Radiological Protection
2019

Occupational Exposures at Nuclear Power Plants

Twenty-Sixth Annual Report of the ISOE Programme, 2016

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Radiological Protection
Information System on Occupational Exposure (ISOE)

Occupational Exposures at Nuclear Power Plants

Twenty-Sixth Annual Report of the ISOE Programme, 2016

NEA No. 7453

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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, as low as reasonably achievable (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 of new nuclear build, the task of ensuring that occupational exposures are ALARA, taking into account operational costs and social factors, continues to present challenges to radiation protection professionals.

Since 1992, the Information System on Occupational Exposure (ISOE), jointly sponsored by the 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 and other analyses promoting the application of the ALARA principle in local radiological protection programmes.

The Twenty-Sixth Annual Report of the ISOE Programme presents the status of the ISOE Programme for the year 2016.

"... 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, 2016-2019)

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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 26th Annual Report of the ISOE Programme presents the status of the ISOE Programme for the calendar year 2016.

ISOE is jointly sponsored by the Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (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 2016-2019 came into force on 1 January 2016. As of 31 December 2016, the ISOE Programme included 74 Participating Utilities in 28 countries (343 operating units; 53 shutdown units; 7 units under construction), as well as the regulatory authorities in 26 countries. The ISOE database includes occupational exposure information for over 400 units, covering over 85% of the world's operating commercial power reactors. Four ISOE Technical Centres (Asia, Europe, North America, and the 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 2016 average annual collective doses per reactor and 3-year rolling averages per reactor (2014-2016) were:

	2016 average annual collective dose (person·Sv/reactor)	**3-year rolling average for 2014-2016 (person·Sv/reactor)**
Pressurised water reactors (PWR)	0.44	0.47
Pressurised water reactors (VVER)	0.45	0.44
Boiling water reactors (BWR)	0.69	0.84
Pressurised heavy water reactors (PHWR)	1.02	0.87

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. As these reactor units are generally of different types and sizes, and at different phases of their decommissioning programmes, it is difficult to identify clear dose trends. However, work continued in 2016 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 among its participants. In 2016, the ISOE Network website (www.isoe-network.net) continued to provide the ISOE membership with a comprehensive information and experience exchange portal on dose reduction and ISOE ALARA resources.

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 2016 included: the ISOE North American ALARA Symposium organised by the North American Technical Centre in Fort Lauderdale (United States) on 11-13 January; the ISOE International ALARA Symposium organised by the European Technical Centre in Brussels (Belgium) on 1-3 June; and the ISOE Asian Symposium organised by the Asian Technical Centre in Fukushima (Japan) on 7-9 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) continued acting as a formal working group undertaking its activities to develop a process within the ISOE Programme to better share operational radiological protection (RP) data and experience for nuclear power plants (NPPs) in some stage of decommissioning, or in preparation for decommissioning.

Other achievements/milestones/events of the ISOE Programme in 2016 are listed below:

- The ISOE Strategic Programme Plan (2016-2019) was issued and posted on the ISOE Network website in March 2016. It included both the continuation of current ISOE activities and new activities undertaken by the ISOE participants.
- The ISOE Programme of Work (Roadmap) to implement the Strategic Programme Plan for 2016-2019 was approved by the Management Board.
- The First Joint WGDA/MB Topical Session on RP Education and Training for RP Staff and Exposed Workers was held on 30 November at the Organisation for Economic Co-operation and Development (OECD) Conference Centre in Paris, which attracted 36 participants from 14 ISOE countries as well as the NEA and the IAEA.
- The German utilities withdrew from ISOE on 1 April 2016 but continued to provide their data on the website.
- The WGDA Progress Report for 2012-2015 was approved by the Management Board and posted on the ISOE Network website.
- The participation in ISOE by both utilities and authorities had grown over the previous years, which is a very positive sign for ISOE.
- Technical Co-operation Agreements (TCAs) with SBPR (Brazil) and ORAU (United States) were signed in December 2016.

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

LIST OF ABBREVIATIONS AND ACRONYMS

ALARA	As low as reasonably achievable
CPD	Co-operative Programme on Decommissioning
CSN	Consejo de Seguridad Nuclear (Spain)
DGT	Direction Générale du Travail (France)
FANC	Federal Agency for Nuclear Control (Belgium)
HINT	Handling of reactor INTernals
IAEA	International Atomic Energy Agency
IRRS	Integrated Regulatory Review Service
ISOE	Information System on Occupational Exposure
KHNP	Korean Hydro and Nuclear Power
LTO	Long-term operation
NEA	Nuclear Energy Agency
NEI	Nuclear Energy Institute (United States)
NPP	Nuclear power plant
NRA	Nuclear Regulation Authority (United Kingdom)
NSRA	Nuclear Safety Research Association (Japan)
OECD	Organisation for Economic Co-operation and Development
ORAU	Oak Ridge Associated Universities (United States)
PCE	Personal Contamination Event
PHT	Primary Heat Transport
PWR	Pressurised water reactors

RBLRT	Reactor Building Leak Rate Test
RMS	Radiation monitoring system
RP	Radiological protection
SGR	Steam generator replacement
SNF	Spent nuclear fuel
SRPA	Slovenian Radiation Protection Administration
TAM	Tritium in Air Monitoring
TCA	Technical Co-operation Agreements
TVA	Tennessee Valley Authority
WGDA	Working Group on Data Analysis (NEA)

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 (2013-2016). 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 2016, the ISOE Programme included: 74 Participating Utilities[*] in 29 countries, covering 343 operating units and 53 shutdown units, and 28 Regulatory Authorities in 26 countries. Table 1 summarises total participation by country, type of reactor and reactor status as of December 2016. 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 487 reactor units in 31 countries (378 operating; 109 in cold shutdown or some stage of decommissioning), covering over 85% 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.

1. 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 2016)

Note: The list of the official ISOE participants at the time of 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	14	2	–	–	–	–	16
Czech Republic	–	6	–	–	–	–	6
Finland	–	2	2	–	–	–	4
France	58	–	–	–	–	–	58
Hungary	–	4	–	–	–	–	4
Japan	21	–	22	–	–	–	43
Korea, Republic of	21	–	–	4	–	–	25
Mexico	–	–	2	–	–	–	2
Netherlands	1	–	–	–	–	–	1
Pakistan	2	–	–	1	–	–	3
Romania	–	–	–	2	–	–	2
Russian Federation	–	18	–	–	–	–	18
Slovak Republic	–	4	–	–	–	–	4
Slovenia	1	–	–	–	–	–	1
South Africa	2	–	–	–	–	–	2
Spain	6	–	1	–	–	–	7
Sweden	3	–	6	–	–	–	9
Switzerland	3	–	2	–	–	–	5
Ukraine	–	15	–	–	–	–	15
United Kingdom	1	–	–	–	–	–	1
United States	57	–	29	–	–	–	86
Total	**199**	**54**	**64**	**26**	**0**	**0**	**343**

Operating reactors: Not participating in ISOE, but included in the ISOE database						
Country	**PWR/VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Total**
Germany	6	2	–	–	–	8
United Kingdom	–	–	–	14	–	14
United States	8	5	–	–	–	13
Total	**14**	**7**	**0**	**14**	**0**	**35**

Total number of operating reactors included in the ISOE database						
	PWR/VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Total**
Total	**267**	**71**	**26**	**14**	**0**	**378**

Table 1. The official ISOE participants and the ISOE Database (as of December 2016) *(Cont'd)*

Definitively shutdown reactors: ISOE Participants							
Country	**PWR/ VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Armenia	1	–	–	–	–	–	1
Bulgaria	4	–	–	–	–	–	4
Canada	–	–	3	–	–	–	3
France	1	–	–	6	–	–	7
Italy	1	2	–	1	–	–	4
Japan	3	10	–	1	–	1	15
Lithuania	–	–	–	–	2	-	2
Russian Federation	2	–	–	–	–	–	2
Spain	–	1	–	–	–	–	1
Sweden	–	3	–	–	–	–	3
United States	6	3	–	1	–	1	11
Total	**18**	**19**	**3**	**9**	**2**	**2**	**53**

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	8	5	–	2	–	–	15
Netherlands	–	1	–	–	–	–	1
Spain	1	–	–	1	–	–	2
Ukraine	–	–	–	–	3	–	3
United Kingdom	–	–	–	20	–	–	20
United States	8	3	–	1	–	–	12
Total	**17**	**9**	**3**	**24**	**3**	**0**	**56**

Total number of definitively shutdown reactors included in the ISOE database							
	PWR/ VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Total	**35**	**28**	**6**	**33**	**5**	**2**	**109**

Total number of reactors included in the ISOE database							
	PWR/ VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Total	**302**	**99**	**32**	**47**	**5**	**2**	**487**
Number of **Participating Countries**							**31**
Number of **Participating Utilities**†							**74**
Number of **Participating Authorities**‡							**28**

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

2. OCCUPATIONAL EXPOSURE TRENDS

A key element of ISOE is the tracking of occupational exposure trends from nuclear power facilities worldwide for benchmarking, comparative analysis and experience exchange among ISOE members. This information is maintained in the ISOE Occupational Exposure Database which contains annual occupational exposure data supplied by participating utilities (generally based on operational dosimetry systems). The 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;
- annual collective dose for certain tasks and worker categories.

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

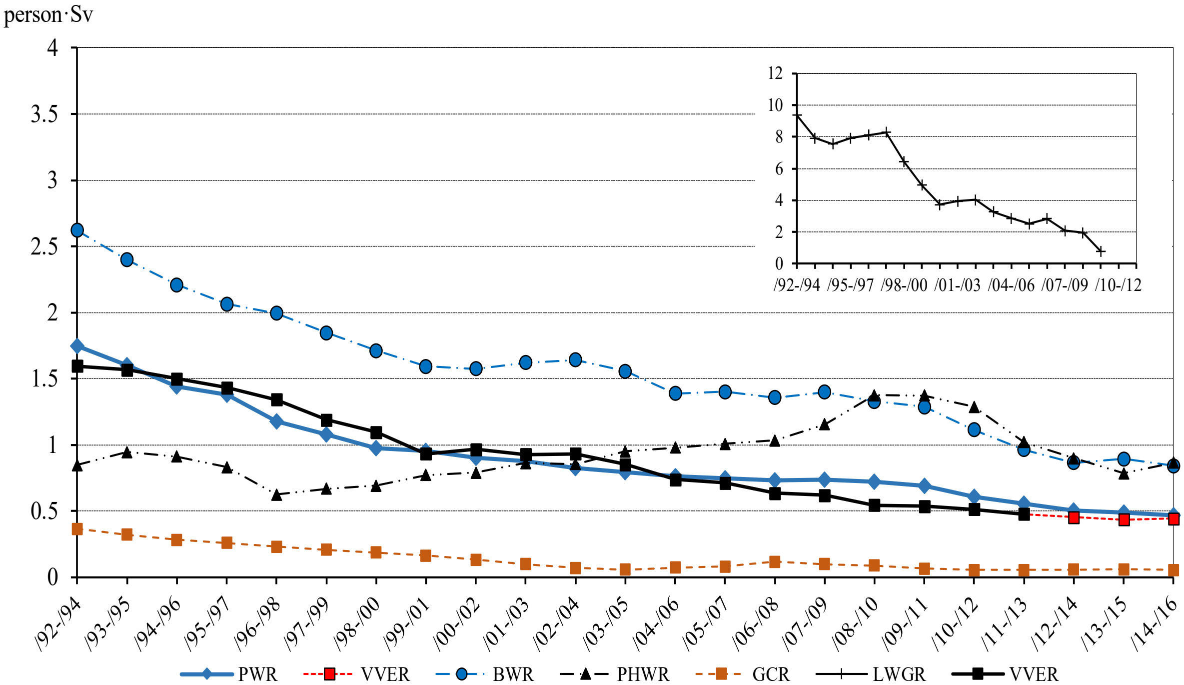
a) Global trends by reactor type

Figure 1 shows the trend in 3-year rolling average collective dose per reactor, by reactor type, for 1992-2016. 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 an increasing trend in 3-year rolling average collective dose from 2009-2012 as a reflection of major refurbishment activities conducted at CANDU nuclear power plants including Point Lepreau, Bruce A Units 1 and 2 and Wolsong and a return to service of Bruce Units 3 and 4. The major CANDU refurbishments include feeder tube and other component replacements as a part of plant-life extension objectives. The commencement of major feeder tube and other component replacements at Darlington Unit 2 in 2016-2018 will again show additional increasing trends in PHWR 3-year rolling average collective dose during this period as a part of important plant-life extension activities at CANDUs.

Average annual collective dose per reactor by country and reactor type for the period of 2014-2016 and 3-year rolling average annual collective dose per reactor, by country and reactor type for the period of 2012-2014 to 2014-2016 are given in Tables 2 and 3, respectively. These results are based primarily on data reported and recorded in the ISOE database during 2016, supplemented by the individual country reports (Section 3) as required. Figures 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 2016.

Figure 1. 3-year rolling average collective dose per reactor for all operating reactors included in ISOE by reactor type, 1992-2016 (man·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.

Figures 2 to 5 show this tabular data from Table 2 in a bar-chart format, for 2016 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, 2014-2016 (man·Sv/reactor)

	PWR			VVER			BWR		
	2014	**2015**	**2016**	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**
Armenia				1.01	0.89	1.49			
Belgium	0.25	0.32	0.29						
Brazil	0.34	0.33	0.32						
Bulgaria				0.30	0.45	0.36			
Canada									
China	0.46	0.52	0.49	0.25	0.26	0.51			
Czech Republic				0.11	0.14	0.15			
Finland				0.42	0.26	0.42	0.32	0.40	0.44
France	0.72	0.71	0.76						
Germany	0.16	0.18	0.14				1.16	1.11	0.91
Hungary				0.39	0.33	0.24			
Japan	0.23	0.19	0.16				0.19	0.22	0.16
Korea, Republic of	0.36	0.36	0.40						
Mexico							5.91	4.83	2.10
Netherlands	0.23	0.22	N/A						
Pakistan	0.60	0.59	0.27						
Romania									
Russian Federation				0.62	0.56	0.51			
Slovak Republic				0.14	0.18	0.16			
Slovenia	0.11	0.79	0.52						
South Africa	0.28	1.09	0.24						
Spain	0.39	0.38	0.44				0.29	2.47	0.20
Sweden	0.72	0.68	0.36				0.94	0.83	0.55
Switzerland	0.26	0.57	0.36				1.23	1.23	1.02
Ukraine				0.48	0.55	0.55			
United Kingdom	0.37	0.05	0.55						
United States	0.51	0.44	0.31				1.09	1.22	0.98
Average	**0.49**	**0.48**	**0.44**	**0.44**	**0.45**	**0.45**	**0.89**	**0.95**	**0.69**

	PHWR			GCR		
	2014	**2015**	**2016**	**2014**	**2015**	**2016**
Canada	0.90	0.83	1.14			
Korea, Republic of	0.37	0.43	0.65			
Pakistan	2.01	1.84	1.48			
Romania	0.30	0.19	0.43			
United Kingdom				0.08	0.07	0.02
Average	**0.81**	**0.76**	**1.02**	**0.08**	**0.07**	**0.02**

Note: Data provided directly from country reports, rather than calculated from the ISOE database: United Kingdom (2014, 2015, and 2016: GCR), Japan (2014, 2015, 2016), Korea (2016), Germany (2016, PWR).
BWR dose from China contains only 7 reactors from the ISOE database.

	2014	2015	2016
Global Average	**0.54**	**0.54**	**0.52**

Figure 2. 2016 PWR average collective dose per reactor by country (man·Sv/reactor)

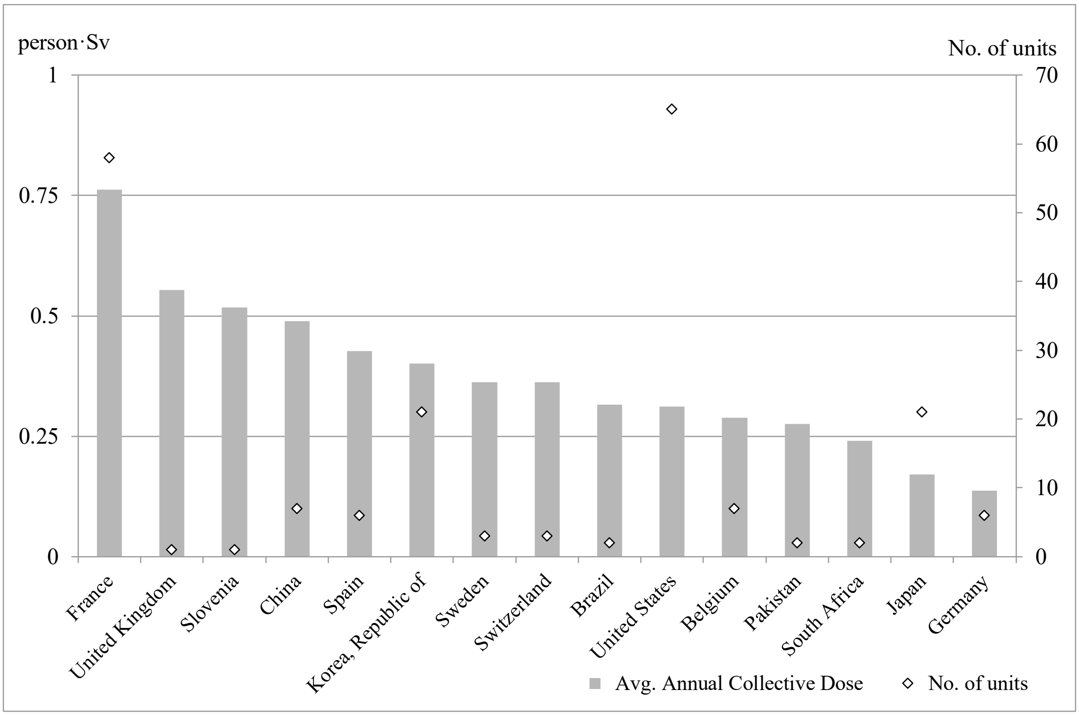


Figure 3. 2016 VVER average collective dose per reactor by country (man·Sv/reactor)

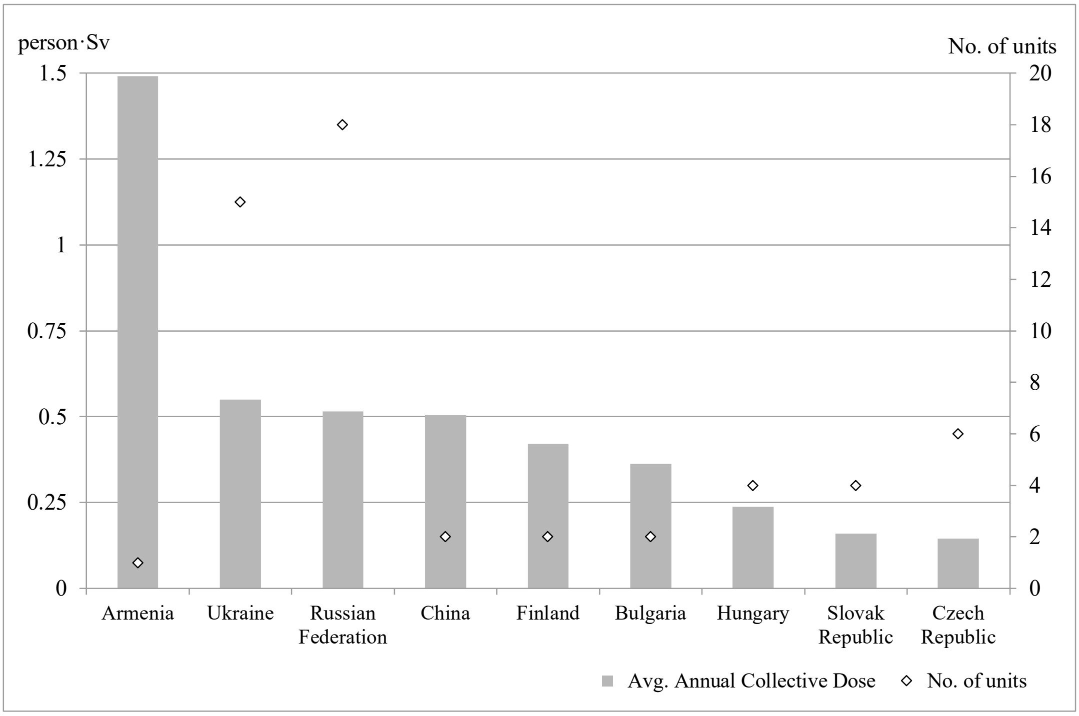


Figure 4. 2016 BWR average collective dose per reactor by country (man·Sv/reactor)

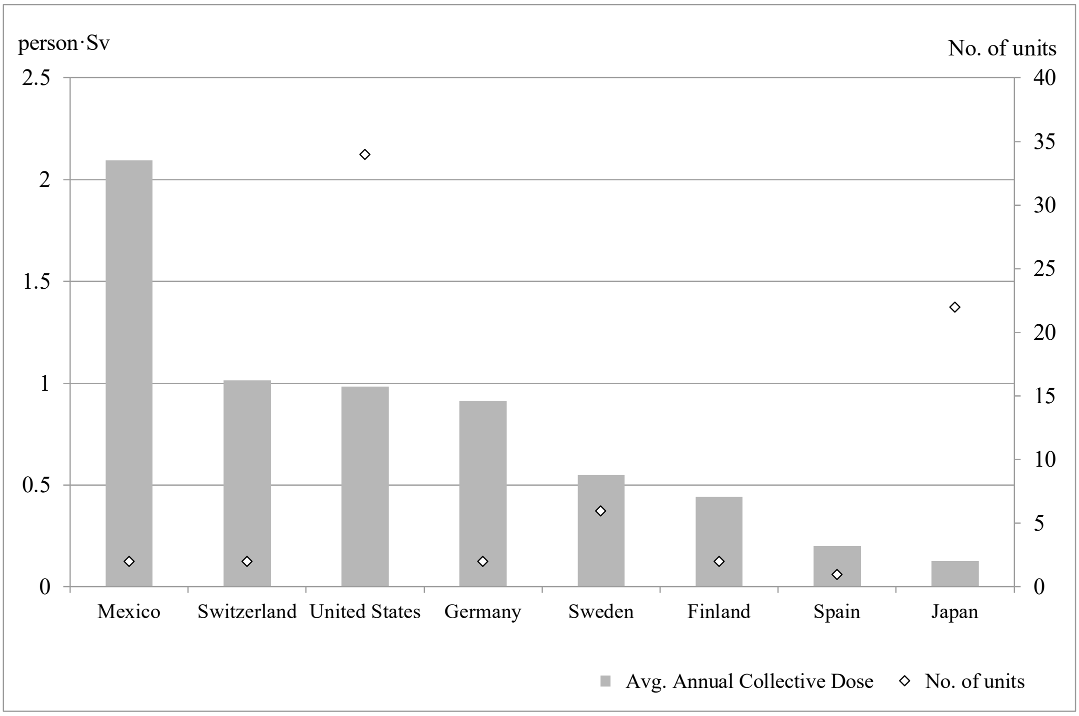
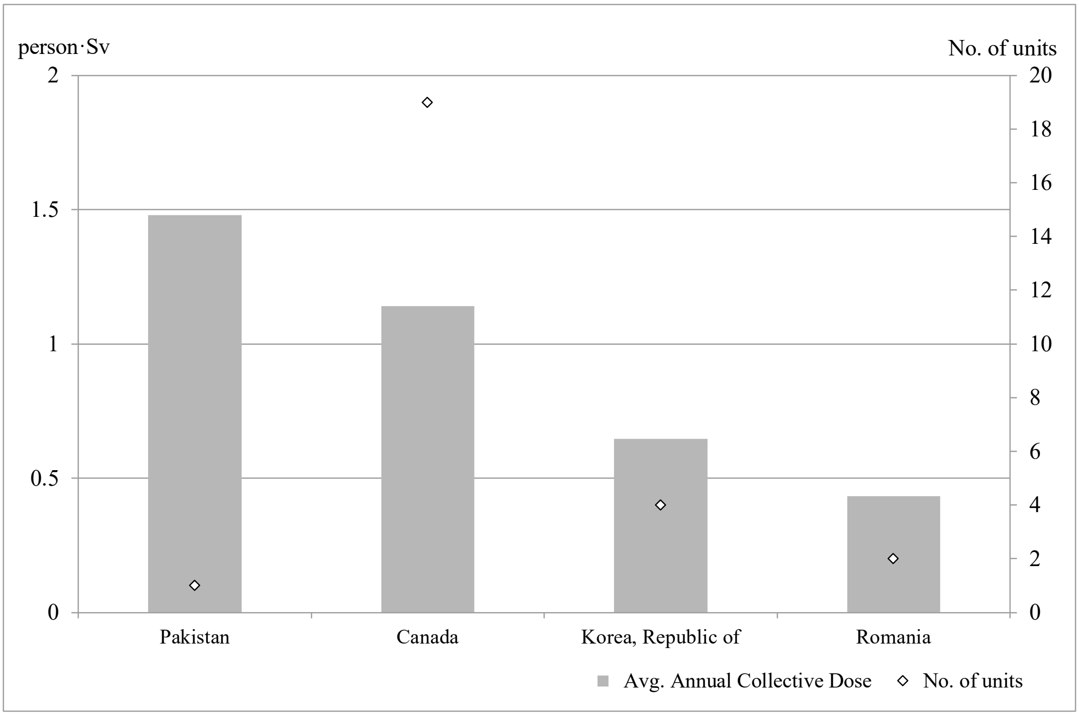


Figure 5. 2016 PHWR average collective dose per reactor by country (man·Sv/reactor)



c) Three-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 2012-2014 to 2014-2016. Figures 6-14 present the 3-year rolling average annual collective dose from 2003 to 2016 in different countries by taking into account the reactor types, including PWR, VVER, BWR and PHWR.

Table 3. Three-year rolling average annual collective dose per reactor, by country and reactor type, 2012-2014 to 2014-2016 (man·Sv/reactor)

	PWR			VVER			BWR		
	/12-/14	/13-/15	/14-/16	/12-/14	/13-/15	/14-/16	/12-/14	/13-/15	/14-/16
Armenia				0.88	0.87	1.13			
Belgium	0.26	0.26	0.28						
Brazil	0.30	0.38	0.33						
Bulgaria				0.23	0.32	0.37			
Canada									
China	0.59	0.61	0.49	0.24	0.25	0.34			
Czech Republic				0.12	0.13	0.13			
Finland				0.51	0.32	0.37	0.33	0.35	0.39
France	0.73	0.74	0.73						
Germany	0.23	0.22	0.16				1.11	1.12	1.06
Hungary				0.45	0.41	0.32			
Japan	0.21	0.22	0.20				0.23	0.21	0.18
Korea, Republic of	0.44	0.42	0.37						
Mexico							3.62	3.81	4.28
The Netherlands	0.46	0.43	0.22						
Pakistan	0.40	0.57	0.49						
Romania									
Russian Federation				0.58	0.56	0.56			
Slovak Republic				0.15	0.15	0.16			
Slovenia	0.78	0.75	0.47						
South Africa, Rep. of	0.45	0.56	0.54						
Spain	0.42	0.39	0.40				0.93	1.67	0.99
Sweden	0.59	0.64	0.59				0.77	0.83	0.77
Switzerland	0.35	0.39	0.40				1.28	1.19	1.16
Ukraine				0.53	0.52	0.53			
United Kingdom	0.26	0.27	0.32						
United States	0.49	0.44	0.42				1.16	1.19	1.10
Average	**0.50**	**0.49**	**0.47**	**0.45**	**0.44**	**0.44**	**0.87**	**0.89**	**0.84**

	PHWR			GCR		
	/12-/14	/13-/15	/14-/16	/12-/14	/13-/15	/14-/16
Canada	1.00	0.86	0.96			
Korea, Republic of	0.50	0.43	0.48			
Pakistan	1.67	1.85	1.78			
Romania	0.34	0.25	0.31			
United Kingdom				0.06	0.06	0.06
Average	**0.90**	**0.78**	**0.87**	**0.06**	**0.06**	**0.06**

	/12-/14	/13-/15	/14-/16
Global Average	**0.55**	**0.53**	**0.53**

Note: calculated from the ISOE database, supplemented by data provided directly by country (See Notes, Table 3).

Figure 6. Three-year rolling average collective dose by country from 2002 to 2016 for PWRs (1)

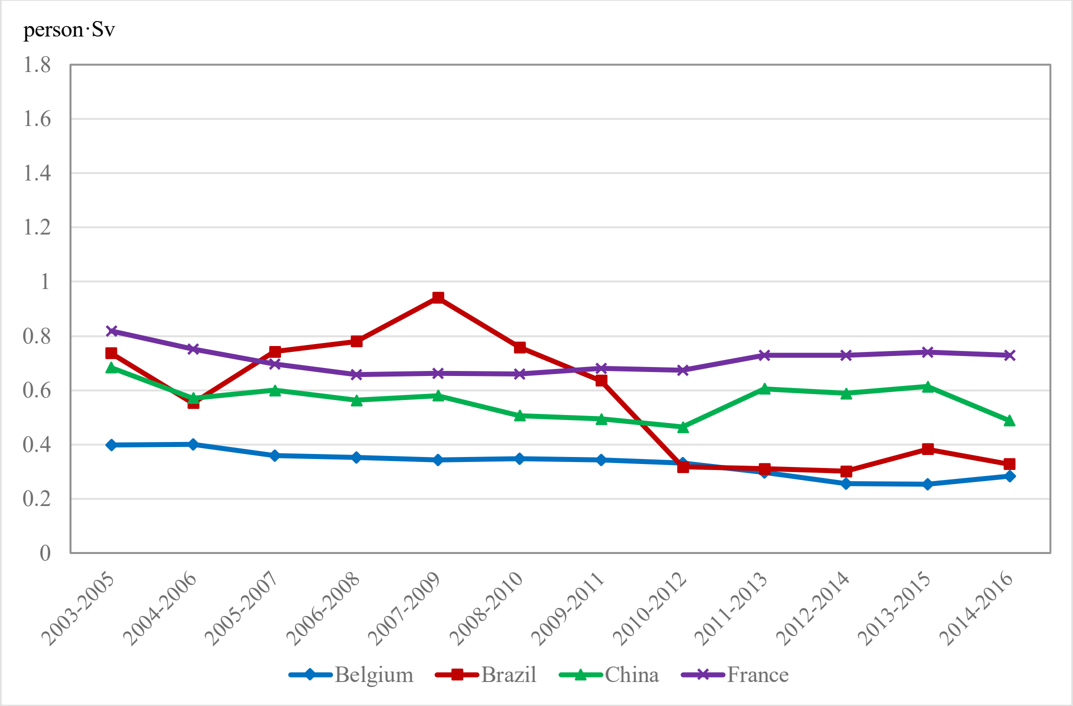


Figure 7. Three-year rolling average collective dose by country from 2002 to 2016 for PWRs (2)

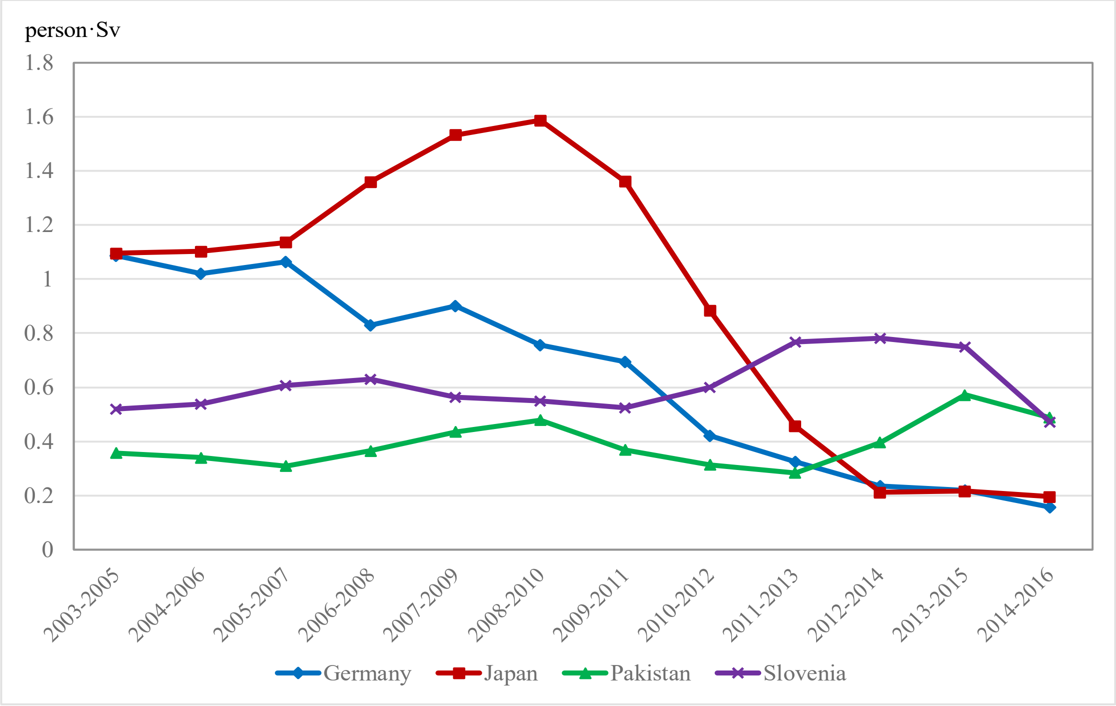


Figure 8. Three-year rolling average collective dose by country from 2002 to 2016 for PWRs (3)

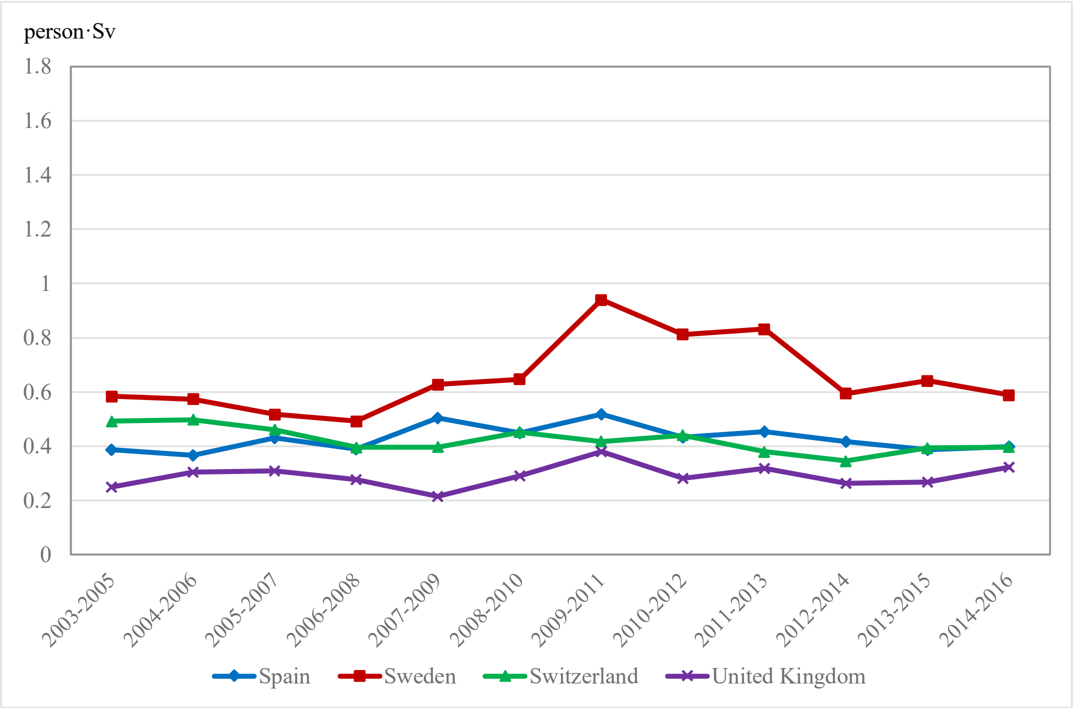


Figure 9. Three-year rolling average collective dose by country from 2002 to 2016 for PWRs (4)

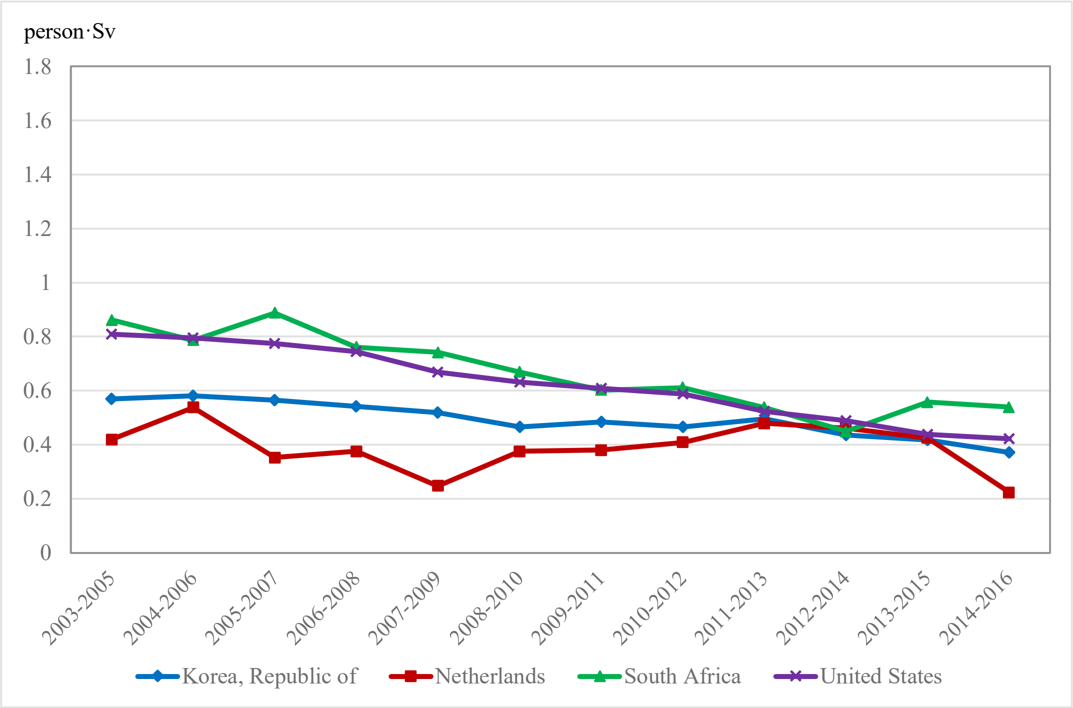


Figure 10. Three-year rolling average collective dose by country from 2002 to 2016 for VVERs (1)

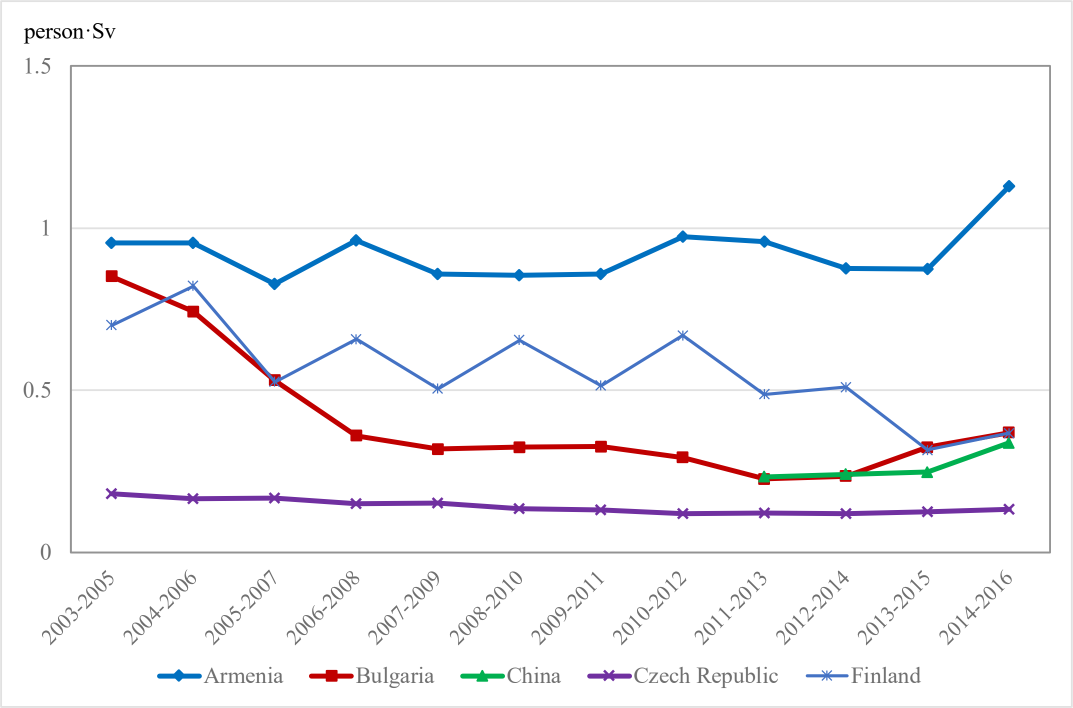


Figure 11. Three-year rolling average collective dose by country from 2002 to 2016 for VVERs (2)

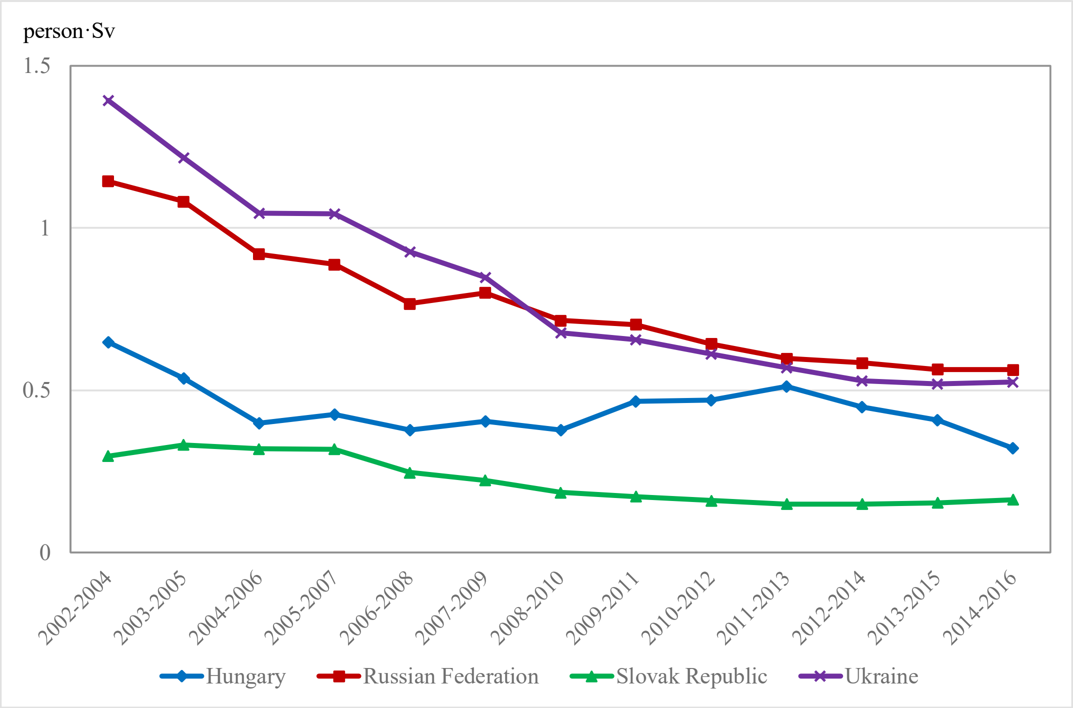


Figure 12. Three-year rolling average collective dose by country from 2002 to 2016 for BWRs (1)

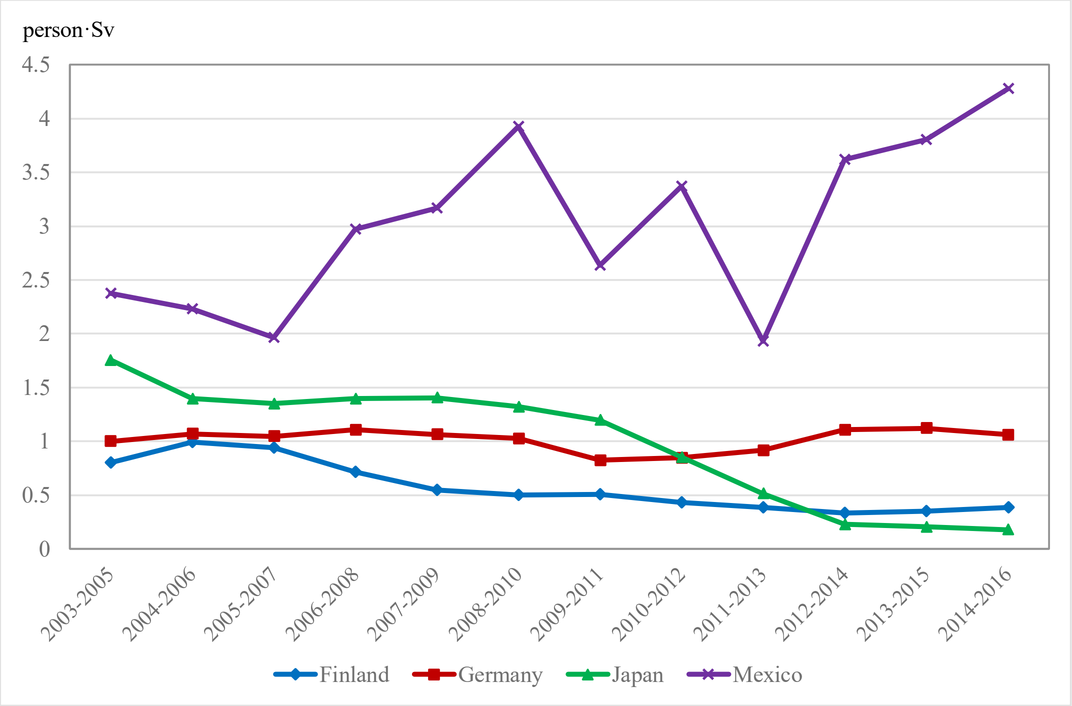


Figure 13. Three-year rolling average collective dose by country from 2002 to 2016 for BWRs (2)

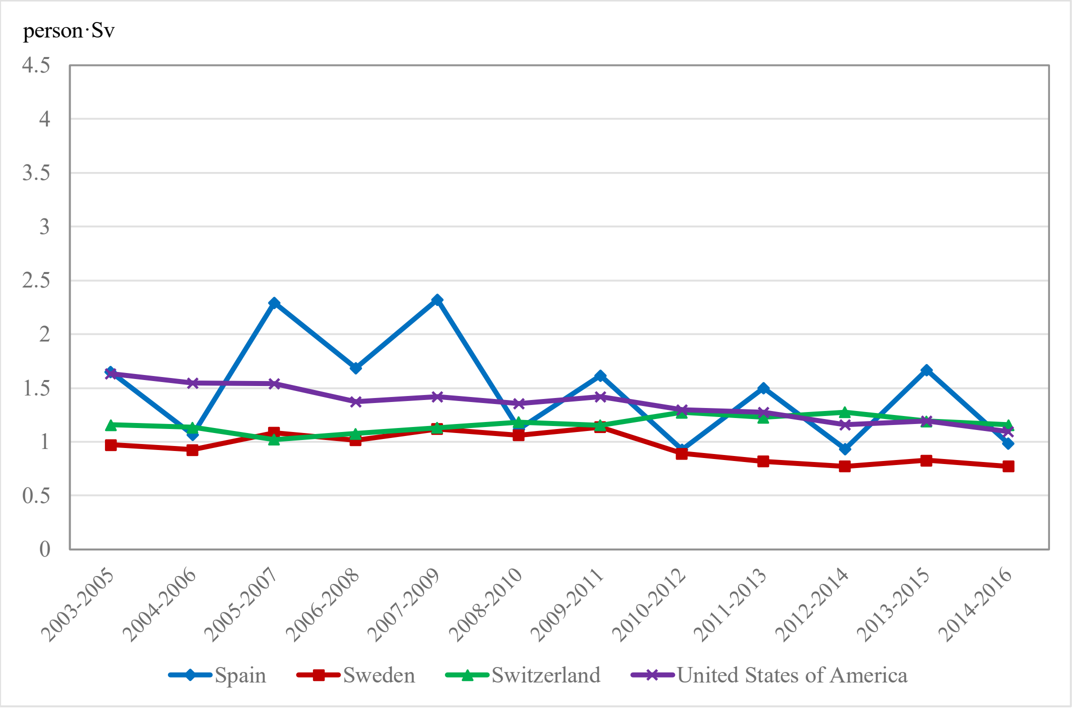
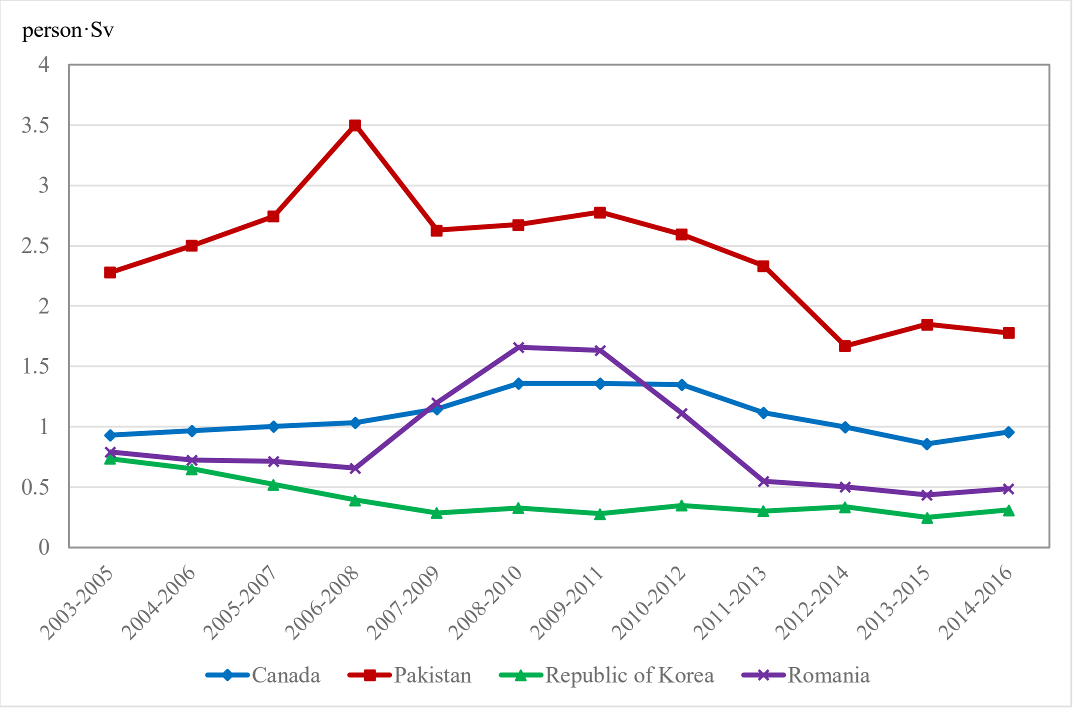


Figure 14. Three-year rolling average collective dose by country from 2002 to 2016 for PHWRs



2.2 Occupational exposure trends: Definitely shutdown reactors

In addition to information from operating reactors, the ISOE database contains dose data from 117 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 2014-2016 period. These reactor units are generally of different types and sizes, 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. Under the ISOE Working Group on Data Analysis, work continued in 2016 to improve data collection for shutdown and decommissioned reactors in order to achieve better benchmarking.

Table 4 provides average annual collective doses per unit for definitely shutdown reactors by country and reactor type for 2014-2016, 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 2014-2016 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, 2014-2016 (man·mSv/reactor)

		2014		2015		2016	
		No.	**Dose**	**No.**	**Dose**	**No.**	**Dose**
PWR	France	1	88.8	1	73.3	1	51.0
	Germany	7	76.4	8	80.0	2	83.0
	Italy	1	7.3	1	17.8	1	34.2
	Japan					3	88.0
	Spain	1	591.3	1	438.4	1	730.7
	United States	10	83.4	12	121.5	8	78.0
	Average	*20*	*102.8*	*23*	*114.2*	*16*	*116.9*
VVER	Bulgaria	4	1.8	4	5.5	4	8.3
	Russian Federation	2	44.7	2	69.4	2	52.5
	Average	*6*	*16.1*	*6*	*26.8*	*6*	*23.1*
BWR	Germany	5	61.9	5	73.0		N/A
	Italy	2	17.4	2	40.0	2	24.4
	Japan*	2	28.0	2	44.0	4	154.0
	Netherlands	1	0.0	1	0.0		N/A
	Spain	1	102.0	1	119.9	1	76.1
	Sweden	2	3.9	2	8.4	3	19.3
	United States	3	60.6	5	111.1	4	41.0
	Average	*16*	*43.2*	*18*	*68.0*	*14*	*68.8*
GCR	France	6	23.3	6	20.0	6	5.4
	Germany	1	0.0	1	0.0	1	0.0
	Italy	1	7.7	1	0.4	1	73.6
	Japan	1	0.0	1	0.0	1	10.0
	Spain	1	0.0	1	0.0	1	0.0
	United Kingdom	19	52.0	20	90.2	20	36.5
	Average	*29*	*39.7*	*29*	*39.2*	*29*	*64.1*
PHWR	Canada	3	36.3	4	1.8	3	0.7
LWGR	Lithuania	2	304.4	2	342.7	2	305.4
LWCHWR	Japan	1	29.8	1	45.82	1	111.88

* without Fukushima Daiichi NPP.

Figure 15. Average annual collective dose by country from 2012 to 2016 for PWRs

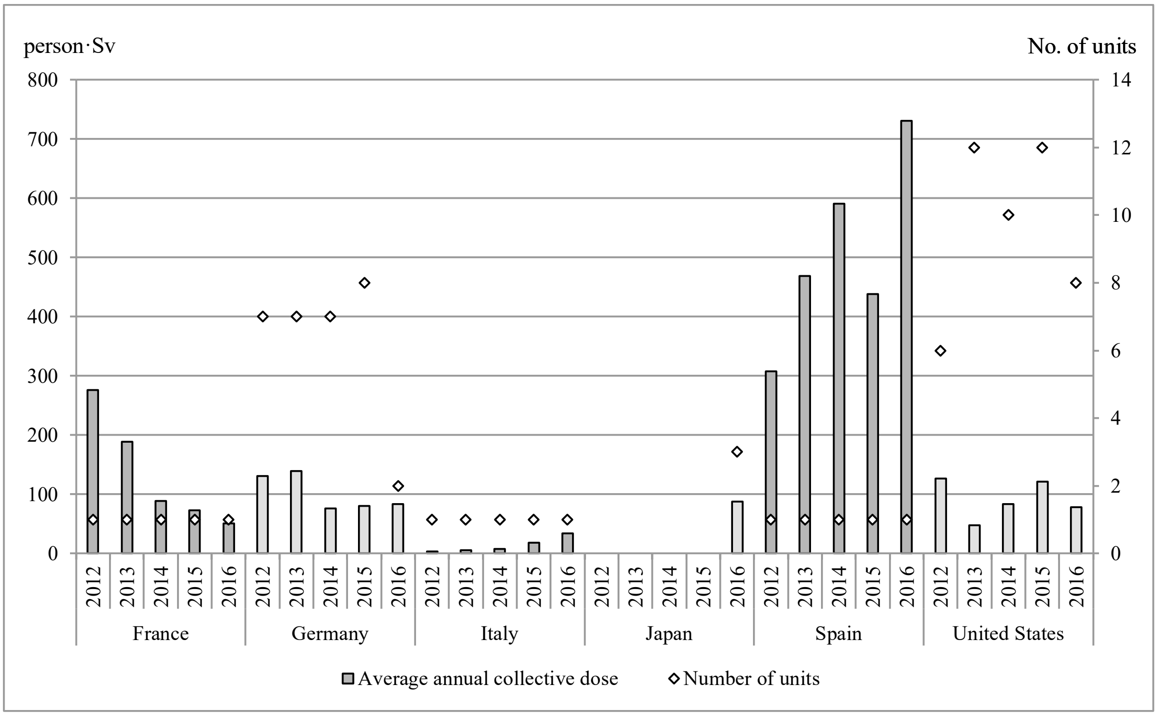


Figure 16. Average annual collective dose by country from 2012 to 2016 for VVERs

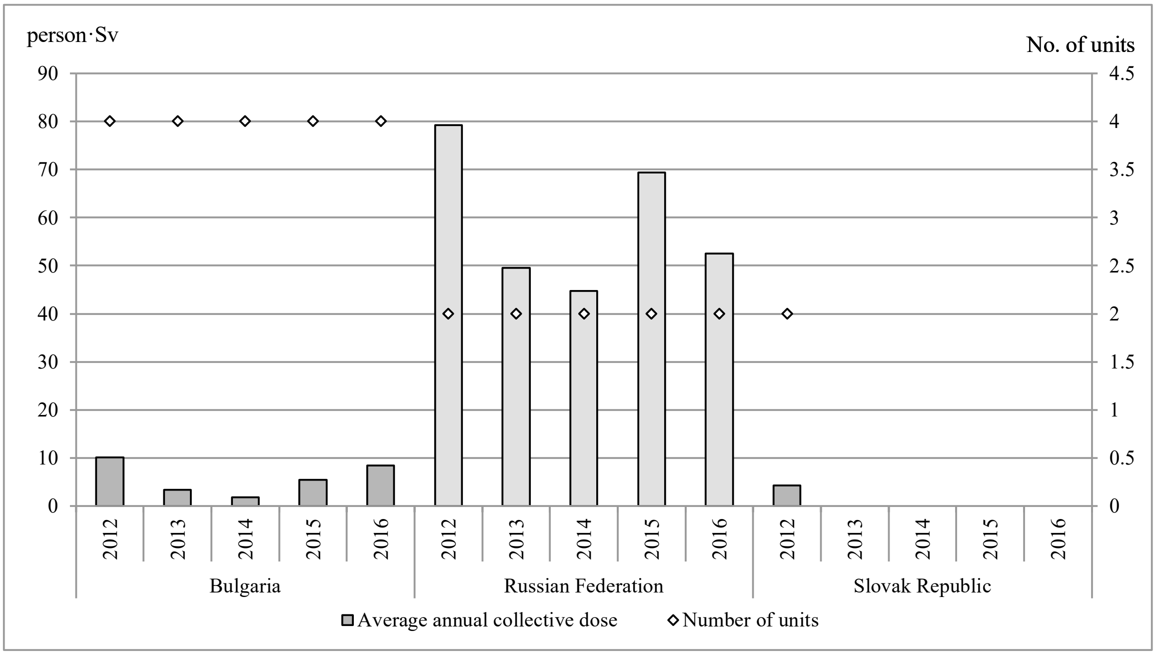


Figure 17. Average annual collective dose by country from 2012 to 2016 for BWRs

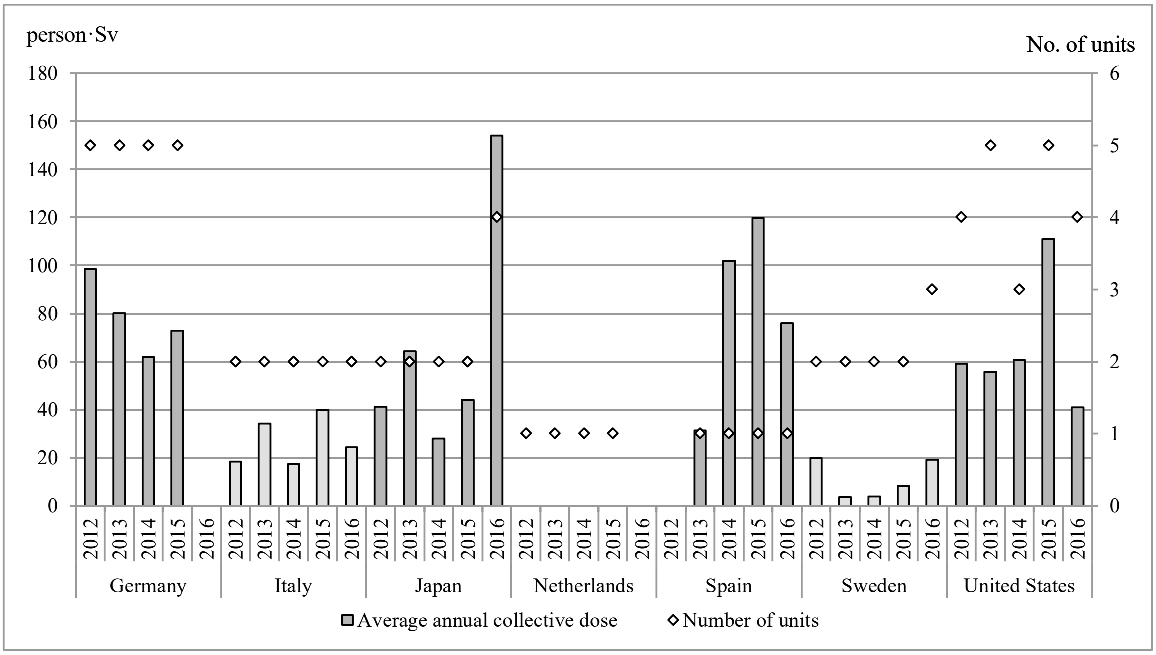
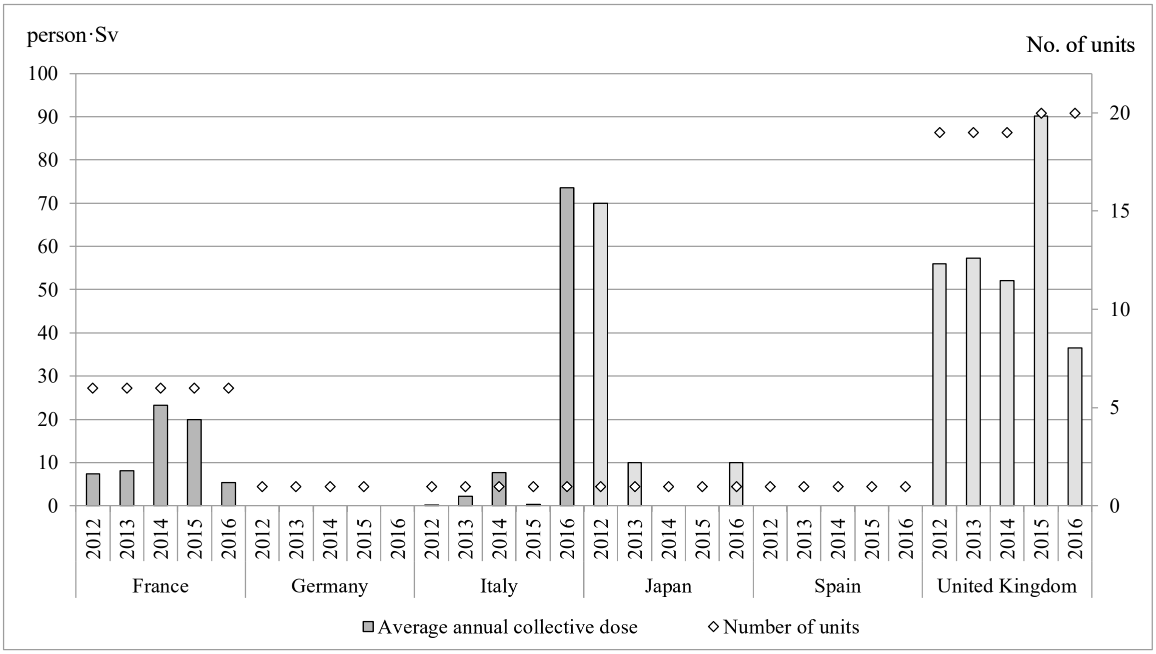


Figure 18. Average annual collective dose by country from 2012 to 2016 for GCRs



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 2016. 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 enhance this numerical data, this section provides a short list of important events which took place in ISOE participating countries during 2016 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. The national reports were published as provided by the countries with minimal editorial input from the NEA.

ARMENIA

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	1	1491 341
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	1	N/A

2) Principal events of the year 2016

Outage information

The main contributions to the collective dose in 2016 were planned outage. The dosimetric trend at the Armenian NPP was increased comparing with the 2015 due to the ANPP life extension activities.

Collective doses during the 2016 outage.

Outage number	Outage dates	Personal collective dose (person·mSv)		
		ANPP		Outside workers
		Planned	Received	Received
2016	19.09.16-25.11.16	1 469	1043 067	214 952

Maximum personal doses during the 2016 outage.

Outage number	Outage dates	Maximum personal dose (mSv)	
		ANPP	Outside workers
2016	19.09.16 – 25.11.16	25 888	13 474

The 25.888mSv dose was received by the worker who was involved in activities on the ANPP equipment life extension (replacement of telescopic mast, drives of control and protection system, and examination of upper unit, basket, protective tubing, the pit with bottom, and reactor vessel) in 2016.

– *Organisational evolutions*

With the purpose of the ALARA principle further implementation at the Armenian NPP the “Program of the Armenian NPP Radiation protection for 2016” was developed which sets the objectives and tasks for minimisation of the radiation impact and ensuring the effective radiation protection for the Armenian NPP personnel.

The tasks were the following:

- Non exceeding of annual personnel collective dose above 1,771 man·Sv;
- Non exceeding of personnel collective dose during outage above 1,521 man·Sv;
- Non exceeding annual individual dose above 20 mSv.

BELGIUM

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	7	290

2) Principal events of the year 2016

- *Events influencing dosimetric trends*

  a) As in 2014 and 2015, licensing for the conditioning of ion exchange resins had to be renewed for both the Doel and Tihange sites. As a consequence, there is no more conditioning activity for this type of waste. The same situation occurred for the concentrates at Doel.

  b) More extensive plant outages for the long term operation at Doel 1 and 2 and Tihange 1 (10 additional years).

  c) Unplanned shutdown for Tihange 1 since 7 September 2016, as a consequence of the unavailability of the Emergency Feed Water induced by an uncontrolled concrete jet grouting event.

  d) Detailed collective dosimetry (outage information):

2016	Doel 1	Doel 2	Doel 3	Doel 4	Tihange 1	Tihange 2	Tihange 3
Outage dates	23/9 – 22/10	9/4 – 19/6	14/10 – 07/12	/	30/4 – 13/08	/	11/9 – 29/10
Outage man·mSv	152.6	254.8	394.4	0.0	644.4	0.0	218.2
Total man·mSv	481.6		422.2	15.4	824.9	42.2	240.2

- *New/experimental dose-reduction programmes*
  a) Slight reduction of the dose rate at Doel 3, likely related to the zinc injection programme (follow-up in progress).
  b) Progressive implementation of the new dosimetry support software at Doel. This will be also implemented at Tihange during 2017.
- *Organisational evolutions*
  a) Replacement of the personal electronic dosimeters completed at Doel.
  b) Several new RP collaborators engaged and trained at both sites.
- *Regulatory requirements*
  a) National safety authority proposed a modification of the base regulation for the protection against ionising radiation. In particular, this proposal addresses the translation of the European concept of RPO and RPE into the Belgian regulation.

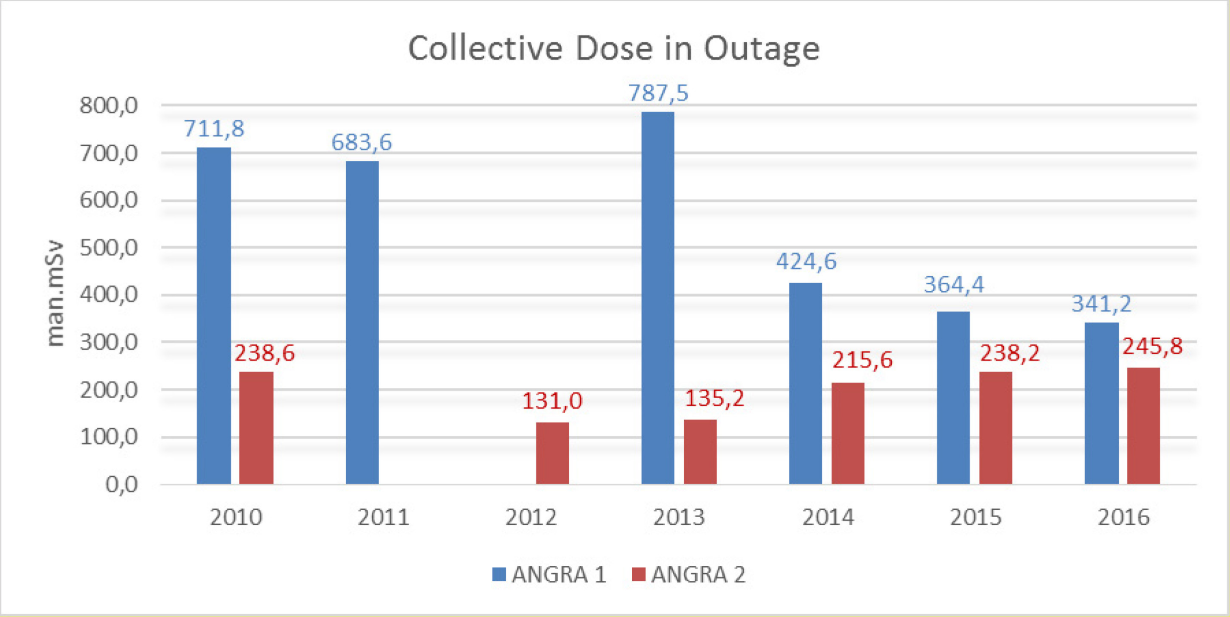
BRAZIL

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	2	631.165 (Angra 1: 367.017 Angra 2: 264.148)

2) Principal events of the year 2016

– *Events influencing dosimetric trends*



Unit	Days of outage	Outage information
Angra 1	33	Refuelling and maintenance activities
Angra 2	35	Refuelling and maintenance activities

BULGARIA

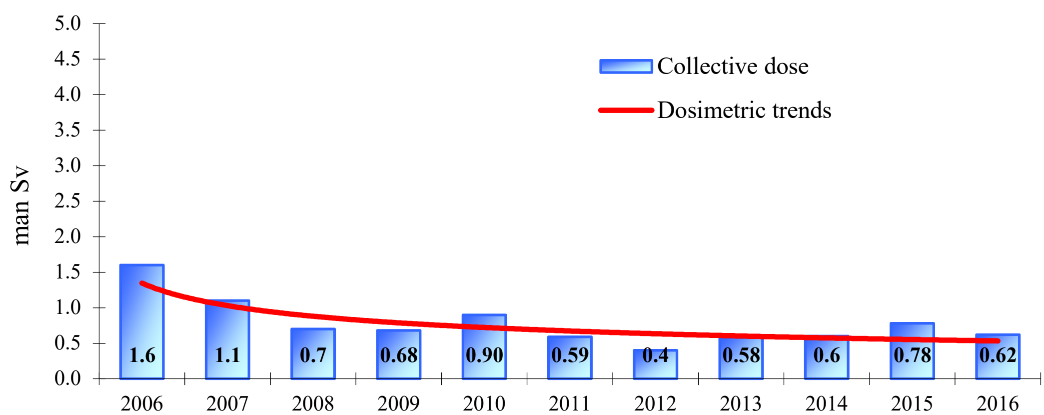
1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER-1000	2	293
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER-440	4	8.3

2) Principal events of the year 2016

– *Events influencing dosimetric trends*

Summary of dosimetric trends



Unit No.	Outage duration – days	Outage information
Unit 5	38 d	Refuelling and maintenance activities
Unit 6	41 d	Refuelling and maintenance activities

The main contributors to the collective dose in the year 2016 were the works carried out during the outages. In 2016 continued the refurbishment activities started several years ago aimed at increasing of the thermal power and life time extension of Units 5 and 6. Many of these activities involve systems and components located in the RCA and contribute to the collective dose. As examples could be given the following:

- systems and components investigation related to the life time extension project;

- modernisation of the steam generator separation system;
- replacement of the temperature measurement system of the first circuits;
- increased volume of radiography control;
- thermal insulation replacement;

Despite the same scope of the works performed in the RCA in 2015 and 2016, the collective dose in 2016 is lower than in 2015 because of the experience that have been already gained.

The outage activities resulted in more than 90% of the total collective dose in 2016. The collective doses received during the outages of unit 5 and unit 6 are almost equal.

CANADA

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
CANDU	19	900

REACTORS IN COLD SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
CANDU	3	1*

*Includes only those shutdown reactors that report occupational dose separate from operating reactor units or other licensed activities, i.e. Gentilly-2. The three shutdown reactors included Pickering 2,3 and Gentilly-2.

2) Principal events of the year 2016

Summary for national diametric trends

- 17.08 Person-Sv for 19 operating units in 2016;
- Average annual dose per unit 0.90 person-Sv in 2016.

The total collective effective doses and the average collective dose per unit at operating Canadian nuclear plants increased slightly in 2016 (approximately 8 percent) from 2015. However, the trends remain steady since 2010. The increase in Canadian annual dose reflects plant management attention to major repairs and improvements made to the national fleet of 19 operating reactors to assure safe and efficient operation. It is also noted that Darlington Unit 2 commenced the major feeder tube refurbishment activities in 2016 which had previously been accomplished at Bruce Power Units 1, 2 and Pt. Lepreau.

The average calculated dose for 2016 includes nineteen (19) units. The dose associated with activities performed at two units in safe storage (Pickering Units 2 and 3) is negligible and therefore not included in the calculated average. Therefore, the dose is not reported separately but instead included under the operational Pickering Units. Gentilly-2 transitioned from an operational site to safe storage in 2013. Gentilly-2 annual dose is reported separate from the operating units.

In 2016, approximately 74% of the collective dose was due to outage activities, and most of the radiation dose received by workers came from external exposure. Approximately 26% of the dose received was from internal exposure, with tritium being the main contributor to the internal dose of exposed workers.

The implementation of dose-reduction initiatives at Canadian nuclear power plants (NPPs) and improved work planning and control, continue to contribute to keeping worker doses as low as reasonably achievable (ALARA) at the 19 operating units. Distribution of annual effective doses to workers at Canadian NPPs showed that approximately 85% of the workers received an annual effective dose below 1 mSv.

Bruce Power A

In 2016, all four units were operational at Bruce A Nuclear Generating Station. Bruce A, Units 1-4 had 268 outage days in 2016. 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.

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 2016 internal dose was slightly lower than the 7% recorded in 2015. Internal dose ALARA initiatives in 2016 included reducing primary water heat transport leak rates and repairing vault vapour recovery dries.

Bruce A, Units 1-4 routine operations dose for 2016 was 0.325 person-Sv and the maintenance outage dose was 4 121 person-Sv. The total collective dose for Bruce A Units 1-4 was 4 446 person-Sv which resulted in an average collective dose 1 111 person-Sv/unit.

Bruce B

Bruce B, Units 5-8 were operational in 2016 with a total of 110 outage days. Outage activities accounted for approximately 91% of the total collective dose. Routine operations accounted for approximately 9 percent of the total station collective dose.

Bruce B, Units 5-8 routine operations dose was 0.468 person-Sv. The outage dose was 4 864 person-Sv in 2016. The total dose was 5.332 person-Sv which resulted in an average collective dose 1.333 person-Sv/unit.

Darlington Units 1-4

In 2016, all four units were operational at Darlington Nuclear Generating Station with a total of 10 outages over 134.9 days. Outage activities accounted for approximately 84% of the total collective dose at Darlington. This is slightly higher than 2015 and reflect the scope and type of outage work scope. Planned outage work scope included:

1. Unit 3 PHT Cut and Cap, ACU Coil Replacement, Ion Chamber Replacement, PHT Pressurizer Heater Gasket Replacement
2. Unit 4: Feeder Inspections, Shield Tank Overpressure Protection mod, Pressure tube scrape, Moderator value refurbishments
3. Unit 4: Boiler inspections ACU coil Inspection and Replacement, PHT Value Maintenance and a vacuum building inspection.

Darlington Unit 2 commenced a refurbishment outage to replace feeder tubes and other components on 15 October 2016. Hence, the actual number of operating units in 2016 was 3.78 units. In 2016, the Unit 2 outage consisted of 76 days of the scheduled 1 071 day refurbishment outage. 433 out of 480 channels were defueled in 2016.

Internal dose accounted for approximately 16% of the total collective dose, a slight decrease from the internal dose of 20% reported in 2015.

Darlington Units 1-4 had routine operations dose of 0.495 person-Sv. Routine operations accounted for approximately 16% of the total collective dose. The total outage dose was 2.600 person-Sv. The internal dose for 2016 was 0.519 person-Sv. The external dose was 2.576 person-Sv which resulted in an average collective dose 0.774 person-Sv/unit.

Pickering Nuclear

In 2016, Pickering Nuclear Generating Station had six units in operation (Units 1,4,5,6,7,8), with a total of approximately 405 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. This decrease can be attributed to the scope and type of work performed.

The routine collective dose for operational units was 0.834 person-Sv in 2016.
The outage dose for the operational units was 4.802 person-Sv. The total dose was 5.635 person-Sv which resulted in an average of collective dose 0.939 person-Sv/unit..

The dose associated with radiological activities performed at Pickering Units 2 and 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 2016, Point Lepreau was fully operational with a planned maintenance of 72 days. The station experienced an unplanned outage from 6-9 October 2016. Outage activities accounted for approximately 80% of the total collective dose at Pt. Lepreau. The major planned outage work included:

1. fueling machine bridge maintenance (including ball screw replacement);
2. boiler Eddy current inspections;
3. fuel channel wet SCRAPE;
4. repair of moderator pump rotating assembly;
5. boiler secondary side inspections.

Internal dose accounted for approximately 20% of the total collective dose. This increased dose contribution from tritium was due in part to a leaking fitting on the primary heat transport system.

The routine collective dose for operational activities was 0.199 person-Sv in 2016. Routine collective dose accounted for approximately 20% of the total collective dose at Pt. Lepreau in 2016.

The internal dose was 0.183 person-Sv. The external dose was 0.822 person-Sv. The total dose was 1.005 person-Sv.

Gentilly-2

Gentilly-2 is a single unit CANDU station. In 2016, Gentilly-2 continued transition from operation to safe storage state. The reactor was shut down in 28 December 2012.

There was a decrease in the collective doses at Gentilly-2 because the majority of radiological work activities with the transition form an operational unit to a safe storage state occurred in 2014. The 2016 station collective dose is only attributed to safe storage transition activities

The total site collective dose in 2016 was 0.208 person-Sv. The highest individual dose in 2016 was 0.0085 mSv.

Major 2016 Highlights

Safety-related issues
No safety-related issues were identified in 2016.

Decommissioning issues
Gentilly-2 continued to transition to safe storage in 2016.

New plants under construction/plants shutdown
No units under construction in 2016.

No units were shutdown in 2016.

Conclusions
The 2016 average collective dose per operating unit for the Canadian fleet was 0.90 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.

Various initiatives were implemented at Canadian units to keep doses ALARA. Initiatives included improved shielding, source term reduction activities, use of CZT 3D isotopic mapping systems and improved work planning.

3) Report from Authority

Regulatory Update:

The implementation of radiation protection programmes 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.

CHINA (PEOPLE'S REPUBLIC OF)

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	31	346.62
VVER	2	505.00
PHWR	2	504.69
All types	35	364.70

Summary of occupational dose in 2016

Reactor type	Number of reactors	Total collective dose	Average dose per reactor
PWR	31	10.745 man·Sv	0.35 man·Sv/unit
VVER	2	1.010 man·Sv	0.51 man·Sv/unit
PHWR	2	1.009 man·Sv	0.50 man·Sv/unit

The total collective dose for the Chinese nuclear fleet (31 PWR units, 2 VVER units and 2 PHWR units) in 2016 was 12.764 man·Sv. The resulting average collective dose was 0.36 man·Sv/unit. No individuals received a dose higher than 10 mSv in 2016 (within the annual dose constraint of 15 mSv for nuclear power plants in China).

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 2015, and stayed at a low level.

2) Principal events of the year 2016

– *Events influencing dosimetric trends*

In 2016, 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.

Seven new PWR units (HONGYANHE-4, NINGDE-4, FUQING-3, YANGJIANG-3, CHANGJIANG-2, FANGCHENGGANG-1 and FANGCHENGGANG-2) began commercial operation in 2016. For the 35 reactors, refuelling outages were performed for 19 of 32 PWR units, 1 of 2 PHWR units, and 2 of 2 VVER units in 2016.

In 2016, the IAEA Integrated Regulatory Review Service (IRRS) was conducted of China's governmental and regulatory framework for nuclear and radiation safety.

– *Regulatory requirements*

  - In 2016, the Safety Regulations on the Design of Nuclear Power Plant (HAF102) was revised and proclaimed.
  - In 2016, the Thirteenth Five-year Plan and 2025 Perspective Plan on Nuclear Safety and Prevention and Control of Radioactive Pollution was submitted to the State Council of the People's Republic of China for approval.
  - In 2016, China's top legislature finished soliciting public opinions on the draft revision to the Nuclear Safety Act of the People's Republic of China.

CZECH REPUBLIC

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	6	146
All types	6	146

2) Principal events of the year 2016

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	122 days, prolonged maintenance outage with refuelling and weld radiography	137
Temelin, Unit 2	135 days, prolonged maintenance outage with refuelling and weld radiography	117
Dukovany, Unit 2	182 days, prolonged maintenance outage with refuelling, weld radiography and LTO (long-term operation) process	182
Dukovany, Unit 3	157 days, prolonged maintenance outage with refuelling and weld radiography	115
Dukovany, Unit 4	100 days, prolonged maintenance outage with refuelling and weld radiography	139

CED remained stable in comparison with the previous year, but increased in comparison with previous years mainly due to the excessive weld radiography (all units). CED was also affected by Secondary pipe welding during the outage of Unit 2 at Dukovany NPP.

Low values of outage and total effective doses represent results of 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 2016, the Radiation Work Permit Working Group (WG) finished their activities. Revised RWP system was implemented.

The Activity of Personal Contamination Event (PCE) reduction Working Group, which aims for overall improvement of personnel perception of PCEs and ultimate reduction of the number of PCEs, continued in 2016.

- *Regulatory requirements*

  The Post-Fukushima National Action Plan was implemented at Temelin NPP and Dukovany NPP.

  The LTO process was under way at Dukovany 2. Regulatory requirements were implemented progressively.

FINLAND

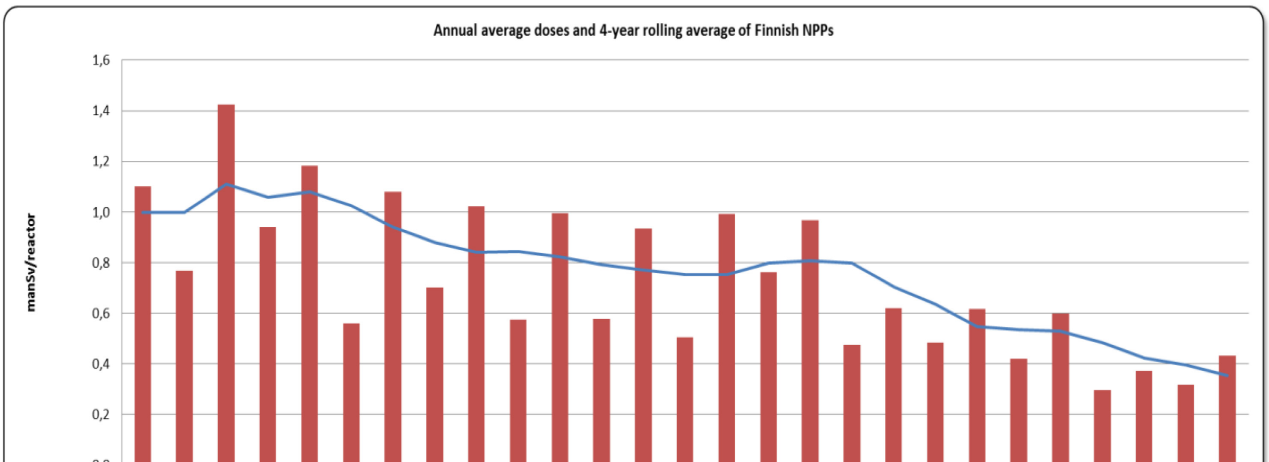
1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	2	421
BWR	2	442
All types	4	432

2) Principal events of the year 2016

Summary of national dosimetric trends

The annual collective dose strongly depends on the length and type of annual outages. The 2016 collective dose (1.726 man·Sv) of Finnish NPPs resulted in continuing the decreasing trend in the 4-year-rolling average of collective doses. The decrease has continued since the early 90s.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Annual average	1,10	0,77	1,42	0,94	1,18	0,56	1,08	0,70	1,02	0,57	1,00	0,58	0,93	0,50	0,99	0,76	0,97	0,47	0,62	0,49	0,62	0,42	0,60	0,297	0,372	0,317	0,432
4 year rolling average	1,00	1,00	1,11	1,06	1,08	1,03	0,94	0,88	0,84	0,84	0,82	0,79	0,77	0,75	0,75	0,80	0,81	0,80	0,71	0,64	0,55	0,53	0,53	0,483	0,422	0,397	0,355

Olkiluoto

At the OL1 unit a fuel leak was detected in February 2016 when an increase in the activity level of the off-gas system monitor was detected. The fuel leak developed quickly into an open failure, and the monitoring point indicated the presence of e.g. Np-239, Sr-92, Cs-134 and Cs-137 isotopes in the reactor water.

In the beginning of April 2016, a decision was made to shut down the plant for an extra refuelling outage in order to remove the leaking fuel elements. Three leaking fuel assemblies were located and removed from the core. These assemblies had been in the reactor for three years and were of the same type and of the same delivery batch. The collective radiation dose was approximately 0.025 man·Sv.

Nine days after the full power level was achieved, an increase in the activity levels of the off-gas system was detected at OL1, and a sample of the reactor water was collected, which confirmed a new fuel leak. During annual outage in May, again three leaking fuel assemblies were located and removed from the core. These assemblies had been in the reactor for three years. These assemblies were of a different delivery batch from the assemblies previously removed from the reactor in April 2016. All six cases were pellet–cladding interaction (PCI) fuel failures.

During the 21 days of the OL1 maintenance outage, the main work was the replacement of one main circulation pump and the renewal of the related frequency converter, the modernisation of the neutron flux calibration system, the replacement of low-voltage switchgear, and the modernisation of heating system affecting the residual heat removal in one subsystem. A tightness test of the containment building was also carried out. The collective radiation dose was 0.558 man·Sv.

The total effect of fuel failures on radiation doses is difficult to estimate, but it is in range of 0.070-0.100 man·Sv. The amount of uranium dissolved into reactor water was about 20–25 g.

At Olkiluoto 1, noble gases as well as some iodine (I-131) were released into certain rooms of the turbine building after the annual outage. It was the result of a leak in a flange downstream of a valve. The leak was located in the off-gas radiation monitoring system and was repaired successfully. The releases caused by the leak in the flange connection were significant as a result of the fuel leaks that occurred during previous operating period. Without the fuel leaks, the leak in the flange connection would not necessarily have been detected. The event had an impact on the radiation safety of the plant and the environment. However, the releases remained with a good margin below the release limits specified in the Technical Specifications. Thus the calculated radiation dose of a person representing the most exposed population group is estimated to be below the specified limit value. The radiation doses of the employees also remained below the limit values.

The annual maintenance of OL2 included the replacement of fuel and annually repeated maintenance work. The collective radiation dose was 0.172 man·mSv.

Loviisa

At Unit 1 a long inspection outage was performed. The duration of the outage was about 38 days. Collective dose of the outage was 0.492 man·Sv which was mainly caused by primary side inspections, internal inspections of steam generators, maintenance works and related auxiliary tasks (insulation, scaffolding, RP and cleaning).

At Unit 2 the outage was a normal, short maintenance outage with a collective dose accumulation of 0.295 man·Sv and duration of about 20 days.

The collective dose of LO1 outage was the lowest compared to similar outage types and among the lowest outage doses on Unit 2.

Source term reduction: During the outages in 2012-2014 an antimony reduction project took place at both plant units. During the project, antimony-bearing gaskets of primary coolant pumps were replaced by antimony free ones. The gasket 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

In order to meet the updated IAEA regulations and new European Directives, a process to update the Nuclear Energy Act, the Radiation Act, and the new regulatory guides (YVL Guides) was started in 2016.

A periodic safety review was carried out for Loviisa NPP during 2016. The operating licence renewal, including a periodic safety review, was started for Olkiluoto NPP.

Finland has one NPP unit under construction (Olkiluoto 3). The unit entered into the commissioning phase, and the licensee submitted the operating licence application in April 2016.

One new NPP unit is in the construction licence phase (Fennovoima Hanhikivi unit 1, AES-2006) and STUK is currently reviewing first parts of the CLA documentation.

On 12 November 2015, the Finnish Government granted a construction license for Olkiluoto spent nuclear fuel encapsulation plant and disposal facility. During 2016 both Posiva (operator) and STUK were preparing for the upcoming construction work.

One research reactor has entered into the decommissioning phase.

FRANCE

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	58	760
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	1	51
GCR	6	3
GCHWR	1	5
SFR	1	3

2) Principal events of the year 2016

Summary of national dosimetric trends

In 2016, the average collective dose of the French nuclear fleet (58 PWR) was 0.76 man·Sv/unit (as compared to the 2016 annual EDF objective of 0.80 man·Sv/unit). The average collective dose for the 3-loop reactors (900 MWe – 34 reactors) was 0.96 man·Sv/unit and the average collective dose for the 4-loop reactors (1 300 MWe and 1 450 MWe – 24 reactors) was 0.48 man·Sv/unit.

Type and number of outages

Type	Number
ASR – short outage	22
VP – standard outage	22
VD – ten-year outage	5
No outage	9
Forced outage	1

Specific activities

Type	Number
Partial activities prior SGR + tube sleeving and plugging of old SG	1 (Gravelines 5)
RVHR	0

The outage collective dose represented 84% of the total collective dose. The collective dose received when the reactor is in operation represented 16% of the total collective dose. The collective dose due to neutron was 0.224 man·Sv; 77% of which (0.172 man·Sv) was due to spent fuel transport.

Individual doses

In 2016, no worker received an individual dose higher than 16 mSv in 12 rolling months on the EDF fleet. 78% 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 2016 events with a dosimetric impact were the following:

- Paluel 2 steam generator replacement (SGR)

  Fall of a used SG (March 2016), no immediate radiological impact but extension of outage until November 2017.

- Gravelines 5 SGR

  Following the delay in obtaining the conformity declaration for the new SG, it has been decided to cancel the SGR and to perform activities allowing continuing operation with the current SGs.

  Every SGR activity planned prior to the cutting of primary piping was performed: removal of insulation, installation of biological shielding, cutting of auxiliary piping, removal of electrical and mechanical interferings, removal of floors, specific works and installation of cutting tools.

  Due to the change in strategy, the old SGs had to be returned to conformity with tube sleeving and plugging for some of them, closing of tubes, welding and non-destructive testing of auxiliary piping, reinstallation of floors, interferings and insulations.

- Seismic resistance of biological shielding following a generic safety event on the fleet

  Biological shielding for which the seismic resistance was not proved have been removed. These removals impact the radiological conditions of areas in the nuclear auxiliary building and also for field and radiological protection inspections. The last removals were performed in 2016.

- Radiography inspection with selenium

  All French NPPs are now using Selenium 75 for radiographic inspections. With this technology, radiographic inspections can be carried out at the same time as other activities in the turbine building, thereby saving time for the outage schedule and bringing radiological protection benefits. In 2016, between 15 and 20% of radiographic inspections were performed using Selenium 75 on EDF NPPs.

3-loop reactors – 900 MWe

In 2016, Cruas 1 had 2 forced outages, one for 27 days and an occupational exposure of 0.59 man·mSv and the other for 8 days and an occupational exposure of 2.16 man·mSv. Fessenheim 1 had a forced outage for 20 days and an occupational exposure of 32 man.mSv and Tricastin 4 had a forced outage for 5 days and an occupational exposure of 2.7 man.mSv.

The 3-loop reactors outage programme was composed of 14 short outages, 16 standard outages and 3 ten-year outages. The steam generator replacement planned for Gravelines 5 was modified by SG tube sleeving and plugging.

One outage of the 2015 programme will continue until end of June 2017: Bugey 5.

Two outages of 2016 were not finished at the end of the year:

- Bugey 4: end of standard outage plan in January 2017
- Tricastin 4: end of standard outage plan in January 2017
- Fessenheim 2: end of standard outage plan in July 2017
- Gravelines 5: end of ten-year outage plan in June 2017

The lowest collective doses for the various outage types were:

- Short outage: 0.145 man·Sv at Dampierre 1
- Standard outage: 0.494 man·Sv at Gravelines 6
- Ten-year outage: 1.617 man·Sv at Chinon B2

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

In 2016, 7 units had no outage. The 4-loop reactors outage programme was composed of 8 short outages, 6 standard outages and 2 ten-year outages.

One outage was not finished at the end of 2016: the 3rd ten-year outage with SGR of Paluel 2 (fall of the SG in 2016) began in 2015 and the end of the outage is planned at the end of 2017.

The lowest collective doses for the various outages types were:

- Short outage: 0.157 man·Sv at Golfech 1
- Standard outage: 0.512 man·Sv at Cattenom 4
- Ten-year outage: 1.197 man·Sv at Cattenom 1

Main radiation protection significant events (ESR)

In 2016, 5 events have been classified at level 1 on the INES scale. They all concern skin or extremity dose.

- Paluel NPP

  One event on unit 4 in March 2016: Contamination on the cheek. The skin dose was estimated to be higher than one quarter of the annual limit.

- Chinon B NPP

  Two events on unit 2 with skin dose higher than one quarter of the annual limit.

  - April 2016: Contamination on the ear by Co-60 of activity estimated at 40 kBq during the maintenance of the loading machine.
  - September 2016: Contamination on the neck by Co-60 of activity estimated at 68.8 kBq during the surveillance of the security exit of the reactor building.

- Gravelines NPP

  - One event on unit 5 in May 2016: skin/extremity dose higher than one quarter of the annual limit. Contamination on the knee of the protective clothing by Co-60 of activity estimated at 93.7 kBq during penetrant testing of the welded support of Residual Heat Removal System.
  - One event on unit 3 in September 2016: skin/extremity dose higher than one quarter of the annual limit. Contamination on the feet during supply and disposal of clothing.

2017 goals

The collective dose objective for 2017 for the French nuclear fleet is set at 0.68 man·Sv/unit.

For the individual dose, one of the objectives is to reduce the individual dose of the most exposed workers by 10% in 3 years. The objective of no worker with an individual dose > 18 mSv over 12 rolling months is maintained. The following indicators are used:

- Number of workers > 10 mSv over 12 rolling months ≤ 270
- Number of workers > 14 mSv over 12 rolling months ≤ 0

Future activities in 2017

For individual dose: the pre-alert level is fixed at 13 mSv (over 12 rolling months).

Collective dose: continuation of the activities initiated since 2012.

- Simplification of the orange area entrance process
- Source term management (oxygenation and purification during shutdown; management and removal of hotspots)
- Chemical decontamination of the most polluted circuits
- Optimisation of biological shielding (using CADOR software)
- Organisational preparation of the RMS, deployment on the fleet planned until 2018

Forty-five outages are planned for 2017 with 19 short outages, 23 standard outages and 3 ten-year outages. Four outages that have begun in 2015 and 2016 are planned to end in 2017: the standard outage started in 2015 in Bugey 5, the ten-year outage combined with a SGR started in 2015 at Paluel 2 (fall of SG), the standard outage started in 2016 in Fessenheim 2 and the ten-year outage started in 2016 in Gravelines 5.

For 2017, hydrotests on RHRS circuits are expected: Civaux 1, Chinon B1, Paluel 3, Golfech 1, Dampierre 3, Flamanville 2, Saint-Alban 1 and Penly 1.

3) Report from Authority

In 2016, ASN carried out 24 radiation protection inspections. The Paluel, Penly and Flamanville NPPs and the EPR under construction underwent a reinforced inspection in 2016.

The collective dosimetry on all the reactors was up in 2016 by comparison with 2015 with an increased volume of maintenance. The average dose received by the workers for one hour of work in a controlled area also increased in 2016 but remains lower than the value recorded in 2014.

ASN considers that the radiation protection situation of the NPPs in 2016 could be improved on a certain number of points:

- Control of radiological zoning and the associated provisions could be improved. More specifically the risk assessments for the work do not always identify the risk of entering a specially regulated "limited stay" or "prohibited" area.
- Weaknesses remain in the control of industrial radiography sites: ASN more specifically identifies several events involving overstepping of operation areas demarcation lines or the presence of workers inside the exclusion zone demarcation lines. Progress is required in the preparation of the worksites, more specifically multiple contractor activities 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 observes non-compliance with instructions for contamination checks on personnel exiting worksites.
- On several sites, the ASN inspectors found a lack of radiation protection culture on the part of certain workers.
- ASN notes that five bodily contamination situations leading to the workers integrating dosimetry greater than one quarter the regulation limit per square centimetre of skin were recorded in 2016. The above-mentioned inadequacies in radiological cleanliness can contribute to the delayed detection of worker bodily contamination.
- Despite the actions presented to ASN, improvements are still required in the optimisation of the forecast dosimetry for reactor outages and in preparation of the worksites.

HUNGARY

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	4	336 (with electronic dosimeters) 331 (with TLDs)

2) Principal events of the year 2016

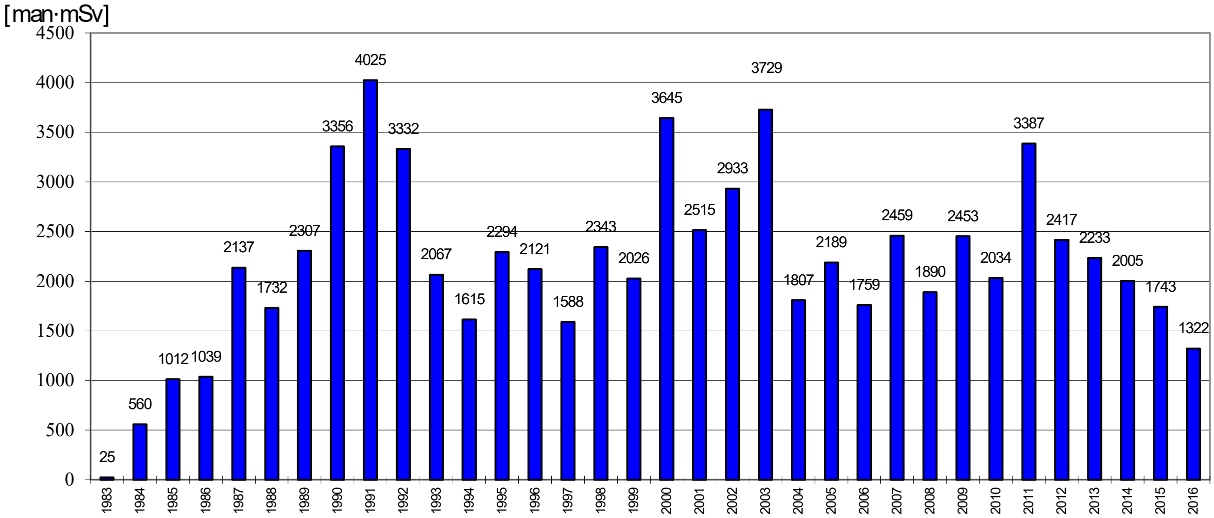
Summary of national dosimetric trends

Using the results of operational dosimetry, the collective radiation exposure was 1 345 man·mSv for 2016 at Paks NPP (949 man·mSv with dosimetry work permit and 396 man·mSv without dosimetry work permit). The highest individual radiation exposure was 9.11 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 Paks having received the permit from the Hungarian Atomic Energy Authority to switch to the 15-month refuelling cycle (campaign) from the previous 12-month cycle by the end of 2015. 15-month operation was implemented at all four power plant units, simultaneously with the refuelling schedule, until late 2016. With the introduction of the 15-month operation interval, and proportional reduction of outage work volume, the collective dose significantly decreased.

The electronic dosimetry data correspond well with TLD data in 2016.

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



From 2000, this data shall be quoted as individual dose equivalent /Hp(10)/

- *Events influencing dosimetric trends*

  There was one general overhaul (long maintenance outage) in 2016. The collective dose of the outage was 466 man·mSv on Unit 2.

- *Number and duration of outages*

  The durations of outages were 29 days on Unit 1, 68 days on Unit 2 and 26 days on Unit 4. The Unit-3 was not shut down for outage.

ITALY

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	1	34.23
BWR	2	48.70
GCR	1	73.62

2) Principal events of the year 2016

Reactor type	Number of reactors	Units reporting (contribution to annual collective dose [man·mSv])
PWR	1	1 unit – Trino NPP (34.23)
BWR	2	1 unit – Caorso NPP (4.22) 1 unit – Garigliano NPP (44.48)
GCR	1	1 unit – Latina NPP (73.62)

JAPAN

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	21	170
BWR	22	127
All types	43	148
REACTORS OUT OF OPERATION OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	3	88
BWR	10	4 686
GCR	1	10
LWCHWR	1	112

2) Principal events of the year 2016

– *Outline of national dosimetric trend*

The average annual collective dose for operating reactors decreased from 205 man·mSv /unit in the previous year (2015) to 148 man·mSv /unit in 2016. The average annual collective dose for reactors out of operation or in decommissioning excluding Fukushima Daiichi NPP was 154 man·mSv /unit, and that of Fukushima Daiichi NPP was 7 652 man·mSv /unit.

The average annual collective dose of operating reactors was almost at the same level as for 2015. 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 2016, only three PWRs operated.

From 1 April to 14 August 2016:	2 units (Sendai 1,2)
From 15 August to 5 October 2016:	3 units (Sendai 1,2, Ikata 3)
From 6 October to 10 December 2016:	2 units (Sendai 2, Ikata 3)
From 11 December to 15 December 2016:	3 units (Sendai 1,2, Ikata 3)
From 16 December 2016 to 25 February 2017:	2 units (Sendai 1, Ikata 3)
From 26 February to 31 March 2017:	3 units (Sendai 1,2, Ikata 3)

– *Exposure dose distribution of workers in Fukushima Daiichi NPP*

Exposure dose distributions at Fukushima Daiichi NPP for dose during FY 2016 are shown below.

Cumulative dose Classification (mSv)	Fiscal year 2016 (April 2016 – March 2017)		
	TEPCO	Contractor	Total
＞50	0	0	0
20 ～ 50	0	216	216
10 ～ 20	22	1139	1161
5 ～ 10	90	1393	1483
1 ～ 5	404	4370	4774
≦1	1162	7039	8201
Total	1678	14157	15835
Max. (mSv)	14.75	38.83	38.83
Ave. (mSv)	1.27	3.09	2.90

* 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. Five PWRs obtained approval in FY 2016.

3) Report from Authority

– *The Equivalent dose limits to the lens of the eye*

Japanese legislation defines that the equivalent dose of radiation workers must not exceed 150 mSv in a year for the lens of the eye.

However, in receiving the IAEA IRRS mission, the Nuclear Regulation Authority (NRA) declared in its action plan to implement the ICRP recommendation on new equivalent dose limit (50 mSv in a year and 100 mSv in 5 years) for the lens of the eye applicable to occupational exposure, which have already been also introduced in the IAEA BSS.

Since the amended Act on technical standards for prevention of radiation hazard was in force in April 2017, the Radiation Council, established within the NRA, has a function of conducting investigation and making proposals related to technical standards of radiation protection to related government ministries and agencies by its own initiative.

In July 2017, The Radiation Council has started investigation for the possible revision the equivalent dose limit for the lens of the eye recommendation, including the lens dose monitoring and protection methods based on the standard of the ICRP and the IAEA BSS, by establishing an expert group. The interim version of the report by the expert group on the revision of the equivalent dose limits to the lens of the eye will be issued by the end of 2017 and the final version will be reported to the Radiation Council by the end of March 2018.

The reduced dose limit will be incorporated into legislation after the Council's decision.

– *Measures for the prevention from Radiation Hazards due to the Exposure of the Eye lens in Radiation works*

Ministry of Health, Labour and Welfare issued the "Occupational Safety and Health Department Notification" in April 2017 to responsible organisations including TEPCO to reduce radiation dose in accordance with the ALARA principle. The NRA also guided TEPCO to take necessary measure in Fukushima Daiichi NPP site to properly implement the new dose limit for the lens of the eye in future.

Considering the remarkably high dose areas with beta and gamma rays in Fukushima Daiichi NPP site, TEPCO has a plan to conduct autonomous efforts to ensure the dose limit for the lens of the eye of 50 mSv per a year in FY 2018, based on the ICRP recommendation and the ALARA principle.

KOREA

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	21	401
PHWR	4	647
All types	25	440

2) Principal events of the year 2016

– *Outline of national dosimetric trend*

For the year 2016, 25 NPPs were in operation; 21 PWR units and 4 PHWR units. The average collective dose per unit in 2016 was 440 man·mSv. The dominant contributors of the collective dose in 2016 were the works carried out during the outages, resulting in 87% of the total collective dose. 14 386 people were engaged in radiation works and the total collective dose was 11 011.01 man·mSv.

– *Number and duration of outages*

Overhauls were performed at 16 PWRs and 4 PHWRs. The total duration for the outages was 1 339 days for PWRs and 116 days for PHWRs. Total outage duration was increased by compared to that in 2015.

– *New reactors online in 2016*

Shin Kori Unit 3 has started commercial operation on 20 December 2016.

– *New dose-reduction programmes*

An application of zinc injection to reduce source term has been applied to Hanul 1 since 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. Korean Hydro and Nuclear Power (KHNP) is planning to extend zinc injection to other reactors. Zinc injection is scheduled to be applied to 4 NPPs (Hanbit 3,4/ Hanul 5,6) from 2017 and 2 NPPs (Hanbit 5,6) from 2018.

LITHUANIA

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
LWGR	2	316.99

2) Principal events of the year 2016

– *Events influencing dosimetric trends*

In 2016, the occupational doses at the Ignalina NPP (INPP) were upheld as being low as possible, taking into account all economic, social and technological conditions: 587 man·mSv in 2012, 655 man·mSv in 2013, 638 man·mSv in 2014, 684 man·mSv in 2015 and 634 man·mSv (62% of planned dose) in 2016. The collective dose for INPP personnel was 589.2 man·mSv (63% of planned dose) and for contractor personnel was 44.8 man·mSv (45% of planned dose). External dosimetry system used – Thermoluminescence dosimeters (TLD).

A 20 mSv individual dose was not exceeded. The highest individual effective dose for INPP staff was 11.77 mSv, and for contractor personnel – 2.51 mSv. The average effective individual dose for INPP staff was 0.34 mSv, and for contractor personnel – 0.04 mSv.

The main works that contributed to the collective dose during technical service and decommissioning of Units 1 and 2 at the INPP were decommissioning of equipment, CONSTOR®RBMK-1500/M2 containers treatment, fuel handling; repairing of the hot cell; modernisation 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; isolation of the main circulation circuit.

In 2016 no component or system replacements were performed. In 2016 there were no unexpected events.

– *New/experimental dose-reduction programmes*

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

- *Organisational evolutions*

In 2016 the most important stage of decommissioning was achieved – the VATESI license for the operation of the interim spent nuclear fuel storage facility was obtained (Project B1, ISFSF) and the fuel removal from units to the storage facility has started after a long period.

To ensure the safety of the fuel that is still in Unit 2 and in the spent fuel pond, the necessary systems must function in accordance to the same requirements as it was during the INPP operation period. It is planned to remove all spent nuclear fuel (SNF) to the storage facility until the end of 2022.

Every year as the scope of dismantling works increases, ambitious plans are established and implemented. The dismantling works of the Turbine Hall of Unit 1 that started in 2011 are now accomplished. Some 38 thousand tonnes of the equipment and related constructions had been dismantled since 2010 and during the whole period of decommissioning. In 2016 the collaboration with foreign countries was continued, the seminars to discuss the most important questions on decommissioning and radioactive waste treatment and sharing experience were organised. The IAEA seminar on Safety Analysis Reports and assessment of complex dismantling projects impact on the environment was held in the INPP. In 2016 much attention was given to the meetings with foreign ambassadors and the Members of the EU Parliament. Financing decommissioning works after 2020 remains the important issue on the INPP agenda.

The INPP must ensure the storage of radioactive waste according to the Nuclear and Radiation Safety Requirements by taking maximum measures to prevent radioactive contamination. Consequently, the construction of the Fuel Storage Facilities and Radioactive Waste Repositories is being an aspect of the strategical importance of the activities performed in the INPP.

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 2016 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, calibration and testing of individual and workplace monitoring equipment, workplace monitoring during hot trials of the new spent fuel storage facility. Inspections results showed that Ignalina NPP activities were carried out in accordance with the established radiation protection requirements.

Two nuclear safety legal documents related to radiation protection were approved in 2016: BSR-1.9.3-2016 “Radiation Protection at Nuclear Facilities” (revision of BSR-1.9.3-2011) and BSR-1.9.4-2016 “Procedure of Obligatory Radiation Protection Training, Examination, Briefing of Radiation Workers and Radiation Protection Officers Involved in Activities with Sources of Ionising Radiation in Nuclear Energy Area and of Certification of Natural Persons Seeking to Obtain Right to Teach Radiation Protection”.

MEXICO

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATIONG REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
BWR	2	4 191

PAKISTAN

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	2	274.979
PHWR	1	1 478.330
All types	3	676.096

2) Principal events of the year 2016

- *Events of influencing dosimetric trends*

  - PHWR 6 Outages, 70.58 days
  - PWR (Chashma-1) 4 Outages (3 Outages, 1 RFO), 21 days
  - PWR (Chashma-2) 3 Outages (2 Outages, 1 RFO), 44.66 days

ROMANIA

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PHWR	2	434

2) Principal events in the year 2016

Summary of national dosimetric trends

Occupational exposure at Cernavoda NPP (2000-2016)			
Year	**Internal effective dose man·mSv**	**External effective dose man·mSv**	**Total effective dose man·mSv**
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)	56.0	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
2016 (2 units)	141.7	726.3	867.9

– *Events influencing dosimetric trends*

Normal operation of the plant (U1 and U2)

At the end of 2016:

- there are 268 employees with annual individual doses exceeding 1 mSv; 19 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 2016 is 6.71 mSv;
- the contribution of internal dose due to tritium intake is 16.3%.

Planned outages

A 52-day planned outage was done at Unit 1 between May 6th and June 26th 2016. Activities with major contribution to the collective dose were as follows:

- 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 damages in the feeder cabinets;
- Planned outages systematic inspections;
- Feeder thickness measurements, feeder clearance measurements, feeder-yoke measurements, elbow UT examination;
- Snubbers inspection; piping supports inspection;
- Implementation of engineering changes.

Total collective dose at the end of the planned outage was 637.48 man·mSv (520.37 man·mSv external dose and 117.14 man·mSv internal dose due to tritium intakes).

Finally this planned outage had a 73% contribution to the collective dose of 2016.

Planned outages dose history

Year	Unit	Interval	External collective dose man·mSv	Internal collective dose man·mSv	Total collective dose 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	9.09-4.10	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
2016	1	06.05-26.06	520.37	117.14	637.48

Unplanned outages

Unit 1 – 8-11 November: Unit was shut down in an orderly fashion after identifying a heavy water leak (31 man·mSv external dose).

Radiation protection-related issues

The IAEA OSART mission during November 2016 concluded that the managers of Cernavoda NPP are committed to improving the operational safety and reliability of their plant. The team found some good practices, the most notable ones being:

- The plant developed an innovative solution to leak check individual cable penetrations without the need for conducting a full-scale Reactor Building Leak Rate Test (RBLRT).

  To verify the leak tightness of the penetration, a box is fitted around the penetration and a vacuum pump is used to establish a differential pressure to simulate a RBLRT pressure test. While vacuum is maintained by a pump, leakage through the penetration is determined by measuring a self-maintaining vacuum inside the box for a period of time.

This allowed earlier installation of new cabling to improve post-accident Calandria level monitoring.

- The plant applied an accurate heavy water leak rate determination method through the use of the Tritium in Air Monitoring System (TAM).

  The Tritium in Air Monitoring (TAM) System has multiple, distributed sample points, including many inaccessible areas. Long-term monitoring of noble gases activity and concentrations have been performed to provide the most appropriate correction factor for noble gas compensation, which results in the ability to accurately correlate radiation levels to Tritiated water leak rates. This allows for a quick and accurate leak rate determination, and with the radiation monitoring system (RMS), the location of the leak can also be identified.

  The use of this system improves safety performance by providing:

  1. Rapid and accurate identification of leak location;
  2. Ability to differentiate varying tritium fields (influence on other areas of interest);
  3. Reliable estimation and prediction of leak rate evolution;
  4. Assessment of personnel exposure during corrective maintenance activities, as proven during the management of a Primary Heat Transport (PHT) heavy water leak from July to November 2016.

- The plant developed Gamma dose rate simulation software with the possibility to simulate gamma dose rate evolution over unlimited time periods. (Gamma dose rate simulation software incorporated into the On-site/Off-site on-line Gamma Monitoring System).
- The On-site/Off-site online Gamma Monitoring System contains fifteen on-site and off-site gamma monitoring stations that provide accurate, real-time data to the main control rooms and emergency response centres computers. Data are transmitted to these facilities through radio system or by Satellite system as back-up.

This online monitoring system has a software capability to simulate gamma radiation fields at all gamma stations. The simulation software has the possibility to simulate gamma dose rate evolution over unlimited time periods. The operators and emergency response personnel use these inputs to quickly determine emergency classifications (Emergency Action Levels), to assist in dose assessment and to develop protective action recommendations. Consequently, this software is a very good tool that can be used during emergency exercises to make the scenarios more realistic.

By using this software during emergency exercises, improvements were noted in the timely recognition and classification of radiological events (achieving the performance criteria of 15 minutes for classification). This also contributes to a significant reduction of field monitoring teams' exposure, and to improving accuracy and timeliness of dosimetry data transmission to emergency response personnel. This software also helps the On-site Emergency Response Organisation to inform and make recommendations to the Public Authorities in a timely and user-friendly manner.

Issues of concern in 2016

The main concerns for 2016 were important works, with high radiological impact, performed during the Planned Outage of Unit 1.

Issues of concern in 2017

The main concerns for 2017 are activities with high radiological impact, to be performed during the Planned Outage of Unit 2:

- ECT inspection of Steam Generators;
- Fuelling machine bridge components preventive maintenance;
- Feeder – yoke clearance measurements and correction;
- Inspection for tubing and supports damages in the feeder cabinets;
- Planned outages systematic inspections;
- Feeder thickness measurements, feeder clearance measurements, feeder – yoke measurements, elbow UT examination;
- Snubbers inspection; piping supports inspection;
- Implementation of engineering changes;
- Reactor Building Leak Rate Test.

RUSSIAN FEDERATION

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	18	515.0
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	2	52.5

2) Principal events of the year 2016

Summary of national dosimetric trends

In 2016, the total effective annual collective dose of utilities' employees and contractors at eighteen operating VVER type reactors was 9 269.8 man·mSv. This value represents a 802.7 man·mSv (8.0%) decrease from the year 2015 total collective dose of 10 072.5 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 2016, the results were as follows:

- 645.9 man·mSv/unit with respect to the group of six operating VVER-440 reactors (Kola 1-4, Novovoronezh 3-4);
- 449.2 man·mSv/unit with respect to the group of twelve operating VVER-1000 reactors (Balakovo 1-4, Kalinin 1-4, Rostov 1-3, Novovoronezh 5).

These results demonstrate that average annual collective dose of VVER-440 reactors was higher at 43.8% in comparison with VVER-1000 reactors.

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 52.5 man·mSv/unit.

Individual doses

In 2016, 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 and VVER-1000 reactor.

The maximum recorded individual dose was 17.5 mSv. This dose was gradually received over the full year by a worker of Kalinin NPP maintenance department during the repair of reactor component equipment at Units 1-4.

The maximum annual effective individual doses at other nuclear plants with VVER type reactors in 2016 were:

- Balakovo – 14.6 mSv;
- Kola – 14.7 mSv;
- Novovoronezh – 15.9 mSv;
- Rostov – 7.8 mSv.

- *Events influencing dosimetric trends*

In 2016, the main contribution to decrease the total effective annual collective dose of all Russian VVER reactors was determined by a collective dose decrease at VVER-440 units. The maximum decrease was registered at Novovoronezh 4: from 1 677.1 man·mSv/unit for the year 2015 with the major repair outage of 70 days duration to 933.4 man·mSv/unit for the year 2016 with a standard repair outage of 33 days' duration.

The average annual collective dose for the group of twelve VVER-1000 reactors remained similar to the previous years.

The average annual collective dose for two reactors at the stage of decommissioning decreased by 24.2% in 2016. The main reason is the decrease of radiation-dangerous works. This corresponds to a decrease of total RWP man·hour values from 177 650 in 2015 to 146 805 in 2016.

– *Outage information*

Planned outages duration and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Balakovo 1	No outage	--
Balakovo 2	No outage	--
Balakovo 3	61	1 004.9
Balakovo 4	31	289.0
Kalinin 1	54	855.4
Kalinin 2	89	912.4
Kalinin 3	111	443.8
Kalinin 4	41	136.6
Kola 1	73	900.2
Kola 2	73	423.5
Kola 3	48	535.9
Kola 4	52	283.7
Novovoronezh 3	29	469.0
Novovoronezh 4	33	699.8
Novovoronezh 5	39	569.2
Rostov 1	No outage	--
Rostov 2	30	125.1
Rostov 3	81	183.2

The total planned outages collective dose of utilities' employees and contractors represents 84.5% of the total collective dose.

Forced outages duration and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Kalinin 1	28	230.0
Rostov 2	6	7.0
Rostov 3	5	3.0

The total forced outages collective dose of utilities' employees and contractors represents 2.6% of the total collective dose.

– *New/experimental dose-reduction programmes*
  - A new programme based on ALARA principles and aimed at the decrease of individual and collective doses of outside workers in the period of outage was developed by Concern Rosenergoatom.
  - An experimental programme of whole body monitors intercalibration on the basis of anthropomorphic phantoms was performed at Concern Rosenergoatom NPPs.
  - Results of 2015 collective dose budget for all Russian nuclear power plants and projects for 2016 were approved.

- *Organisational evaluations*

In 2016, the special independent engineering centre of decommissioning was created on the basis of Novovoronezh Units 1 and 2.

SLOVAK REPUBLIC

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	4	145.997
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	2	Not included in ISOE
GCR	1	Not included in ISOE

2) Principal events of the year 2016

- *Events influencing dosimetric trends*
  - Bohunice NPP (2 units): The total annual effective dose in Bohunice NPP in 2016, calculated from legal film dosimeters, was 391.840 man·mSv (employees – 133.504 man·mSv, outside workers – 258.336 man·mSv). The maximum individual dose was 4.524 mSv (contractor) without internal contamination and without anomalies in radiation conditions.
  - Mochovce NPP (2 units): The total annual effective dose in Mochovce NPP in 2016, evaluated from legal film dosimeters and E_{50}, was 192.146 man·mSv (employees – 93.608 man·mSv, outside workers – 98.538 man·mSv). The maximum individual dose was 2.584 mSv (contractor worker).
- *Outage information*

  Bohunice NPP:
  - Unit 3 – 43.59 days' standard maintenance outage. The collective exposure was 98.482 man·mSv from electronic operational dosimetry.
  - Unit 4 – 58.89 days' major maintenance outage. The collective exposure was 321.559 man·mSv from electronic operational dosimetry.

  Note: due to works on common systems, both units were shut down simultaneously

  Mochovce NPP:
  - Unit 1 – 24.2 days' standard maintenance outage. The collective exposure was 93.956 man·mSv from electronic operational dosimetry.
  - Unit 2 – 21.5 days' major maintenance outage. The collective exposure was 72.834 man·mSv from electronic operational dosimetry.

- *Component or system replacements*
  - Mochovce NPP – The modification of the Teledosimetric system was finished (replacement of 40 dose rate probes, replacement of 8 aerosol and iodine continuous monitors, new seismic resistant wireless data collection network was built for on-site TDS stations). A new seismic resistant meteorological station was built on-site.
- *New reactors on line*
  - Mochovce NPP, Unit 3 and 4 still under construction.
- *New/experimental dose-reduction programmes*
  - Bohunice NPP: Changes from 1 February 2016:
    - Change in the measurement of internal contamination – Annual checks or entry or exit measurements performed by FASTSCAN have been replaced by monitoring each person at enter/exit point to/from change rooms by gamma portal monitors;
    - Change in the monitoring of the equivalent dose for the lens of the eye – the reference level set on 20 mSv/y and the new procedure for dose assessment agreed with the regulatory body and implemented.

3) Report from Authority

In 2016 the Slovak Radiation Regulatory Authority made inspections at both nuclear power plant facilities in operation concerning the optimisation of radiation protection. The conclusions from the inspections are that the authority calls for further short- and long-term concrete and proactive goals for the optimisation of radiation protection.

The Slovak Radiation Regulatory Authority continued to review the potential to change the regulations for radiation protection according to Council Directive 2013/59/EURATOM. The major change in this revision includes: (1) to lower the individual effective dose limit from the current value of 50 mSv/year to a value more in alignment with the individual dose limits as published in Council Directive 2013/59/EURATOM; (2) to lower the current lens dose equivalent limit to a value more in alignment with the lens dose limit as published in Council Directive 2013/59/EURATOM.

During 2016, the Slovak Radiation Regulatory Authority staff have been continuing to engage all licensee categories, industry groups, radiation protection professional organisations and public interest groups for input related to the potential changes to the radiation protection regulations.

SLOVENIA

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	1	518

2) Principal events of the year 2016

- *Events influencing dosimetric trends*
  - Refuelling outage duration of 36 days (1 October 2016-5 November 2016). Outage collective dose was 475 man·mSv.
  - The collective dose was lower than before due to positive effects of the completed long-term dose-reduction programme. The main improvements during the last years were as follows:

    2009: Installation of additional ion exchanger for the Spent Fuel Pit / refuelling water purification.

    2010: Introduction of pneumatic cleaning device for reactor cavity sump; accreditation of a new passive dosimetry method instead of TLD, and in 2011, accreditation of electronic dosimetry method.

    2012: Installation of permanent radiation shield with reactor head replacement, integrated missile shield and removable neutron shields below reactor cavity.

    2013: Installation of stairs to the reactor cavity; removal of RTD bypass measurement lines; eight vital locations equipped with autonomous battery supplied wide range dose rate detectors in the auxiliary building, temporary roll doors for containment equipment hatch, robust teledosimetry sets suitable for local control of workers at exposed locations.

    2014: Tailored computer software for radiation surveys with modernised data presentation and access for different users, use of handy gamma camera with CZT detector, hot spot detector, CZT in situ detector, formal implementation of a new revision of alpha monitoring and control guidelines, installation of hand and foot detectors inside the RCA and a fast walk-through detection of personal contamination, replacement of personal electronic dosimeters with a more reliable model.

    2015: Reactor vessel up-flow conversion modification (to prevent fuel failures which occurred before outage in 2013), temporary dose rate monitoring detectors in the reactor building and in the penetration room (17 locations connected with short radio link during outages).

2016: Construction of Waste Manipulation Building to improve working conditions for the staff and water management.

3) Report from Authority

The main activity of the regulatory authorities in 2016 was the transposition of the new European BSS directive. A draft of the Ionising Radiation Protection and Nuclear Safety Act was prepared as a main part of this process. The Act was in public discussion at the end of 2016 and was submitted to Parliament. Secondary legislation was drafted in parallel.

SOUTH AFRICA

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	2	240.94

2) Principal events of the year 2016

- *Events influencing dosimetric trends*
  - One refuelling outage was conducted on Unit 1 during the course of 2016. The dose for this outage was 366.664 man·mSv. Both units operated reliably with no intervention.
  - Zinc injection has been established on both units in the cycle preceding the outages in 2015. A reduction in the hot, cold and cross over leg piping has been noted from the previously monitored points.

SPAIN

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	6	317.02
BWR	1	200
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	1	730.70
BWR	1	75.94
GCR	1	0

2) Principal events of the year 2016

PWRs

ALMARAZ NPP

- *Number and duration of outages*
  - 24th outage of ALMARAZ Unit 1:
    Duration: 47 days.
    Beginning: 3 January 2016.
    Ending: 19 February 2016.
    Collective dose: 407.121 man·mSv.
    Maximum individual dose: 3.264 mSv.
  - 23th outage of ALMARAZ Unit 2:
    Duration: 39 days.
    Beginning: 7 November 2016.
    Ending: 15 December 2016.
    Collective dose: 385.849 man·mSv.
    Maximum individual dose: 2.994 mSv.

- *Component or system replacement:*
  - Installation of H_2 autocatalytic recombiners in Unit 1 and Unit 2.

- *New/experimental dose-reduction programmes*
  - Limitation of maximum exposed workers for contractor enterprises during refuelling 23rd of Unit 2.

ASCÓ NPP

- *Number and duration of outages*
  - 23th refuelling outage of Ascó 2

    Duration: 38 days

    Collective dose: 499.39 man·mSv.

    Maximum individual dose: 3.738 mSv.

    Relevant activities from RP point of view performed during refuelling outage:
    - Reactor cavity injection design modification
    - H2 Passive Autocatalytic Recombiners installation;
    - Fire detection system substitution in reactor containment and mechanical penetrations buildings;
    - Walk-down for inspection in reactor coolant nozzle-safe end region

  - Unit 1 shutdown for reactor coolant pump (RCP-A) seal inspection:

    Duration: from 07/02/2016 to 15/02/2016)

    Collective dose: 9.102 man·mSv.

  - Reactor containment Cooling unit engine substitution (80B01D) of Ascó 1, during normal operation:

    Duration: from 02/05/2016 to 05/05/2017

    Collective dose: 24.004 man·mSv.

TRILLO NPP

- *Number and duration of outages*

  Duration: 28 days
  Collective dose 253.07 man·mSv
  Maximum individual dose 2.52 mSv

VANDELLÓS 2 NPP

- *Number and duration of outages*

  One outage with 51 days of duration and a collective dose of 871.5 man·mSv.

<u>BWR</u>

SANTA MARIA DE GAROÑA NPP

- *Events influencing dosimetric trends*

Date	Event	Collective Dose (man·mSv)
2 January to 30 December	Reconditioning of drums containing waste built-in MICROCEL	53.247

COFRENTES NPP

- *Events influencing dosimetric trends*
  - Spare reactor water clean-up back-up pump was revised;
  - Maintenance works were performed in nuclear steam sensitive areas taking advantage of power downs for restructuring of control rods;
  - Installation of hydrogen recombiners in the reactor building;

- Maintenance works were performed in nuclear security systems on line;
- Works has been done in spent fuel pools and inspection of fuel elements.

– *Number and duration of outages*
  - There were not forced outages;
  - There was not fuel outage.

– *New/experimental dose-reduction programmes*
  - Temporary shieldings and permanent shieldings;
  - Hydrogen and noble metals injection

– *Organisational evolutions*
  RP manager changed in January, 2016. Nowadays Mrs María Amparo García Martínez is the new one.

3) Report from Authority

Throughout the year 2016 the CSN drafted a revision of the regulation on Health Protection against ionizing radiation, and participated in the Inter-Ministerial Working Group for the transposition of Directive 2013/59/Euratom.

A revision of the Safety Guide 07.06 "*Content of the radiological protection manual for nuclear facilities and radioactive nuclear fuel cycle facilities*" was issued. This review establishes specific criteria and guidelines for elaboration and update the content of each of the chapters of this manual on radiation protection required by regulation.

Regarding the implementation of the post-Fukushima requirements, the CSN appreciated the requests for the commissioning of the Alternative Centre of Emergency Management in all operating NPPs. This building provides an alternate centre for the direction and management of the emergency in case of forced evacuation of normal centres or in case of extensive damage. The CSN also appreciated the requests for the commissioning of the filtering system of the containment for Ascó, Almaraz and Vandellós II NPP.

In 2016 the CSN continued with the assessment process of the documentation submitted to request the construction permit for a centralised interim storage facility (CTS). This facility will provide temporary storage for all spent fuel and high-level waste from Spanish nuclear power plants.

SWEDEN

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	3	391
BWR	7	476
All types	10	442
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
BWR	2	6

2) Principal events of the year 2016

The total annual collective dose in Swedish NPPs in 2016 was 4.44 man·Sv, the average individual dose was 1.26 mSv and the maximum individual dose was 16.4 mSv.

- *Events influencing dosimetric trends*

Barsebäck Unit 1 and 2: Both reactors are being decommissioned since, respectively, 1999 and 2005.

The major event influencing the dose has been project HINT (Handling of reactor INTernals); the dose outcome was approximately 6 man·mSv.

Forsmark Unit 1, 2 and 3: As part of ALARA optimisation and dose control, there has been a focus on increased use of teledosimetry in high radiation situations.

Furthermore concerning contamination control and fuel pool cleaning, the continued use of robotic pool cleaning equipment is implemented in order to decrease dose and minimise time on a critical timeline.

Oskarshamn Unit 1, 2 and 3: Oskarshamn 2, the decision to not restart the reactor after the extensive restoration carried out in the years 2013 to 2016, and the less extensive efforts undertaken during 2016 resulted in a significantly lower collective dose than planned.

Work has been done during 2016 to increase the quality of the dose budget work for the facilities by "rolling out" individual dose budgets to departments and units. The purpose of the work is to gain a greater understanding of the need for high quality in the plans made in the line organisations and in the documentation delivered to the radiation protection organisation, in advance of the preparation of the dose budgets. The aim is also to raise awareness of the lines radiation protection responsibilities when planning.

Data collection and analysis have been carried out regarding planned investments at the O_3 reactor, such as an independent core cooling system.

Decisions on the final shutdown of two of the three reactors in the OKG area have resulted in a restructuring programme, with staff reductions, to start in the summer of 2017.

Ringhals Unit 1, 2, 3 and 4: the owner of Ringhals NPP, Vattenfall, took the decision to finally shut down reactor Ringhals 1 and 2, respectively in 2020 and 2019. This decision will provoke a significant reduction of the collective dose in the coming years because of fewer jobs/projects generating high doses; especially regarding life time extension, further modernisation and the big project era regarding reactor safety have been implemented.

Ringhals 1 has a very satisfying trend regarding reactor source-term evolution which in principle has levelled out at 60 % at RH-system, compared to levels before chemical decon in 2014.

Ringhals PWRs are from a source term point of view behaving basically as predicted. Unit 4 has, however, slightly higher releases of Co-58 during RFO clean-up with traditional H_2O_2 addition and RH purification. Reactor 2 has since 2014 RFO showed a significant amount of Sb-124 in RH-system after the clean-up sequence; from an activity point of view, the surface ratio Sb-124/ Co-60 is 70/30, Sb-124 gave initially the dominating dose beside Co-60 from RH-system.

Independent core cooling system (OBH) will be installed at units 3 and 4. These reactors will be operating in the future (beyond 2035).

Developments in the area of RP instrumentation are for example, the use of electronic Beta/Neutron dosimeters, electronic extremity/ eye dosimeters (Hp07, Hp3), beta dose rate instruments, and increased use of gamma camera devices.

– *Outage information*

Reactor Refuelling Outage days during cycle (ISOE database)		
Reactor type	**Number of RFO**	**Average annual RFO duration per unit and reactor type [days]**
BWR	6	38
PWR	2	49
All types	8	46

Note: 2 reactors had no RFO 2016.

3) Report from Authority

The Swedish Radiation Safety Authority (SSM) is working on a draft of a new radiation protection law, and a complete radiation protection legislation framework, supporting the law. The regulations include nuclear safety, radiation protection, security and safeguards, with an implementation planned in spring 2018.

- SSM is actively following the planning of the decommissioning of the four reactors that will close down from 2016 to 2020 and normal surveys of the operating nuclear reactors.
- During 2016 SSM has requested a self-evaluation of education and competence regarding RP-training from each of the licensees, the self-evaluation is currently being reviewed by the Authority.

SWITZERLAND

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [person·mSv/unit]
PWR	3	323
BWR	2	945

2) Principal events of the year 2016

- *Events influencing dosimetric trends*

  Gösgen NPP: Since the beginning of Zn-64 injection in 2005 the average dose rate of primary circuit components has been reduced by about 66 % compared to the dose rate of 2005 and the years before. As a result, annual doses as well as the average individual doses have been lowered significantly.

- *Outage information*

  The Leibstadt NPP Outage of 2016 was longer than planned, therefore the outage dose was higher than planned:
  - planned: 25 days / 740 man·mSv;
  - real: 91 days / 1 071 man·mSv.

  The discovery of dry-out-damage to several fuel rods and its investigation caused a prolongation of outage duration. Additional jobs on safety valves increased the collective dose.

  Beznau NPP: Outage dates were:
  - Unit 1 – 1 January 2016-31 December 2016;
  - Unit 2 – 5 August 2016-17 August 2016.

  Mühleberg NPP:
  The outage of 28 days led to 509 man·mSv (planned collective dose target 655 man·mSv). The highest individual dose was 5.1 mSv. No incorporation or permanent contamination of any person was detected. During operation a collective dose of 337 man·mSv led to the annual collective dose of 846 man·mSv.

In addition to the prevention of stress crack corrosion, the water chemistry with noble chemistry and continuous hydrogen injections has continued to result in a reduction of the dose rate levels on the recirculation loops. After more than 10 years of operation without any problem, a cladding failure of one fuel element was detected. This failure had no detrimental effect on the radiological conditions for the outage.

UKRAINE

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
VVER	15	623

2) Principal events of the year 2016

- *Events influencing dosimetric trends*

In 2016 the dose rate per unit was the same level as in 2015, but higher than previous years. The reason could be the increased duration and scope of works when performing overhauls and planned outages of the NPP units.

This degradation is also related to a significant scope of rehabilitation work performed with the intent of extending the life of NPP units beyond their original design lifetime and involving a significant number of contracted personnel to perform these activities.

UNITED KINGDOM

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	1	553.97
GCR	14(1)	21.18
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
GCR	20(2)	36.49

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

2) Principal events of the year 2016

Sizewell B recorded a 2016 calendar year Collective Radiation Exposure of approximately 554 man·mSv which was 6% above the station goal. Britain's only commercial PWR completed its second 10-year refuelling outage, RO14, in the spring of 2016, this being the largest ever refuelling outage, as measured by calendar duration, work scope and RCA hours. Nearly 130 000 RCA hours were worked at an effective dose rate of 4 µSv/hr. The outage was around two weeks longer than the original plan due to, notably on the nuclear island, emergent work on a Pressuriser Safety Relief Valve cabinet and an Emergency Boration System valve.

Sizewell B commissioned a new Dry Fuel Store with the intention of loading the first irradiated fuel into storage casks in early 2017.

Elsewhere in the EDF Energy operational fleet the annual collective radiation exposures recorded by the Advanced Gas Cooled reactors were low, ranging from 21 man·mSv to 76 man·mSv. The low radiation doses reflect the absence of any significant or novel work during the year.

The majority of the decommissioning 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. Wylfa NPP is the only Magnox site still in the defueling phase of decommissioning and is expected to have removed all irradiated fuel from its site by the end of 2018. Decommissioning site doses varied from 6.4 man·mSv to 265.8 man·mSv, with doses being very dependent upon the scope of work being carried out.

3) New Nuclear Build

In July 2016 the EDF board gave the final approval for the commencement of the Hinkley Point C new build. The project to build two EPR reactors is expected to complete in 2025. EDF Energy also intends to construct two further EPRs at Sizewell C, alongside the existing Sizewell B plant. 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. EDF and Chinese General Nuclear have also agreed to advance plans for two Chinese Hualong HPR-1000 PWRs at Bradwell.

UNITED STATES

1) Dose information for the year 2016

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	65	311.793
BWR	34	982.075
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
PWR	7	896.68
BWR	3	87.763

2) Principal events of the year 2016

– *Events influencing dosimetric trends*

The US PWR and BWR occupational dose averages for 2016 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 and 3 are in 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	20 266.54 person mSv	311.793 person mSv/unit
BWR	34	33 390.55 person mSv	982.075 person mSv/unit

The total collective dose for the 99 reactors in 2016 was 53 657.09 person mSv, a decrease of 24% from the 2015 total collective dose of 70 190 person mSv from 99 operating reactors. The resulting average collective dose per reactor for US LWR was 541,99 person mSv/unit or a 23% decrease from 2015 (709.00 person mSv/reactor unit).

17 transient workers who accrued dose at more than one nuclear power plant, received doses equal to or greater than 20 mSv in 2016

US PWRs

The total collective dose for US PWRs in 2016 was 20 266.54 person mSv for 65 operating PWR units. The 2016 PWR total collective dose was 29% lower than the 2015 US PWR total collective dose of 28 638.15 person mSv. The 2016 average collective dose per reactor was 311.793 person mSv which was 29% lower than the 2015 average collective dose per reactor of 440.587 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 2016 were:

• Ginna	18.82 person mSv
• Palisades	56.67 person mSv
• Robinson 2	37.04 person mSv
• Seabrook	16.72 person mSv
• Summer 1	28.62 person mSv
• Waterford	33.92 person mSv
• Watts Bar 1	44.89 person mSv

US BWRs

The total collective dose for US BWRs in 2016 was 33 390.55 person mSv compared to 41 552.73 person mSv in 2015 for the 34 operating US BWRs. The 2016 BWR total collective dose was 20% lower than the 2015 US BWR total collective dose of 41 552.73 person mSv for 34 operating BWR units. The 2016 average collective dose per reactor was 982.075 person mSv/reactor unit compared to 1 222 person mSv/BWR unit in 2015.

Most US BWR units are on 24-month refuelling cycles. The highest 2016 annual US BWR site dose was 3 389.85 person mSv at LaSalle County 1,2 and Browns Ferry 1,2,3 at 4 045.85 person mSv.
US BWRs have faced occupational dose challenges due to high CRUD levels on piping, and power up-rate, modifications in 2016.

– *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 and 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. Demolition of the major buildings, Turbine, Auxiliary, Containment and Control buildings, was achieved in 2016. Vermont Yankee, Kewaunee, San Onofre 2,3 and Crystal River transitioned into the decommissioning phase during the period of 2013- 2014. The sites are now in SAFSTOR.

Vermont Yankee Nuclear Power Station was a 1,912 MWt BWR which began operations in 1972. The reactor was permanently shut down on 29 December 2014. The nuclear fuel was removed on 12 January 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. Licence termination is scheduled to take place by 2073.

– *Major evolutions*

Four US PWR sites continued their transition to decommissioning status. The annual occupational doses for selected US units undergoing SAFSTOR or decommissioning are as follows:

Site	2014 (person mSv)	2015 (person mSv)	2016 (person mSv)
Crystal River	6.96	7.00	147
San Onofre 2, 3	13.69	12.02	17.87
Kewaunee	19.64	1.56	0.92
Humboldt Bay	123.81	43.91	0.0
Zion 1,2	787.30	1 426.05	457.88

– *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 275 baffle bolts and Indian Point 2 replaced 97 baffle bolts as emergent work scope during their scheduled refuelling outages. Cook 1,2 are replacing approximately 800 baffle bolts in each unit over the next several outages. Each outage about 48 batches are completed with 6 bolts per batch.

– *New/experimental dose-reduction programmes*

US RPMs are searching for new ALARA tools including real-time isotopic mapping to plant components and piping using a 3D CZT detector system (e.g. that developed by the University of Michigan). The new ALARA tool has been found to be effective in verifying the adequacy of temporary shielding, radwaste shipments and confirmation of effectiveness of in-plant contamination control measures.

– *Organisational evolutions*

Technical plans for major work in 2016

FLEX equipment and programmes were fully implemented in 2016 at US licensees. Two regional FLEX Centers 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 ongoing emphasis at US PWRs.

Extensive source-term reduction initiatives were initiated at the LaSalle County site (BWR) in 2016 to reduce CRUD in the BWR piping and reactor cavity. Over 72 000 Curies of Co-60 were removed using reactor vessel vacuuming, chemical decontamination of piping and BWR fuel cleaning.

US fleets and alliances are continuing to standardise RP procedures and policies across the fleets/alliances to improve efficiency of RP operations and minimise confusion of traveling RP techs. Annual radworker training for US utility employees has been extended to every 4 years from the previous annual requirement.

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 programme 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 to the renewable, carbon-free generation that nuclear units provide to the state. Quad Cities 1,2 and Clinton were given another 10 years of operation by legislative action of the State of Illinois and the Illinois Governor.

Loading of spent fuel assemblies into dry casks continued in 2016.

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

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 among 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 2016.

4.1 ISOE ALARA Symposia

ISOE International ALARA Symposium

The 2016 ISOE International ALARA Symposium, organised by the European Technical Centre in collaboration with and the support of ENGIE Electrabel and the Federal Agency for Nuclear Control (FANC), was held on 1-3 June 2016 in Brussels, Belgium. In total, 140 participants from 24 countries attended; a Technical exhibition attracted 10 vendors. Three distinguished papers were selected by the participating technical centres:

- *Radiation Protection Success of Steam Generator Replacement in Blayais unit 3 (2014),* J. Bonnefon, G. Ranchoux, O. Backes (EDF DIPDE, France), B. Roustit, H. Caullier (Blayais NPP, France), J. Sergeat, K. Hamon, D. Marié (AREVA NP, France).
- *ALARA Programme and RP Activities for the Reactor Vessel Head Replacement at CN Vandellòs II,* A. Prim Pujals, J. L. Sarria Gálvez, I. Vildósola Hernandez, A. Ribas Goset (Vandellòs II NPP, Spain).
- *The Way to Optimize Radiation Exposure Index at the Russian Nuclear Power Plants,* I. Doljenkov (Rosenergoatom, Russia), A. Kuchin (Kola NPP, Russia).
- *Lessons Learned from the Failure of Leak Monitoring System of Steam Generator (poster),* Moonhyung Cho, Kidoo Kang, Yuho Weon (Central Research Institute, Korea Hydro & Nuclear Power, South Korea).

ISOE Regional ALARA Symposia

North American Symposium

The 2016 ISOE North American ALARA Symposium was held on 11-13 January 2016 in Fort Lauderdale/USA. The symposium was organised by the North American Technical Centre. 165 participants, including 30 vendors attended. Two distinguished papers were selected by the participating technical centres:

- *Pickering Dynamic Learning video training on RWP knowledge,* Karen McDougall, (Pickering, OPG, Canada).

Braidwood 2015 Refuelling Outages ALARA Successes, J. Cady, (Braidwood NPP, USA).

Asian Symposium

The 2016 ISOE Asian ALARA Symposium was held on 7-9 September 2016 in Fukushima/Japan. The symposium was organised by the Asian Technical Centre and Nuclear Safety Research Association (NSRA). Thirty-two participants from 4 countries attended. Distinguished papers selected by the participating technical centres are listed below:

– *New Radiological Control of Areas in Fukushima Daiichi NPS,* Katsuhiro Yasui (TEPCO Holdings Inc., Japan).
– *Analysis on Occupational Exposure of Radiation Workers in Korea based on KISOE Database (2005-14),* Byeongsoo Kim (Institute of Nuclear Safety, Republic of Korea).

In connection with the symposium, the participants had the opportunity to participate in a technical tour of Fukushima Daiichi NPP.

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

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 among 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 has been decided 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. In 2016, nine new analyses have been 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 2016, 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 for 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 among the participating utilities in the four technical centre regions. These visits are organised 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 2016 are summarised below.

Benchmarking visits organised by NATC

- Visit to Palissades to study high dose PWR plants. Cook and Prairie Island.
- Tepco and JSME: 18 Japanese engineers benchmarked Palo Verde, Diablo Canyon and US NRC Regional office to evaluate FLEX Programmes, Fukushima upgrades, seismic and RP programmes.
- Cook went to Paolo Verde to assess and benchmark High CRUD in Steam Generators from April 2016 outage.

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 2016, including:

ISOE Meetings	Date
ISOE Bureau	May; Nov/Dec
Working Group on Data Analysis (WGDA)	May; Nov
26th ISOE Management Board Meeting	Dec
Joint WGDA-Management Board Topical Session	Dec
Working Group on Decommissioning (WGDECOM)	Apr; Oct

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 2016 and approving the programme of work for 2017. The 2016 mid-year meeting of the ISOE Bureau focused on the status of the ISOE activities for 2016, the status of the renewal of the ISOE Terms and Conditions, planning for the ISOE annual session 2016.

ISOE Working Group on Data Analysis (WGDA)

The Working Group on Data Analysis (WGDA) met in May and November 2016, 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 NPPs (WGDECOM)

The WGDECOM was established in 2014 by the ISOE Management Board during its 24th annual session, with a draft TOR after having a joint topical session with the International Co-operative Programme on Decommissioning (CPD). The WGDECOM met in June and October 2015, continuing their focus on RP aspects of decommissioning activities at NPPs. The programme of work (2016-2017) was developed by the WGDECOM and approved by the ISOE Management Board.

The objective of the Working Group on Radiological Aspects of Decommissioning Activities in Nuclear Power Plants 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.

Annex 1

STATUS OF ISOE PARTICIPATION UNDER THE RENEWED ISOE TERMS AND CONDITIONS (2016-2019)

Note: This annex provides the status of ISOE official participation as of 31 December 2016

Officially participating utilities: Operating reactors

Country	**Utility**[4]	**Plant name**	
Armenia, Republic of	Armenian Nuclear Power Plant (CJSC)	Medzamor 2	
Belgium	ENGIE Electrabel	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	China Guangdong Nuclear Power Group (CGN)	Daya Bay 1, 2	Ling Ao 1, 2, 3, 4
	CNNC Qinshan Nuclear Power Company, Ltd	Qinshan 1	
	Fujian Ningde Nuclear Power Co., Ltd	Ningde 1, 2, 3, 4	
	Fujian Fuqing Nuclear Power Co., Ltd	Fuqing 1, 2, 3	
	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	

1. Where multiple owners and/or operators are involved, only Leading Undertakings are listed.

	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
Hungary	Magyar Villamos Művek Zvt	Paks 1, 2, 3, 4	
Japan	Chubu Electric Power Co., Inc.	Hamaoka 3, 4, 5	
	Chugoku Electric Power Co., Inc.	Shimane 2	
	Hokkaido Electric Power Co., Inc.	Tomari 1, 2, 3	
	Hokuriku Electric Power Co.	Shika 1, 2	
	Japan Atomic Power Co.	Tokai 2	Tsuruga 2
	Kansai Electric Power Co., Inc.	Mihama 3 Ohi 1, 2, 3, 4	Takahama 1, 2, 3, 4
	Kyushu Electric Power Co., Inc.	Genkai 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, Republic of	Korea 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, 3 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	Balakovo 1, 2, 3, 4 Kalinin 1, 2, 3, 4 Kola 1, 2, 3, 4	Novovoronezh 3, 4, 5 Rostov 1, 2, 3
Slovak Republic	Slovenské elektrárne, 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 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 TMI 1
	FirstEnergy 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
	Omaha Public Power District	Fort Calhoun 1	
	Pacific Gas & Electric Company	Diablo Canyon 1, 2	
	PPL Susquehanna, Llc.	Susquehanna 1, 2	
	Public Service Electric & Gas Co.	Hope Creek 1	Salem 1, 2
	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, 2
	Wolf Creek Nuclear Operation Corp.	Wolf Creek	
	XCel Energy	Monticello Prairie Island 1, 2	

Reactors under construction

Country	Utility	Plant name
China	CNNP Sanmen Nuclear Power Company	Sanmen 1, 2
	Fujian Fuqing Nuclear Power Co., Ltd	Fuqing 4, 5, 6
United States	Southern Nuclear Operating Company, Inc.	Vogtle 3, 4

Officially participating utilities: Definitively shutdown reactors

Country	Utility[4]	Plant name	
Armenia	Armenian Nuclear Power Plant (CJSC)	Medzamor 1	
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
Italy	SOGIN Spa	Caorso Garigliano	Latina Trino
Japan	Chubu Electric Power Co., Inc.	Hamaoka 1, 2	
	Chugoku Electric Power Co., Inc.	Shimane 1	
	Japan Atomic Energy Agency	Fugen	

	Japan Atomic Power Co.	Tokai 1	Tsuruga 1
	Kansai Electric Power Co., Inc.	Mihama 1, 2	
	Kyushu Electric Power Co., Inc.	Genkai 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	Santa María de Garoña	
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	
	Exelon Generation Co., LLC	Dresden 1	Peach Bottom 1
	FirstEnergy Nuclear Operating Co. (FENOC)	TMI 2	
	Pacific Gas & Electric Company	Humboldt Bay 1	
	Southern California Edison Co.	San Onofre 1, 2, 3	

Participating regulatory authorities

Country	Authority
Armenia	Armenian Nuclear Regulatory Authority (ANRA)
Belarus, Republic of	Scientific Practical Centre of Hygiene, Ministry of Health
Belgium	Federal Agency for Nuclear Control (FANC)
Brazil	Brazilian Nuclear Energy Commission (CNEN)
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)
South Africa	National Nuclear Regulator (NNR)
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 (SNRIU)
United Arab Emirates	Federal Authority for Nuclear Regulation (FANR)
United Kingdom	The Office for Nuclear Regulation (ONR)
United States	US Nuclear Regulatory Commission (US NRC)

Country – Technical centre affiliations

Country	Technical Centre*	Country	Technical Centre
Armenia	IAEATC	Mexico	NATC
Belarus, Republic of	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	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, Republic of	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 (NSRA) Tokyo, Japan http://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.asp

North American Region (NATC)	University of Illinois Champagne-Urbana, Illinois, USA http://hps.ne.uiuc.edu/natcisoe/
Joint Secretariat	
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

Nuclear Energy Agency (NEA)

RAKHUBA, Alexandr
Nuclear Energy Agency
Division of Radiological Protection and Human Aspects of Nuclear Safety
46, quai Alphonse Le Gallo
92100 Boulogne-Billancourt, France
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Email: isoe.secretariat@oecd-nea.org

GUZMÁN LÓPEZ-OCÓN, Olvido
Nuclear Energy Agency
Division of Radiological Protection and Human Aspects of Nuclear Safety
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International Atomic Energy Agency (IAEA)

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International Atomic Energy Agency
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ISOE Technical Centres

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Nuclear Safety Research Association (NSRA)
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Tokyo 105-0004

Tel: +81 3 5470 1983
Email: isoeatc@nsra.or.jp

European Technical Centre (ETC)

SCHIEBER, Caroline
European Technical Centre
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IAEA Technical Centre (IAEATC)

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IAEA Technical Centre
Radiation Safety and Monitoring Section
International Atomic Energy Agency
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Tel: +43 1 2600 26173
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North American Technical Centre (NATC)

MILLER, David W.
NATC Regional Co-ordinator
North American ALARA Center
Radiation Protection Department
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Annex 3

ISOE MANAGEMENT BOARD AND NATIONAL CO-ORDINATORS (2016)

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

ARMENIA	
PYUSKYULYAN, Konstantin	Medzamor 2 NPP
AVETISYAN, Aida	Armenian Nuclear Regulatory Authority (ANRA)
BELARUS	
NIKALAYENKA, Alena	Republican Unitary Enterprise "Scientific Practical Centre of Hygiene", Ministry of Health
BELGIUM	
LANCE, Benoit	ELECTRABEL Corporate Nuclear Safety Department
HENRY, François	Federal Agency for Nuclear Control (FANC)
BRAZIL	
DO AMARAL, Marcos Antônio	Angra NPP (retired)
BULGARIA	
NIKOLOV, Atanas	Kozloduy NPP
KATZARSKA, Lidia	Bulgarian Nuclear Regulatory Agency
CANADA	
PRITCHARD, Colin.	Bruce Power
ELLASCHUK, Bernard	Canadian Nuclear Safety Commission (CNSC)
MILLER, David E	Bruce Power
CHINA	
YANG, Duanjie	Nuclear and Radiation Safety Centre (MEP)
JIANG, Jianqi	Qinshan NPP
CZECH REPUBLIC	
FARNIKOVA, Monika	Temelin NPP, ČEZ a.s.
FUCHSOVÁ, Dagmar	State Office for Nuclear Safety (SÚJB)
FINLAND	
KONTIO, Timo	Loviisa NPP
RIIHILUOMA, Veli	Radiation and Nuclear Safety Authority (STUK)

FRANCE	
MICHELET, Marie	Électricité de France (EDF)
GUANNEL, Yves	Autorité de Sûreté Nucléaire (ASN)
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)	
KIM, Byeong-Soo	Korea Institute of Nuclear Safety (KINS)
HWANG, Tea-Won	Korea Hydro and Nuclear Power. Co. Ltd (KHNP)
AN, Yong-min	Korea Hydro and Nuclear Power. Co. Ltd (KHNP)
LITHUANIA	
TUMOSIENĖ, Kristina	State Nuclear Power Safety Inspectorate (VATESI)
RAUBA, Kestus	Ignalina NPP
MEXICO	
HUESCA GUEVARA, Luis Rafael	Laguna Verde NPP
NETHERLANDS	
MEIJER, Hans	EPZ – Borssele NPP
ARENDS, Patrick	Authority for Nuclear Safety and Radiation Protection (ANVS)
PAKISTAN	
MANNAN, Abdul	Chasnupp NPP
ROMANIA	
SIMIONOV, Vasile	Cernavoda NPP
RUSSIAN FEDERATION	
DOLJENKOV, Igor	Rosenergoatom Concern OJSC
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)	Koeberg NPP
MAREE, Marc	National Nuclear Regulator (NNR)
MPETE, Louisa	
SPAIN	
ROSELL HERRERA,	Almaraz NPP
Borja	Consejo de Seguridad Nuclear (CSN)
LABARTA, Teresa	
SWEDEN	
HANSSON, Petra	Swedish Radiation Safety Authority (SSM)
SVEDBERG, Torgny	Ringhals NPP
SWITZERLAND	
TAYLOR, Thomas	Mühleberg NPP
JAHN, Swen-Gunnar	Swiss Nuclear Safety Inspectorate (ENSI)
UKRAINE	
BEREZHNAYA, Tatyana	National Nuclear Energy Generation Company “Energoatom”
CHEPURNYI, Jurii	State Nuclear Regulatory Inspectorate
UNITED ARAB	
EMIRATES	Federal Authority for Nuclear Regulation
AZIZ, Maha	(FANR)
UNITED KINGDOM	
RENN, Guy	Sizewell B NPP
REES, Vaughan	Office for Nuclear Regulation (ONR)
UNITED STATES OF	
AMERICA	US Nuclear Regulatory Commission
BROCK, Terry	Prairie Island NPP
BOYER, Brad	D.C. Cook NPP
WOOD, David	

Participation in the ISOE Management Board meetings in an advisory capacity:

Technical Centre Representatives

ATC

NOMURA, Tomoyuki	Nuclear Safety Research Association (NSRA), Japan
TEZUKA, Hiroko	Nuclear Safety Research Association (NSRA), Japan

ETC

BELTRAMI, Laure-Anne	CEPN, France
D'ASCENZO, Lucie	CEPN, France
SCHIEBER, Caroline	CEPN, France

IAEATC

MA, Jizeng	IAEA, Austria

NATC

DOTY, Richard	College of Engineering, University of Illinois, USA
MILLER, David W.	D.C. Cook NPP, USA

Chairs of ISOE Working Groups

WGDA

PRITCHARD, Colin	Bruce Power, Canada

WGDECOM

HALE, James Mike	Kewaunee NPP, USA

Annex 4

ISOE WORKING GROUPS (2016)

Working Group on Data Analysis (WGDA)

Chair: PRITCHARD, Colin (Canada) Vice-Chair: HAGEMEYER, Derek (US)

BRAZIL

DO AMARAL, Marcos Antonio	Angra NPP (retired) (ISOE Chair)

CANADA

ELLASCHUK, Bernard	Canadian Nuclear Safety Commission (CNSC)
PRITCHARD, Colin	Bruce Power

CZECH REPUBLIC

FARNIKOVA, Monika	Temelin NPP

FRANCE

BELTRAMI, Laure-Anne	CEPN/ETC
D'ASCENZO, Lucie	CEPN/ETC
GENIAUX, Aude	Autorité de Sûreté Nucléaire (ASN)
JOLIVET, Patrick	Institut de Radioprotection et de Sûreté Nucléaire (IRSN)
MICHELET, Marie	Électricité de France (EDF)
ROCHER, Alain	Électricité de France (EDF)
SCHIEBER, Caroline	CEPN/ETC

GERMANY

STAHL, Thorsten	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH

JAPAN

BESSHO, Yasunori	Nuclear Regulation Authority (NRA)
NOMURA, Tomoyuki	Nuclear Safety Research Association (NSRA)/ATC
SUZUKI, Akiko	Nuclear Regulation Authority (NRA)
TEZUKA, Hiroko	Nuclear Safety Research Association (NSRA)/ATC

KOREA (REPUBLIC OF)	
BANG, Soo-il HWANG, Tae-won KIM, Byeong-soo SON, Jung-kwon	Korea Hydro and Nuclear Power Corporation Ltd. (KHNP) Korea Hydro and Nuclear Power Corporation Ltd. (KHNP) Korea Institute of Nuclear Safety (KINS) 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	
REES, Vaughan	Office for Nuclear Regulation (ONR)
UNITED STATES OF AMERICA	
ANDERSON, Ellen	Nuclear Energy Institute (NEI) (under TCA)
BOYER, Brad	Prairie Island NPP
BROCK, Terry	US Nuclear Regulatory Commission
HAGEMEYER, Derek HARRIS, Willie O.	Oak Ridge Associated Universities (ORAU, under TCA)
MILLER, David .W	Exelon Nuclear D.C. Cook Plant / NATC
ISOE JOINT SECRETARIAT	
MA, Jizeng	International Atomic Energy Agency (IAEA)
RAKHUBA, Aleksandr	Nuclear Energy Agency (NEA)
GUZMÁN LÓPEZ-OCÓN, Olvido	Nuclear Energy Agency (NEA)

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

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

BRAZIL	
ALBUQUERQUE	Angra NPP
VIEIRA, Flavia	Angra NPP
ESTANQUEIRA PINHO, Bruno	
CANADA	
ELLASCHUK, Bernard	Canadian Nuclear Safety Commission (CNSC)
GAGNON, Jean-Yves	Gentilly-2 NPP
FRANCE	
ARIES NASSER, Marie-Eve	Autorité de Sûreté Nucléaire (ASN)
BOUSSETTA, Benjamin	EDF – DP2D
DIDELOT, Nicolas	Institut de Radioprotection et de Sûreté Nucléaire (IRSN)
VAILLANT, Ludovic	European Technical Centre (ETC), CEPN
GERMANY	
BRENDEBACH, Boris	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH
ITALY	
MANCINI, Francesco	Sogin SpA
KOREA (REPUBLIC OF)	
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 (under TCA)
MUÑOZ GOMEZ, Raul	UNESA
SWEDEN	
ELLMARK, Christoffer	AB SVAFO
HANSSON, Petra	Swedish Radiation Safety Authority (SSM)
SWITZERLAND	
NEUKÄTER, Erwin	Mühleberg NPP

UNITED STATES OF AMERICA

ANDERSON, Ellen	Nuclear Energy Institute (NEI) (under TCA)
HALE, James Mike	Kewaunee NPP
HARRIS, Willie	Exelon Generation
MILLER, David.W	North American Technical Centre (NATC), D.C. Cook NPP
SCARBERRY, William.	Clinton Power Station, Exelon Corporation

CORRESPONDING MEMBERS

BELGIUM

VANHEMELRYCK, Fery	ENGIE Electrabel

CANADA

MCQUEEN, Maureen	C.N. Associates Inc.

GERMANY

KAULARD, Joerg	TŰV Rheinland ISTec GmbH

KOREA (REPUBLIC OF)

KIM, Byeong-Soo	Korea Institute of Nuclear Safety (KINS)

UNITED STATES OF AMERICA

MESSIER, Christopher C.	BHI Energy
ROBERTS, Sarah	Oak Ridge Associated Universities (ORAU)
TARZIA, James P.	Radiation Safety & Control Services Inc.
WILLIAMS, Donald E. (Nick)	Zion Solutions

JOINT SECRETARIAT

MA, Jizeng	International Atomic Energy Agency (IAEA)
RAKHUBA, Aleksandr	Nuclear Energy Agency (NEA)
GUZMAN, Olvido	Nuclear Energy Agency (NEA)

Annex 5

LIST OF ISOE PUBLICATIONS

Reports

- *Occupational Exposures at Nuclear Power Plants: Twenty-Fifth Annual Report of the ISOE Programme, 2015*, OECD, 2017.
- *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

2016	No. 24 (October)
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. 44: Nov. 2016	Republic of Korea: Summary of national dosimetric trends
No. 43: Nov. 2016	Japanese dosimetric results: FY 2015 data and trends
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
No. 15: Oct. 2001	Japanese Dosimetric results: FY 2000 data and trends
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. 61: Mar. 2018	Survey on the values and uses of the monetary value of the man.Sievert (in 2017)
No. 60: Nov. 2016	European Dosimetric Results for 2015
No. 59: Jul. 2016	European Dosimetric Results for 2014
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

2018 Jun.2018	3-Year Rolling Average Annual Dose Comparisons Canada Reactors (CANDU) 2015-2017 Occupational Dose Benchmarking Charts
2017-5. Jun. 2017	3-Year Rolling Average Annual Dose Comparisons Canada Reactors (CANDU) 2014-2016 Occupational Dose Benchmarking Charts
2017-4. Sept. 2017	North American Boiling Water Reactor (BWR) 2016 Occupational Dose Benchmarking Charts
2017-3. Sept. 2017	North American Pressurized Water Reactor (PWR) 2016 Occupational Dose Benchmarking Charts
2017-2. Sept. 2017	North American Boiling Water Reactor (BWR) 2015 Occupational Dose Benchmarking Charts
2017-1. Sept. 2017	North American Pressurized Water Reactor (PWR) 2015 Occupational Dose Benchmarking Charts
2016-1. Jun 2016	3-Year Rolling Average Annual Dose Comparisons Canada Reactors (CANDU) 2013-2015 Occupational Dose Benchmarking Charts
2015-1. Jun. 2015	3-Year Rolling Average Annual Dose Comparisons Canada Reactors (CANDU) 2012-2014 Occupational Dose Benchmarking Charts

2014-3: Jun. 2014	3-Year Rolling Average Annual Dose Comparisons Canada Reactors (CANDU) 2011-2013 Occupational Dose Benchmarking Charts
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	US PWR – 2002 Occupational Dose Benchmarking Chart
2003-2: July 2003	3-Year rolling average annual dose comparisons – US BWR 2000-2002 Occupational Dose Benchmarking Charts
2003-1: July 2003	3-Year rolling average annual dose comparisons – US PWR 2000-2002 Occupational Dose Benchmarking Charts
2002-5: July 2002	US BWR – 2001 Occupational Dose Benchmarking Chart
2002-4: July 2002	US PWR – 2001Occupational Dose Benchmarking Chart
2002-2: July 2002	3-Year rolling average annual dose comparisons – US BWR 1999-2001 Occupational Dose Benchmarking Charts
2002-1: Nov. 2002	3-Year rolling average annual dose comparisons – US 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 – US BWR 1998-2000 Occupational Dose Benchmarking Charts
2001-1: July 2001	3-Year rolling average annual dose comparisons – US PWR 1998-2000 Occupational Dose Benchmarking Charts

ISOE International and Regional Symposia

Asian Technical Centre

Sept. 2016 (Fukushima, Japan)	2016 ISOE Asian ALARA Symposium
Sept. 2015 (Tokyo, Japan)	2015 ISOE Asian ALARA Symposium
Sept. 2014 (Gyeongju, 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, 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

Jun. 2016 (Brussels, Belgium)	2016 ISOE International ALARA Symposium
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

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

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Jan. 2016 (Ft. Lauderdale, FL, USA)	2016 ISOE North American ALARA Symposium
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

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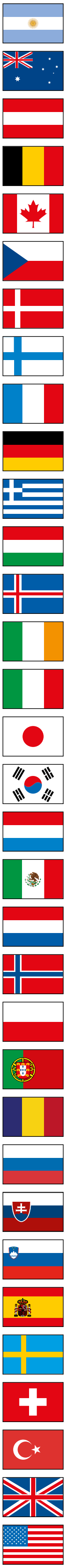

Occupational Exposures at Nuclear Power Plants

This 26th Annual Report of the International System on Occupational Exposure (ISOE) Programme presents the status of the Programme in 2016.

As of 31 December 2016, the ISOE programme included 74 participating utilities in 28 countries (343 operating units; 53 shutdown units; 7 units under construction), as well as the regulatory authorities in 26 countries. The ISOE database includes occupational exposure information for over 400 units, covering over 85% of the world's operating commercial power reactors.

This report includes a global occupational exposure data and analysis collected and accomplished in 2016, information on the programme events and achievements as well as principal events in participating countries.

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