanche Peak 1, 2	
	Nextera Energy Resources, Llc.	Duane Arnold 1 Point Beach 1, 2	Seabrook 1 Turkey Point 3, 4
	Pacific Gas & Electric Company	Diablo Canyon 1, 2	
	PPL Susquehanna, Llc.	Susquehanna 1, 2	
	Public Service Electric & Gas Co.	Hope Creek 1	
	South Carolina Electric & Gas Co.	Virgil C. Summer	
	South Texas Project Nuclear Operating Co.	South Texas 1, 2	
	Southern Nuclear Operating Company, Inc.	Hatch 1, 2 Farley 1, 2	Vogtle 1, 2
	Tennessee Valley Authority (TVA)	Browns Ferry 1, 2, 3 Sequoyah 1, 2	Watts Barr 1
	Wolf Creek Nuclear Operation Corp.	Wolf Creek	
	XCel Energy	Monticello Prairie Island 1, 2	

Officially Participating Utilities: Definitively shutdown reactors

Country / Pays	**Utility[1] / Compagnie d'électricité**	**Plant name / Nom de la centrale**	
Bulgaria	Kozloduy NPP Plc.	Kozloduy 1, 2, 3, 4	
Canada	Hydro Quebec	Gentilly 2	
	Ontario Power Generation	Pickering 2, 3	
France	Électricité de France (EDF)	Bugey 1 Chinon A1, A2, A3	Chooz A St. Laurent A1, A2
Germany	E.ON Kernkraft GmbH	Isar 1	Unterweser
	EnBW Kernkraft GmbH	Philippsburg 1	Neckarwestheim 1
	RWE Power AG	Biblis A, B	
	Vattenfall Europe Nuclear Energy GmbH	Brunsbüttel	Krümmel
Italy	SOGIN Spa	Caorso Garigliano	Latina Trino
Japan	Chubu Electric Power Co., Inc.	Hamaoka 1, 2	
	Japan Atomic Energy Agency	Fugen	
	Japan Atomic Power Co.	Tokai 1	
	Tokyo Electric Power Co.	Fukushima Daiichi 1, 2, 3, 4, 5, 6	
Lithuania	Ignalina Nuclear Power Plant	Ignalina 1, 2	
Russian Federation	Rosenergoatom Concern OJSC	Novovoronezh 1, 2	
Spain	UNESA	José Cabrera Santa María de Garoña	Vandellós 1
Sweden	Barsebäck Kraft AB (BKAB)	Barsebäck 1, 2	
United States	Detroit Edison Co.	Fermi 1	
	Dominion Generation	Kewaunee	Millstone 1
	Duke Energy Corp.	Crystal River 3	
	Entergy Nuclear Operations, Inc.	Big Rock Point	
	Exelon Nuclear Corporation	Dresden 1 Peach Bottom 1	TMI 2 Zion 1, 2
	Pacific Gas & Electric Company	Humboldt Bay 1	
	Southern California Edison Co.	San Onofre 1, 2, 3	

Participating Regulatory Authorities

Country / Pays	Authority / Autorités
Armenia	Armenian Nuclear Regulatory Authority (ANRA)
Belarus, Republic of	Republican Unitary Enterprise “Scientific Practical Centre of Hygiene”, Ministry of Health
Belgium	Federal Agency for Nuclear Control (FANC)
Bulgaria	Bulgarian Nuclear Regulatory Agency (NRA)
Canada	Canadian Nuclear Safety Commission (CNSC)
China	Nuclear and Radiation Safety Centre (MEP)
Czech Republic	State Office for Nuclear Safety (SÚJB)
Finland	Radiation and Nuclear Safety Authority (STUK)
France	Autorité de Sûreté Nucléaire (ASN) Direction Générale du Travail (DGT) du Ministère de l'emploi, de la cohésion sociale et du logement, represented by l’Institut de Radioprotection et de Sûreté Nucléaire (IRSN)
Germany	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), represented by Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH
Japan	Nuclear Regulation Authority (NRA)
Korea, Republic of	Korea Institute of Nuclear Safety (KINS)
Lithuania	State Nuclear Power Safety Inspectorate (VATESI)
Netherlands	The Authority for Nuclear Safety and Radiation Protection (ANVS)
Romania	National Commission for Nuclear Activities Control (CNCAN)
Slovak Republic	Public Health Authority of the Slovak Republic (UVZSR)
Slovenia	Slovenian Radiation Protection Administration (SRPA), Ministry of Health Slovenian Nuclear Safety Administration (SNSA)
Spain	Consejo de Seguridad Nuclear (CSN)
Sweden	Swedish Radiation Safety Authority (SSM)
Switzerland	Swiss Federal Nuclear Safety Inspectorate (ENSI)
Ukraine	State Nuclear Regulatory Inspectorate of Ukraine
United Arab Emirates	Federal Authority for Nuclear Regulation (FANR)
United Kingdom	The Office for Nuclear Regulation (ONR)
United States	U.S. Nuclear Regulatory Commission (US NRC)

Country – Technical Centre affiliations

Country	Technical Centre*	Country	Technical Centre
Armenia	IAEATC	Mexico	NATC
Belarus	IAEATC	Netherlands	ETC
Belgium	ETC	Pakistan	IAEATC
Brazil	IAEATC	Romania	IAEATC
Bulgaria	IAEATC	Russian Federation	ETC
Canada	NATC	Slovak Republic	ETC
China	IAEATC	Slovenia	ETC
Czech Republic	ETC	South Africa, Rep. of	IAEATC
Finland	ETC	Spain	ETC
France	ETC	Sweden	ETC
Germany	ETC	Switzerland	ETC
Hungary	ETC	Ukraine	IAEATC
Italy	ETC	United Arab Emirates	IAEATC
Japan	ATC	United Kingdom	ETC
Korea	ATC	United States	NATC
Lithuania	IAEATC		

* Note: ATC: Asian Technical Centre, IAEATC: IAEA Technical Centre
ETC: European Technical Centre, NATC: North American Technical Centre

ISOE Network and Technical Centre information

ISOE Network web portal	
ISOE Network	www.isoe-network.net
ISOE Technical Centres	
European Region (ETC)	Centre d'étude sur l'évaluation de la protection dans le domaine nucléaire (CEPN) Fontenay-aux-Roses, France www.isoe-network.net
Asian Region (ATC)	Nuclear Safety Research Association (NRSA) Tokyo, Japan www.nsra.or.jp/isoe/english/index.html
IAEA Region (IAEATC)	International Atomic Energy Agency (IAEA), Vienna, Austria Agence Internationale de l'Energie Atomique (AIEA), Vienne, Autriche www-ns.iaea.org/tech-areas/rw-ppss/isoe-iaea-tech-centre.htm
North American Region (NATC)	University of Illinois Champagne-Urbana, Illinois, U.S.A. http://hps.ne.uiuc.edu/natcisoe/
Joint Secretariat	
OECD/NEA (Paris)	www.oecd-nea.org/jointproj/isoe.html
IAEA (Vienna)	www-ns.iaea.org/tech-areas/rw-ppss/isoe-iaea-tech-centre.asp

International co-operation

- European Commission (EC)
- United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)

Annex 2

ISOE BUREAU, SECRETARIAT AND TECHNICAL CENTRES

Bureau of the ISOE Management Board

	2011 2012	2013 2014	2015 2016
Chairperson (Utilities)	ABELA, Gonzague EDF FRANCE	HARRIS, Willie EXELON UNITED STATES	HWANG, Tae-Won KHNP KOREA
Chairperson Elect (Utilities)	HARRIS, Willie EXELON UNITED STATES	HWANG, Tae-Won KHNP KOREA	DO AMARAL, Marcus Antonio ANGRA NPP (RETIRED) BRAZIL
Vice-Chairperson (Authorities)	DJEFFAL, Salah Canadian Nuclear Safety Commission CANADA BROCK, Terry US Nuclear Regulatory Commission UNITED STATES	JAHN, Swen-Gunnar ENSI SWITZERLAND	JAHN, Swen-Gunnar ENSI SWITZERLAND
Past Chairperson (Utilities)	SIMIONOV, Vasile Cernavoda NPP ROMANIA	ABELA, Gonzague EDF FRANCE	HARRIS, Willie EXELON UNITED STATES

ISOE Joint Secretariat

OECD Nuclear Energy Agency (OECD/NEA)

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Annex 3

ISOE MANAGEMENT BOARD AND NATIONAL CO-ORDINATORS (2015-2016)

Note: ISOE National Co-ordinators identified in **bold**.

ARMENIA		
	AVETISYAN, Aida	Armenian Nuclear Regulatory Authority
	PYUSKYULYAN, Konstantin	Medzamor 2 NPP
BELARUS		
	NIKALAYENKA, Alena	Republican Scientific and Practical Centre of Hygiene of Ministry of Health of the Republic of Belarus
BELGIUM		
	HENRY, François	FANC - Federal Agency for Nuclear Control
	LANCE, Benoit	ELECTRABEL Corporate Nuclear Safety Department
BRAZIL		
	DO AMARAL, Marcos Antônio	Angra NPP (retired)
	(TBD)	Brazilian Nuclear Energy Commission (CNEN)
BULGARIA		
	KATZARSKA, Lidia	Bulgarian Nuclear Regulatory Agency
	NIKOLOV, Atanas	Kozloduy NPP
CANADA		
	ELLASCHUK, Bernard	Canadian Nuclear Safety Commission (CNSC)
	MILLER, David E.	Bruce Power
	PRITCHARD, Colin	Bruce Power
CHINA		
	JIANG, Jianqi	Qinshan NPP
	YANG, Duanjie	Nuclear and Radiation Safety Centre (NSC)
	(TBD)	Utility
CZECH REPUBLIC		
	FARNIKOVA, Monika	Temelin NPP, ČEZ a.s.
	FUCHSOVÁ, Dagmar	State Office for Nuclear Safety (SÚJB)
FINLAND		
	KONTIO, Timo	Loviisa NPP
	RIIHILUOMA, Veli	Centre for Radiation and Nuclear Safety (STUK)
FRANCE		
	GUANNEL, Yves	Autorité de Sûreté Nucléaire (ASN)
	MICHELET, Marie	Électricité de France (EDF)
	SAINTAMON, Fabrice	Électricité de France (EDF)
GERMANY		
	STAHL, Thorsten	Gesellschaft für Anlagen-und Reaktorsicherheit mbH (GRS)
HUNGARY		
	BUJTAS, Tibor	Paks NPP
ITALY		
	MANCINI, Francesco	SOGIN SpA
JAPAN		
	HASEGAWA, Hideki	Tokyo Electric Power Company
	HATANO, Kyousuke	Kyushu Electric Power Co., Inc.
	ISHII, Yoichi	Nuclear Regulation Authority (NRA)
KOREA (REPUBLIC OF)		
	AN, Yong-min	Korea Hydro and Nuclear Power. Co. Ltd (KHNP)
	HWANG, Tea-Won	Korea Hydro and Nuclear Power. Co. Ltd (KHNP)
	KIM, Byeong-Soo	Korea Institute of Nuclear Safety (KINS)
LITHUANIA		
	RAUBA, Kestus	Ignalina NPP
	TUMOSIENĖ, Kristina	State Nuclear Power Safety Inspectorate (VATESI)
MEXICO		
	HUESCA GUEVARA, Luis Rafael	Laguna Verde NPP

NETHERLANDS		
	ARENDS, Patrick	Authority for Nuclear Safety and Radiation Protection (ANVS)
	MEIJER, Hans	Borssele NPP, E.P.Z.
PAKISTAN		
	MANNAN, Abdul	Chasshma NPGS
ROMANIA		
	SIMIONOV, Vasile	Cernavoda NPP
	(TBD)	National Commission for Nuclear Activities Control (CNCAN)
RUSSIAN FEDERATION		
	DOLJENKOV, Igor	Concern “Rosenergoatom”
	GLASUNOV, Vadim	Research Institute for Nuclear Power Plant Operation (VNIIAES)
SLOVAK REPUBLIC		
	DOBIS, Lubomir	Bohunice NPP
	DRÁBOVÁ, Veronika	Public Health Authority of the Slovak Republic (UVZSR)
SLOVENIA		
	BREZNIK, Borut	Krško NPP
	JUG, Nina	Slovenian Radiation Protection Administration, Ministry of Health
SOUTH AFRICA (REPUBLIC OF)		
	MAREE, Marc	Koeberg NPP
	MPETE, Louisa	National Nuclear Regulator (NNR)
SPAIN		
	LABARTA, Teresa	Consejo de Seguridad Nuclear (CSN)
	ROSELL HERRERA, Borja	Almaraz NPP
SWEDEN		
	HANSSON, Petra	Swedish Radiation Safety Authority (SSM)
	SVEDBERG, Torgny	Ringhals NPP
SWITZERLAND		
	JAHN, Swen-Gunnar	Swiss Nuclear Safety Inspectorate (ENSI)
	TAYLOR, Thomas	Mühleberg NPP
UKRAINE		
	BEREZHNAYA, Tatyana	National Nuclear Energy Generation Company “Energoatom”
	CHEPURNYI, Jurii	State Nuclear Regulatory Inspectorate
UNITED ARAB EMIRATES		
	AZIZ, Maha	Federal Authority for Nuclear Regulation (FANR)
UNITED KINGDOM		
	REES, Vaughan	Office for Nuclear Regulation (ONR)
	RENN, Guy	Sizewell B NPP
UNITED STATES OF AMERICA		
	BOYER, Brad	Prairie Island NPP
	BROCK, Terry	U.S. Nuclear Regulatory Commission
	WOOD, David	D.C. Cook NPP

Annex 4

ISOE WORKING GROUPS (2015)

Working Group on Data Analysis (WGDA)

Chair: HENNIGOR, Staffan (Sweden); Vice-Chair: HAGEMEYER, Derek (US)

BRAZIL	
DO AMARAL, Marcos Antonio	Angra NPP (ISOE Chair Elected)
CANADA	
ELLASCHUK, Bernard	Canadian Nuclear Safety Commission (CNSC)
CZECH REPUBLIC	
FARNIKOVA, Monika	Temelin NPP
FRANCE	
BELTRAMI, Laure-Anne	CEPN (ETC)
COUASNON, Olivier	Autorité de Sûreté Nucléaire (ASN)
D'ASCENZO, Lucie	CEPN (ETC)
JOLIVET, Patrick	IRSN
MICHELET, Marie	Électricité de France (EDF)
ROCHER, Alain	Électricité de France (EDF)
SCHIEBER, Caroline	CEPN (ETC)
GERMANY	
JENTJENS, Lena	VGB PowerTech e.V.
STAHL, Thorsten	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH
STEINEL, Dieter	Philippsburg NPP
JAPAN	
BESSHO, Yasunori	Nuclear Regulation Authority (NRA)
NOMURA, Tomoyuki	Nuclear Safety Research Association (NSRA)
SUZUKI, Akiko	Nuclear Regulation Authority (NRA)
TEZUKA, Hiroko	Nuclear Safety Research Association (NSRA)
KOREA (REPUBLIC OF)	
HWANG, Tae-Won	Korea Hydro and Nuclear Power Corporation Ltd. (KHNP) (ISOE Chair)
KIM, Byeong-Soo	Korea Institute of Nuclear Safety (KINS)
KIM, In Woong	Korea Hydro and Nuclear Power Corporation Ltd. (KHNP)
KIM, Minchul	Korea Hydro and Nuclear Power Corporation Ltd. (KHNP)
MEXICO	
HUESCA GUEVARA, Luis Rafael	Laguna Verde NPP
ROMANIA	
SIMIONOV, Vasile	Cernavoda NPP
RUSSIAN FEDERATION	
GLASUNOV, Vadim	Russian Research Institute for Nuclear Power Plant Operation (VNIIAES)
SLOVENIA	
BREZNIK, Borut	Krško NPP
SPAIN	
LABARTA, Teresa	Consejo de Seguridad Nuclear (CSN)
SWEDEN	
HENNIGOR, Staffan	Forsmark NPP
SVEDBERG, Torgny	Ringhals NPP
UNITED KINGDOM	
INGHAM, Grant	Office for Nuclear Regulation (ONR)
UNITED STATES OF AMERICA	
ANDERSON, Ellen	Nuclear Energy Institute (NEI)
BENEVIDES, Luis Alberto	US Nuclear Regulatory Commission
HAGEMEYER, Derek	Oak Ridge Associated Universities (ORAU)
HARRIS, Willie O.	Excelon Nuclear
MILLER, David W.	D.C. Cook Plant (NATC)
ISOE JOINT SECRETARIAT	
MA, Jizeng	IAEA
RAKHUBA, Aleksandr	OECD Nuclear Energy Agency (NEA)
GUZMÁN LÓPEZ-OCÓN, Olvido	OECD Nuclear Energy Agency (NEA)

Working Group on Radiological Protection Aspects of Decommissioning Activities at Nuclear Power Plants (WGDECOM)

Chair: HALE, James Mike (US) Vice-Chair: -CALAVIA, Ignacio (Spain)

BELGIUM	
VANHEMELRYCK, Fery	Electrabel GDF Suez
BRAZIL	
DE OLIVEIRA SEGABINAZE, Roberto	Angra NPP
LIMA DA SILVA, Tatiana	Angra NPP
CANADA	
ELLASCHUK, Bernard	Canadian Nuclear Safety Commission (CNSC)
GAGNON, Jean-Yves	Gentilly-2 NPP
FRANCE	
ABELA, Gonzague	EDF DIN
ARIES NASSER, Marie-Eve	Autorité de Sûreté Nucléaire (ASN)
BONNET, Jean-Luc	EDF - DPNT
DIDELOT, Nicolas	Institut de Radioprotection et de Sûreté Nucléaire (IRSN)
VAILLANT, Ludovic	European Technical Centre (ETC)
GERMANY	
BRENDEBACH, Boris	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH
STEINEL, Dieter	EnBW Kernkraft GmbH
ITALY	
MANCINI, Francesco	Sogin SpA
KOREA (REPUBLIC OF)	
KIM, Byeong-Soo	Korea Institute of Nuclear Safety (KINS)
SOHN, Wook	Korean Hydro & Nuclear Power (KHNP)
ROMANIA	
SIMIONOV, Vasile	Cernavoda NPP
RUSSIAN FEDERATION	
VOLKOV, Victor	Rosenergoatom Concern OJSC
SPAIN	
CALAVIA, Ignacio	Nuclear Safety Council (CSN)
CAMPOS, José	ENRESA
SWEDEN	
ELLMARK, Christoffer	AB SVAFO
HANSSON, Petra	Swedish Radiation Safety Authority
SWITZERLAND	
NEUKÄTER, Erwin	Mühleberg NPP
UNITED STATES OF AMERICA	
ANDERSON, Ellen	Nuclear Energy Institute (NEI)
HALE, James Mike	Kewaunee NPP
MILLER, David .W.	North American Technical Centre (NATC) D.C. Cook NPP
CORRESPONDING MEMBERS	
CANADA	
MCQUEEN, Maureen	C.N. Associates Inc.
UNITED STATES OF AMERICA	
ROBERTS, Sarah	Oak Ridge Associated Universities (ORAU)
TARZIA, James P.	Radiation Safety & Control Services Inc.
JOINT SECRETARIAT	
MA, Jizeng	International Atomic Energy Agency (IAEA)
RAKHUBA, Aleksandr	OECD Nuclear Energy Agency (NEA)
GUZMAN, Olvido	OECD Nuclear Energy Agency (NEA)

Annex 5

LIST OF ISOE PUBLICATIONS

Reports

- *Occupational Exposures at Nuclear Power Plants: Twenty-Fourth Annual Report of the ISOE Programme, 2014*, OECD, 2017.
- *Occupational Exposures at Nuclear Power Plants: Twenty-Third Annual Report of the ISOE Programme, 2013*, OECD, 2017.
- *Occupational Radiation Protection in Severe Accident Management (EG-SAM) Report,* OECD, 2015.
- *Radiation Protection Aspects of Primary Water Chemistry and Source-Term Management Report,* OECD, 2014.
- *An ALARA Success Story Relying on Strong Individual Commitments, Effective International Feedback and Exchanges, and a Robust Database – 20 Years of Progress,* OECD, 2013.
- *Occupational Exposures at Nuclear Power Plants: Twenty-Second Annual Report of the ISOE Programme, 2012*, OECD, 2012.
- *Occupational Exposures at Nuclear Power Plants: Twenty-First Annual Report of the ISOE Programme, 2011*, OECD, 2011.
- *Occupational Exposures at Nuclear Power Plants: Twentieth Annual Report of the ISOE Programme, 2010*, OECD, 2010.
- *Occupational Exposures at Nuclear Power Plants: Nineteenth Annual Report of the ISOE Programme, 2009*, OECD, 2011.
- *L'organisation du travail pour optimiser la radioprotection professionnelle dans les centrales nucléaires,* OCDE, 2010.
- *Occupational Exposures at Nuclear Power Plants: Eighteenth Annual Report of the ISOE Programme, 2008,* OECD, 2010.
- *Work Management to Optimise Occupational Radiological Protection at Nuclear Power Plants,* OECD, 2009.
- *Occupational Exposures at Nuclear Power Plants: Seventeenth Annual Report of the ISOE Programme, 2007,* OECD, 2009.
- *Occupational Exposures at Nuclear Power Plants: Sixteenth Annual Report of the ISOE Programme, 2006,* OECD, 2008.
- *Occupational Exposures at Nuclear Power Plants: Fifteenth Annual Report of the ISOE Programme, 2005,* OECD, 2007.
- *Occupational Exposures at Nuclear Power Plants: Fourteenth Annual Report of the ISOE Programme, 2004*, OECD, 2006.
- *Occupational Exposures at Nuclear Power Plants: Thirteenth Annual Report of the ISOE Programme*, *2003*, OECD, 2005.
- *Optimisation in Operational Radiation Protection,* OECD, 2005.
- *Occupational Exposures at Nuclear Power Plants: Twelfth Annual Report of the ISOE Programme, 2002,* OECD, 2004.
- *Occupational Exposure Management at Nuclear Power Plants: Third ISOE European Workshop, Portoroz, Slovenia, 17-19 April 2002,* OECD 2003.
- *ISOE – Information Leaflet*, OECD 2003.

- *Occupational Exposures at Nuclear Power Plants: Eleventh Annual Report of the ISOE Programme, 2001,* OECD, 2002.
- *ISOE – Information System on Occupational Exposure, Ten Years of Experience*, OECD, 2002.
- *Occupational Exposures at Nuclear Power Plants: Tenth Annual Report of the ISOE Programme, 2000*, OECD, 2001.
- *Occupational Exposures at Nuclear Power Plants: Ninth Annual Report of the ISOE Programme, 1999*, OECD, 2000.
- *Occupational Exposures at Nuclear Power Plants: Eighth Annual Report of the ISOE Programme, 1998,* OECD, 1999.
- *Occupational Exposures at Nuclear Power Plants: Seventh Annual Report of the ISOE Programme, 1997*, OECD, 1999.
- *Work Management in the Nuclear Power Industry*, OECD, 1997 (also available in Chinese, German, Russian and Spanish).
- *ISOE – Sixth Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1996*, OECD, 1998.
- *ISOE – Fifth Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1995,* OECD, 1997.
- *ISOE – Fourth Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1994,* OECD, 1996.
- *ISOE – Third Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1993,* OECD, 1995.
- *ISOE – Nuclear Power Plant Occupational Exposures in OECD Countries: 1969-1992*, OECD, 1994.
- *ISOE – Nuclear Power Plant Occupational Exposures in OECD Countries: 1969-1991,* OECD, 1993.

ISOE News

2015	No. 23 (November)
2014	No. 22 (March)
2013	No. 20 (July), No. 21 (December)
2012	No. 19 (July)
2011	No. 17 (September), No. 18 (December)
2010	No. 15 (March), No. 16 (December)
2009	No. 13 (January), No. 14 (July)
2008	No. 12 (October)
2007	No. 10 (July); No. 11 (December)
2006	No. 9 (March)
2005	No. 5 (April); No. 6 (June); No. 7 (October); No. 8 (December)
2004	No. 2 (March); No. 3 (July); No. 4 (December)
2003	No. 1 (December)

ISOE Information Sheets

Asian Technical Centre

No. 42: Nov. 2015 Republic of Korea: Summary of National Dosimetric Trends

No. 41: Nov. 2015	Japanese Dosimetric Results: FY 2014 data and trends
No. 40: Nov. 2014	Republic of Korea: Summary of National Dosimetric Trends
No. 39: Oct. 2014	Japanese Dosimetric Results: FY 2013 data and trends
No. 38: Nov. 2013	Republic of Korea: Summary of National Dosimetric Trends
No. 37: Nov. 2013	Japanese Dosimetric Results: FY 2012 data and trends
No. 36: Dec. 2012	Japanese Dosimetric Results: FY 2011 data and trends
No. 35: Nov. 2011	Japanese Dosimetric Results: FY 2010 data and trends
No. 34: Oct. 2009	Republic of Korea: Summary of National Dosimetric Trends
No. 33: Oct. 2009	Japanese Dosimetric Results: FY 2008 data and trends
No. 32: Jan. 2009	Japanese Dosimetric Results: FY 2007 data and trends
No. 31: Nov. 2007	Republic of Korea: Summary of National Dosimetric Trends
No. 30: Oct. 2007	Japanese dosimetric results: FY 2006 data and trends
No. 29: Nov. 2006	Japanese Dosimetric Results : FY 2005 Data and Trends
No. 28: Nov. 2005	Japanese Dosimetric Results : FY 2004 Data and Trends
No. 27: Nov. 2004	Achievements and Issues in Radiation Protection in the Republic of Korea
No. 26: Nov. 2004	Japanese occupational exposure during periodic inspection at PWRs and BWRs ended in FY 2003
No. 25: Nov. 2004	Japanese dosimetric results: FY2003 data and trends
No. 24: Oct. 2003	Japanese Occupational Exposure of Shroud Replacements
No. 23: Oct. 2003	Japanese Occupational Exposure of Steam Generator Replacements
No. 22: Oct. 2003	Korea, Republic of; Summary of National Dosimetric Trends
No. 21: Oct. 2003	Japanese occupational exposure during periodic inspection at PWRs and BWRs ended in FY 2002
No. 20: Oct. 2003	Japanese dosimetric results: FY2002 data and trends
No. 19: Oct. 2002	Korea, Republic of; Summary of National Dosimetric Trends
No. 18: Oct. 2002	Japanese occupational exposure during periodic inspection at PWRs and BWRs ended in FY 2001
No. 17: Oct. 2002	Japanese dosimetric results: FY2001 data and trends
No. 16: Oct. 2001	Japanese occupational exposure during periodical inspection at PWRs and BWRs ended in FY 2000
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No. 14: Sept. 2000	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1999
No. 13: Sept. 2000	Japanese Dosimetric Results: FY 1999 Data and Trends
No. 12: Oct. 1999	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1998
No. 11: Oct. 1999	Japanese Dosimetric Results: FY 1998 Data and Trends
No. 10: Nov. 1999	Experience of 1st Annual Inspection Outage in an ABWR
No. 9: Oct. 1999	Replacement of Reactor Internals and Full System Decontamination at a Japanese BWR
No. 8: Oct. 1998	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1997

No. 7: Oct. 1998	Japanese Dosimetric Results: FY 1997 data
No. 6: Sept. 1997	Japanese Occupational Exposure during Periodical Inspection at LWRs ended in FY 1996
No. 5: Sept. 1997	Japanese Dosimetric Results: FY 1996 data
No. 4: July 1996	Japanese Occupational Exposure during Periodical Inspection at LWRs ended in FY 1995
No. 3: July 1996	Japanese Dosimetric Results: FY 1995 data
No. 2: Oct. 1995	Japanese Occupational Exposure during Periodical Inspection at LWRs ended in FY 1994
No. 1: Oct. 1995	Japanese Dosimetric Results: FY 1994 data

European Technical Centre

No. 58: Oct. 2015	European dosimetric results for 2013
No. 57: Sep. 2015	European dosimetric results for 2012
No. 56: Dec. 2012	European dosimetric results for 2011
No. 55: Nov. 2012	Man-Sievert Monetary Value Survey (2012 Update)
No. 54: Feb. 2012	European dosimetric results for 2010
No. 53: Feb. 2011	European dosimetric results for 2009
No. 52: Apr. 2010	PWR Outage Collective Dose: Analysis per sister unit group for the 2002-2007 period
No. 51: Dec. 2009	European dosimetric results for 2008
No. 50: Sep. 2009	Outage duration and outage collective dose between 1996 – 2006 for VVERs
No. 49: Sep. 2009	Outage duration and outage collective dose between 1996 – 2006 for BWRs
No. 48: Sep. 2009	Outage duration and outage collective dose between 1996 – 2006 for PWRs
No. 47: Feb. 2009	European dosimetric results for 2007
No. 46: Oct. 2007	European dosimetric results for 2006
No. 44: July 2006	Preliminary European dosimetric results for 2005
No. 43: May 2006	Conclusions and recommendations from the Essen Symposium
No. 42: Nov. 2005	Self-employed Workers in Europe
No. 41: Oct. 2005	Update of the annual outage duration and doses in European reactors (1994-2004)
No. 40: Aug. 2005	Workers internal contamination practices survey
No. 39: July 2005	Preliminary European dosimetric results for 2004
No. 38: Nov. 2004	Update of the annual outage duration and doses in European reactors (1993-2003)
No. 37: July 2004	Conclusions and recommendations from the 4th European ISOE workshop on occupational exposure management at NPPs
No. 36: Oct. 2003	Update of the annual outage duration and doses in European reactors (1993-2002)
No. 35: July 2003	Preliminary European dosimetric results for 2002
No. 34: July 2003	Man-Sievert monetary value survey (2002 update)
No. 33: March 2003	Update of the annual outage duration and doses in European reactors (1993-2001)

No. 32: Nov. 2002 — Conclusions and Recommendations from the 3rd European ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants

No. 31: July 2002 — Preliminary European Dosimetric Results for the year 2001

No. 30: April 2002 — Occupational exposure and steam generator replacements - update

No. 29: April 2002 — Implementation of Basic Safety Standards in the regulations of European countries

No. 28: Dec. 2001 — Trends in collective doses per job from 1995 to 2000

No. 27: Oct. 2001 — Annual outage duration and doses in European reactors

No. 26: July 2001 — Preliminary European Dosimetric Results for the year 2000

No. 25: June 2000 — Conclusions and recommendations from the 2nd EC/ISOE workshop on occupational exposure management at nuclear power plants

No. 24: June 2000 — List of BWR and CANDU sister unit groups

No. 23: June 2000 — Preliminary European Dosimetric Results 1999

No. 22: May 2000 — Analysis of the evolution of collective dose related to insulation jobs in some European PWRs

No. 21: May 2000 — Investigation on access and dosimetric follow-up rules in NPPs for foreign workers

No. 20: April 1999 — Preliminary European Dosimetric Results 1998

No. 19: Oct. 1998 — ISOE 3 data base – New ISOE 3 Questionnaires received (since Sept 1998)

No. 18: Sept. 1998 — The Use of the man-Sievert monetary value in 1997

No. 17: Dec. 1998 — Occupational Exposure and Steam Generator Replacements, update

No. 16: July 1998 — Preliminary European Dosimetric Results for 1997

No. 15: Sept. 1998 — PWR collective dose per job 1994-1995-1996 data

No. 14: July 1998 — PWR collective dose per job 1994-1995-1996 data

No. 12: Sept. 1997 — Occupational exposure and reactor vessel annealing

No. 11: Sept. 1997 — Annual individual doses distributions: data available and statistical biases

No. 10: June 1997 — Preliminary European Dosimetric Results for 1996

No. 9: Dec. 1996 — Reactor Vessel Closure Head Replacement

No. 7: June 1996 — Preliminary European Dosimetric Results for 1995

No. 6: April 1996 — Overview of the first three Full System Decontamination

No. 4: June 1995 — Preliminary European Dosimetric Results for 1994

No. 3: June 1994 — First European Dosimetric Results: 1993 data

No. 2: May 1994 — The influence of reactor age and installed power on collective dose: 1992 data

No. 1: April 1994 — Occupational Exposure and Steam Generator Replacement

IAEA Technical Centre

No. 9: Aug. 2003 — Preliminary dosimetric results for 2002

No.8: Nov. 2002 — Conclusions and Recommendations from the 3rd European ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants

No. 7: Oct. 2002 — Information on exposure data collected for the year 2001

No. 6: June 2001 — Preliminary dosimetric results for 2000

No. 5: Sept. 2000 — Preliminary dosimetric results for 1999

No. 4: April 1999	IAEA Workshop on implementation and management of the ALARA principle in nuclear power plant operations, Vienna 22-23 April 1998
No. 3: April 1999	IAEA technical co-operation projects on improving occupational radiation protection in nuclear power plants
No. 2: April 1999	IAEA Publications on occupational radiation protection
No. 1: Oct. 1995	ISOE Expert meeting

North American Technical Centre

2014-2: Aug. 2014	Kewaunee PWR Low Dose Outage Worker Study
2014-1: July 2014	North American Pressurized Water Reactor (PWR) 2013 Occupational Dose Benchmarking Charts
2012-13: Sept. 2012	2011 CANDU Occupational Dose Benchmarking Charts
2012-12: July 2012	North American Boiling Water Reactor (BWR) 2008 Occupational Dose Benchmarking Charts
2012-11: July 2012	North American Pressurized Water Reactor (PWR) 2008 Occupational Dose Benchmarking Charts
2012-10: July 2012	North American Boiling Water Reactor (BWR) 2007 Occupational Dose Benchmarking Charts
2012-9: July 2012	North American Pressurized Water Reactor (PWR) 2007 Occupational Dose Benchmarking Charts
2012-8: Sept. 2012	North American Boiling Water Reactor (BWR) 2011 Occupational Dose Benchmarking Charts
2012-7: Sept. 2012	North American Pressurized Water Reactor (PWR) 2011 Occupational Dose Benchmarking Charts
2012-6: Sept. 2012	North American Pressurized Water Reactor (PWR) 2011 Occupational Dose Benchmarking Charts
2012-5: July 2012	North American Pressurized Water Reactor (PWR) 2010 Occupational Dose Benchmarking Charts
2012-4: July 2012	North American Boiling Water Reactor (BWR) 2009 Occupational Dose Benchmarking Charts
2012-3: July 2012	North American Pressurized Water Reactor (PWR) 2009 Occupational Dose Benchmarking Charts
2012-2: July 2012	North American Boiling Water Reactor (BWR) 2006 Occupational Dose Benchmarking Charts
2012-1: July 2012	North American Pressurized Water Reactor (PWR) 2006 Occupational Dose Benchmarking Charts
2010-14: June 2010	NATC Analysis of Teledosimetry Data from Multiple PWR Unit Outage CRUD Bursts
2003-8: Aug. 2003	U.S. PWR - Reactor Head Replacement Dose Benchmarking Study
2003-5: July 2003	North American BWR - 2002 Occupational Dose Benchmarking Charts
2003-4: July 2003	U.S. PWR - 2002 Occupational Dose Benchmarking Chart
2003-2: July 2003	3-Year rolling average annual dose comparisons - U.S. BWR 2000-2002

	Occupational Dose Benchmarking Charts
2003-1: July 2003	3-Year rolling average annual dose comparisons - U.S. PWR 2000-2002 Occupational Dose Benchmarking Charts
2002-5: July 2002	U.S. BWR - 2001 Occupational Dose Benchmarking Chart
2002-4: July 2002	U.S. PWR - 2001Occupational Dose Benchmarking Chart
2002-2: July 2002	3-Year rolling average annual dose comparisons - U.S. BWR 1999-2001 Occupational Dose Benchmarking Charts
2002-1: Nov. 2002	3-Year rolling average annual dose comparisons - U.S. PWR 1999-2001 Occupational Dose Benchmarking Charts
2001-7: Nov. 2001	US PWR 5-Year Dose Reduction Plan: Donald C. Cook Nuclear Power Plant
2001-5: Dec. 2001	U.S. BWR - 2000 Occupational Dose Benchmarking Chart
2001-4: Dec. 2001	U.S. PWR - 2000 Occupational Dose Benchmarking Chart
2001-3: Nov. 2001	3-Year rolling average annual dose comparisons - Canada reactors (CANDU) 1998-2000 Occupational Dose Benchmarking Charts
2001-2: July 2001	3-Year rolling average annual dose comparisons - U.S. BWR 1998-2000 Occupational Dose Benchmarking Charts
2001-1: July 2001	3-Year rolling average annual dose comparisons - U.S. PWR 1998-2000 Occupational Dose Benchmarking Charts

ISOE International and Regional Symposia

Asian Technical Centre

Sept. 2015 (Tokyo, Japan)	2015 ISOE Asian ALARA Symposium
Sept. 2014 (Gyeongju, Rep. of Korea)	2014 ISOE Asian ALARA Symposium
Aug. 2013 (Tokyo, Japan)	2013 ISOE International ALARA Symposium
Sept. 2012 (Tokyo, Japan)	2012 ISOE Asian ALARA Symposium
Aug. 2010 (Gyeongju, Rep.of Korea)	2010 ISOE Asian ALARA Symposium
Sept. 2009 (Aomori, Japan)	2009 ISOE Asian ALARA Symposium
Nov. 2008 (Tsuruga, Japan)	2008 ISOE International ALARA Symposium
Sept. 2007 (Seoul, Korea)	2007 ISOE Asian Regional ALARA Symposium
Oct. 2006 (Yuzawa, Japan)	2006 ISOE Asian Regional ALARA Symposium
Nov. 2005 (Hamaoka, Japan)	First Asian ALARA Symposium

European Technical Centre

April 2014 (Bern, Switzerland)	2014 ISOE European ALARA Symposium
June 2012 (Prague, Czech Republic)	2012 ISOE European Regional ALARA Symposium
Nov. 2010 (Cambridge, UK)	2010 ISOE International ALARA Symposium
June 2008 (Turku, Finland)	2008 ISOE European Regional ALARA Symposium
March 2006 (Essen, Germany)	2006 ISOE International ALARA Symposium
March 2004 (Lyon, France)	Fourth ISOE European Workshop on Occupational Exposure Management at Nuclear Power Plants
April 2002 (Portoroz, Slovenia)	Third ISOE European Workshop on Occupational Exposure Management at Nuclear Power Plants
April 2000 (Tarragona, Spain)	Second EC/ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants
Sept. 1998 (Malmö, Sweden)	First EC/ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants

IAEA Technical Centre

May 2015 (Rio de Janeiro, Brazil)	2015 ISOE International ALARA Symposium
Oct. 2009 (Vienna, Austria)	2009 ISOE International ALARA Symposium

North American Technical Centre

Jan. 2015 (Ft. Lauderdale, FL, USA)	2015 ISOE North American ALARA Symposium
Jan. 2014 (Ft. Lauderdale, FL, USA)	2014 ISOE North American ALARA Symposium
Jan. 2013 (Ft. Lauderdale, FL, USA)	2013 ISOE North American ALARA Symposium
Jan. 2012 (Ft. Lauderdale, FL, USA)	2012 ISOE International ALARA Symposium
Jan. 2011 (Ft. Lauderdale, FL, USA)	2011 ISOE North American ALARA Symposium
Jan. 2010 (Ft. Lauderdale, FL, USA)	2010 ISOE North American ALARA Symposium
Jan. 2009 (Ft. Lauderdale, FL, USA)	2009 ISOE North American ALARA Symposium
Jan. 2008 (Ft. Lauderdale, FL, USA)	2008 ISOE North American ALARA Symposium

Jan. 2007 (Ft. Lauderdale, FL, USA)	2007 ISOE International ALARA Symposium
Jan. 2006 (Ft. Lauderdale, FL, USA)	2006 ISOE North American ALARA Symposium
Jan. 2005 (Ft. Lauderdale, FL, USA)	2005 ISOE International ALARA Symposium
Jan. 2004 (Ft. Lauderdale, FL, USA)	2004 North American ALARA Symposium
Jan. 2003 (Orlando, FL, USA)	2003 International ALARA Symposium
Feb. 2002 (Orlando, FL, USA)	North-American National ALARA Symposium
Feb. 2001 (Orlando, FL, USA)	2001 International ALARA Symposium
Jan. 2000 (Orlando, FL, USA)	North-American National ALARA Symposium
Jan. 1999 (Orlando, FL, USA)	Second International ALARA Symposium
March 1997 (Orlando, FL, USA)	First International ALARA Symposium