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Occupational Exposures at Nuclear Power Plants

Twenty-fourth Annual Report of the ISOE Programme, 2014

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Radiological Protection

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

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

The Twenty-fourth Annual Report of the ISOE Programme presents the status of the ISOE programme for the year of 2014.

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

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EXECUTIVE SUMMARY

Since 1992, the Information System on Occupational Exposure (ISOE) has supported the optimisation of worker radiological protection in nuclear power plants through a worldwide information and experience exchange network for radiation protection professionals at nuclear power plants and national regulatory authorities, and through the publication of relevant technical resources for ALARA management. This 23rd Annual Report of the ISOE Programme presents the status of the ISOE programme for the calendar year 2013.

ISOE is jointly sponsored by the NEA and the IAEA, and its membership is open to nuclear electricity utilities and radiation protection regulatory authorities worldwide who accept the programme's Terms and Conditions. The current ISOE Terms and Conditions for the period 2012-2015 came into force on 1 January 2012. At the end of 2014, the ISOE programme included 76 Participating Utilities in 29 countries (348 operating units; 57 shutdown units), as well as the regulatory authorities of 18 countries. The ISOE occupational exposure database itself included information on occupational exposure levels and trends at 377 operating reactors; covering about 90% of the world's operating commercial power reactors. Four ISOE Technical Centres (Europe, North America, Asia and IAEA) manage the programme's day-to-day technical operations.

Based on the occupational exposure data supplied by ISOE members for operating power reactors, the 2014 average annual collective doses per reactor and 3-year rolling averages per reactor (2012-2014) were:

	2014 average annual collective dose (man·Sv/reactor)	**3-year rolling average for 2012-2014 (man·Sv/reactor)**
Pressurised water reactors (PWR)	0.49	0.50
Pressurised water reactors (VVER)	0.44	0.45
Boiling water reactors (BWR)	0.89	0.87
Pressurised heavy water reactors (PHWR/CANDU)	0.81	0.90

In addition to information from operating reactors, the ISOE database contains dose data from 99 reactors which are shutdown or in some stage of decommissioning. As these reactor units are generally of different type and size, and at different phases of their decommissioning programmes, it is difficult to identify clear dose trends. However, work continued in 2014 to improve the data collection for such reactors in order to facilitate better benchmarking. Details on occupational dose trends for operating reactors, and reactors undergoing decommissioning are provided in Section 2 of the report.

While ISOE is well known for its occupational exposure data and analyses, the programme's strength comes from its objective to share such information broadly amongst its participants. In 2014, the ISOE Network website (www.isoe-network.net) continued to provide the ISOE membership with a comprehensive web-based information and experience exchange portal on dose reduction and ISOE ALARA resources.

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 2014 included three regional symposia: the Asian symposium in Gyeongju, Republic of Korea, the European symposium in Bern, Switzerland, and the North American symposium in Fort Lauderdale, United States. These 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.

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

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

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

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

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

Based on feedback received by the ISOE Secretariat as of December 2014, the ISOE programme included: 76 Participating Utilities[1] in 29 countries, covering 348 operating units and 57 shutdown units, and the Regulatory Authorities of 18 countries. Table 1 summarises total participation by country, type of reactor and reactor status as of December 2014. 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 476 reactor units in 29 countries (377 operating; 99 in cold-shutdown or some stage of decommissioning), covering about 90% 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 and on CD-ROM.

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 2014)

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

Operating reactors: ISOE Participants							
Country	**PWR**	**VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Total**
Armenia	–	1	–	–	–	–	1
Belgium	7	–	–	–	–	–	7
Brazil	2	–	–	–	–	–	2
Bulgaria	–	2	–	–	–	–	2
Canada	–	–	–	19	–	–	19
China	7	2	–	–	–	–	9
Czech Republic	-	6	–	–	–	–	6
Finland	-	2	2	–	–	–	4
France	58	–	–	–	–	–	58
Germany	7	–	2	–	–	–	9
Hungary	–	4	–	–	–	–	4
Japan	24	–	24	–	–	–	48
Korea, Republic of	19	–	–	4	–	–	23
Mexico	–	–	2	–	–	–	2
Netherlands	1	–	–	–	–	–	1
Pakistan	2	–	–	1	–	–	3
Romania	–	–	–	2	–	–	2
Russian Federation	–	17	–	–	–	–	17
Slovak Republic	–	4	–	–	–	–	4
Slovenia	1	–	–	–	–	–	1
South Africa, Rep. of	2	–	–	–	–	–	2
Spain	6	–	1	–	–	–	7
Sweden	3	–	7	–	–	–	10
Switzerland	3	–	2	–	–	–	5
Ukraine	–	15	–	–	–	–	15
United Kingdom	1	–	–	–	–	–	1
United States	57	–	29	–	–	–	86
Total	**200**	**53**	**69**	**26**	**–**	–	**348**

Operating reactors: Not participating in ISOE, but included in the ISOE database							
Country	**PWR**	**VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Total**
United Kingdom	–	–	–	–	15	–	15
United States	8	–	6	–	–	–	14
Total	**8**	–	**6**	–	**15**	–	**29**

Total number of operating reactors included in the ISOE database						
	PWR/VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Total**
Total	**261**	**75**	**26**	**15**	–	**377**

Table 1. The Official ISOE Participants and the ISOE Database (as of December 2013) (Cont'd)

Definitively shutdown reactors: ISOE Participants							
Country	**PWR/ VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Bulgaria	4	–	–	–	–	–	4
Canada	–	–	3	–	–	–	3
France	1	–	–	6	–	–	7
Germany	4	4	–	–	–	–	8
Italy	1	2	–	1	–	–	4
Japan	–	8	–	1	–	1	10
Lithuania	–	–	–	–	2	–	2
Russian Federation	2	–	–	–	–	–	2
Spain	–	1	–	–	–	–	1
Sweden	–	2	–	–	–	–	2
United States	8	4	–	1	–	1	14
Total	**20**	**21**	**3**	**9**	**2**	**2**	**57**
Definitively shutdown reactors: Not participating in ISOE but included in the ISOE database							
Country	**PWR/ VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Canada	–	–	2	–	–	–	2
Germany	3	1	–	2	–	–	6
Netherlands	–	1	–	–	–	–	1
Spain	1	–	–	1	–	–	2
Ukraine	–	–	–	–	3	–	3
United Kingdom	–	–	–	19	–	–	19
United States	6	2	–	1	–	–	9
Total	**10**	**4**	**2**	**23**	**3**	**–**	**42**
Total number of definitively shutdown reactors included in the ISOE database							
	PWR/ VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Total	**30**	**25**	**5**	**32**	**5**	**2**	**99**

Total number of reactors included in the ISOE database							
	PWR/ VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Total	**291**	**100**	**31**	**47**	**5**	**2**	**476**

Number of **Participating Countries**	**29**
Number of **Participating Utilities**[2]	**76**
Number of **Participating Authorities**[3]	**20**

2. Represents the number of lead utilities; in some cases, plants are owned/operated by multiple enterprises.
3. One country participates with two authorities.

2. OCCUPATIONAL EXPOSURE TRENDS

A key element of the ISOE is the tracking of occupational exposure trends from nuclear power facilities worldwide for benchmarking, comparative analysis and experience exchange amongst 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 following dosimetric information from commercial nuclear power plants (NPPs) in operation, shut down or in some stage of decommissioning are available:

Dosimetric information from commercial NPPs in operation, shut down or in some stage of decommissioning, including:

- annual collective dose for normal operation;
- maintenance/refuelling outage;
- unplanned outage periods, and
- annual collective dose for certain tasks and worker categories.

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.

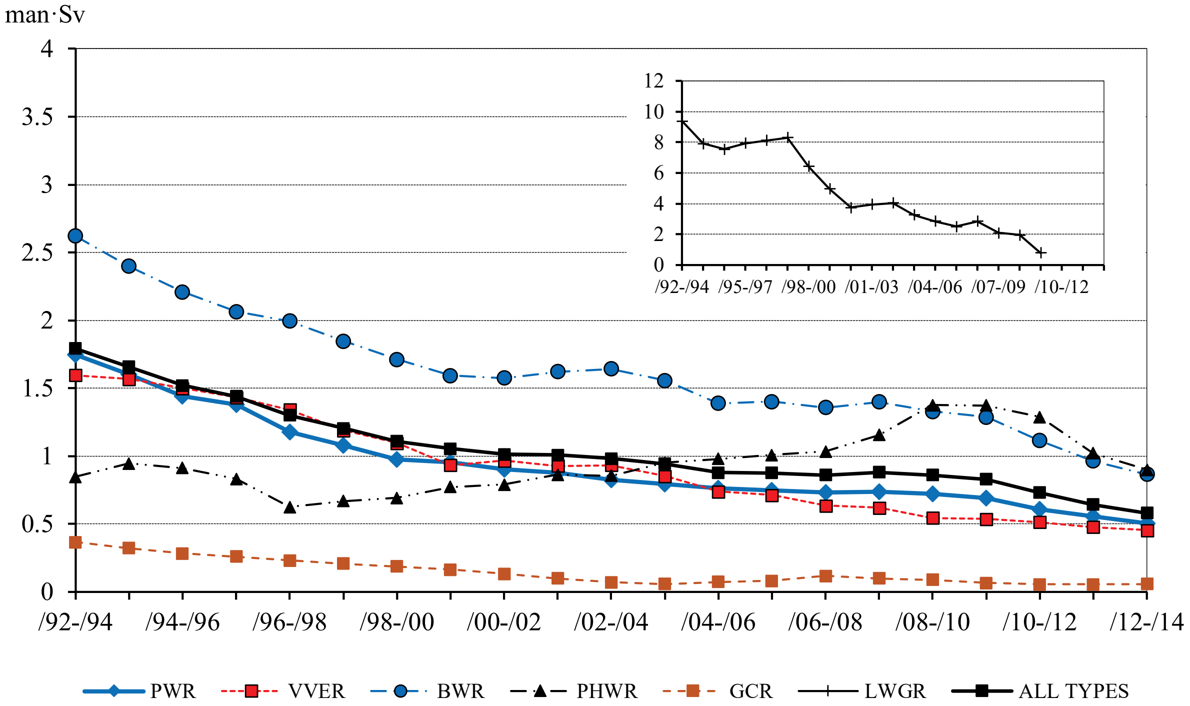
2.1 Occupational exposure trends: Operating reactors

a) Global trends by reactor type

Figure 1 shows the trend in 3-year rolling average collective dose per reactor, by reactor type, for 1992-2014. 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 but is know again decreasing.

Average annual collective dose per reactor by country and reactor type for the period of 2012-2014 and 3 year rolling average annual collective dose per reactor, by country and reactor type for the period of 2010-2012 to 2012-2014 are given in table 2 and 3 respectively. These results are based primarily on data reported and recorded in the ISOE database during 2015, supplemented by the individual country reports (Section 3) as required. Figure 2 to 5 provide information on average collective dose per reactor by country for PWR, VVER BWR and PHWR reactors. In all figures, the "number of units" refers to the number of reactor units for which data has been reported for 2014.

Figure 1. **3-year rolling average collective dose per reactor for all operating reactors included in ISOE by reactor type, 1992-2014 (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.

Table 2. **Average annual collective dose per reactor, by country and reactor type, 2012-2014 (man·Sv/reactor)**

	PWR			VVER			BWR		
	2012	**2013**	**2014**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
Armenia				0.90	0.73	1.01			
Belgium	0.33	0.19	0.25						
Brazil	0.08	0.48	0.34						
Bulgaria				0.18	0.23	0.30			
Canada									
China	0.45	0.86	0.46		0.23	0.25			
Czech Republic				0.12	0.12	0.11			
Finland				0.84	0.27	0.42	0.36	0.32	0.32
France	0.68	0.79	0.72						
Germany	0.23	0.32	0.16				1.07	1.09	1.16
Hungary				0.45	0.50	0.39			
Japan	0.18	0.23	0.23				0.29	0.20	0.19
Korea, Republic of	0.42	0.53	0.36						
Mexico							4.28	0.67	5.91
Netherlands	0.33	0.83	0.23						
Pakistan	0.07	0.53	0.60						
Romania									
Russian Federation				0.62	0.52	0.62			
Slovak Republic				0.17	0.13	0.14			
Slovenia	0.88	1.35	0.11						
South Africa, Rep. of	0.77	0.30	0.28						
Spain	0.47	0.39	0.39				0.25	2.25	0.29
Sweden	0.54	0.52	0.72				0.67	0.71	0.94
Switzerland	0.43	0.35	0.26				1.49	1.11	1.23
Ukraine				0.59	0.53	0.48			
United Kingdom	0.04	0.39	0.37						
United States	0.60	0.36	0.51				1.13	1.27	1.09
Average	**0.51**	**0.50**	**0.49**	**0.50**	**0.42**	**0.44**	**0.87**	**0.84**	**0.89**

Note: Data provided directly from country report, rather than calculated from the ISOE database: UK (2012, 2013, and 2014: GCR).
BWR dose in 2011, 2012 and in 2013 for Japan does not include Fukushima Daiichi Units 1-6.

	PHWR			GCR		
	2012	**2013**	**2014**	**2012**	**2013**	**2014**
Canada	1.24	0.85	0.90			
Korea, Republic of	0.64	0.49	0.37			
Pakistan	1.31	1.68	2.01			
Romania	0.46	0.25	0.30			
United Kingdom				0.06	0.03	0.08
Average	**1.10**	**0.78**	**0.81**	**0.06**	**0.03**	**0.08**

	2012	**2013**	**2014**
Average	**0.61**	**0.51**	**0.54**

Figure 2. **2014 PWR average collective dose per reactor by country (man·Sv/reactor)**

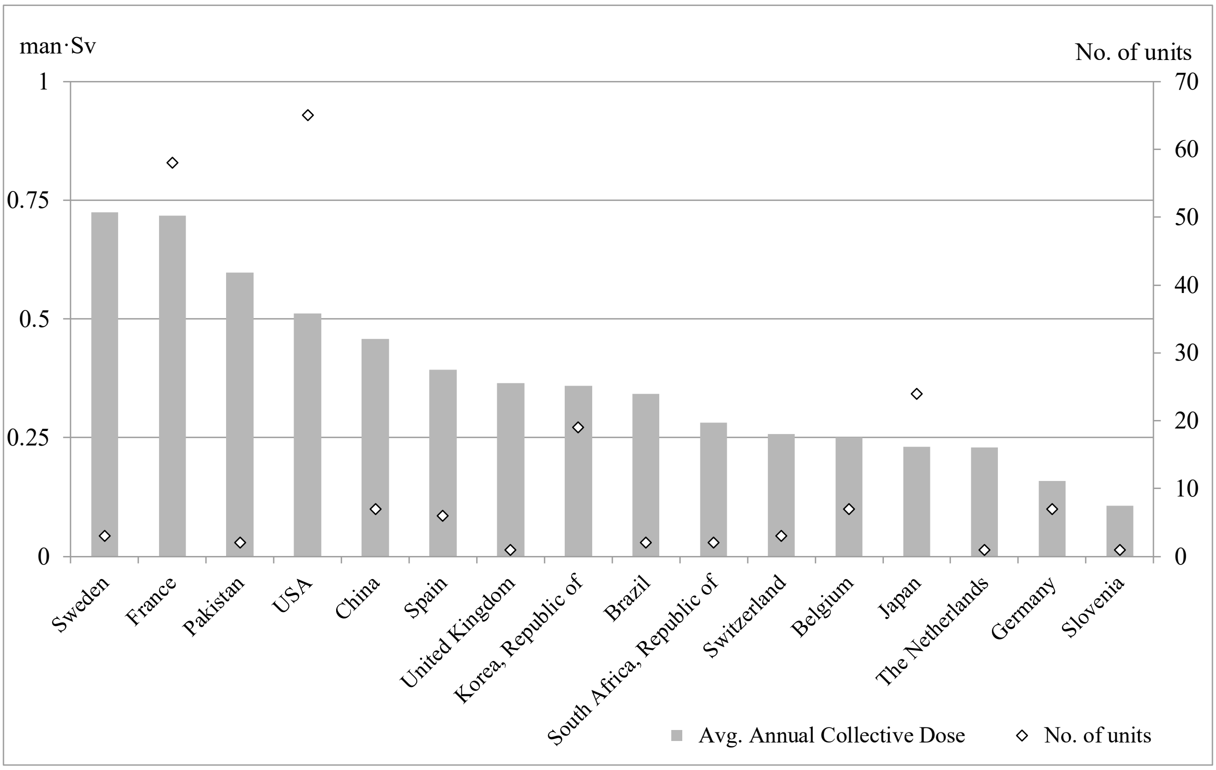


Figure 3. **2014 VVER average collective dose per reactor by country (man·Sv/reactor)**

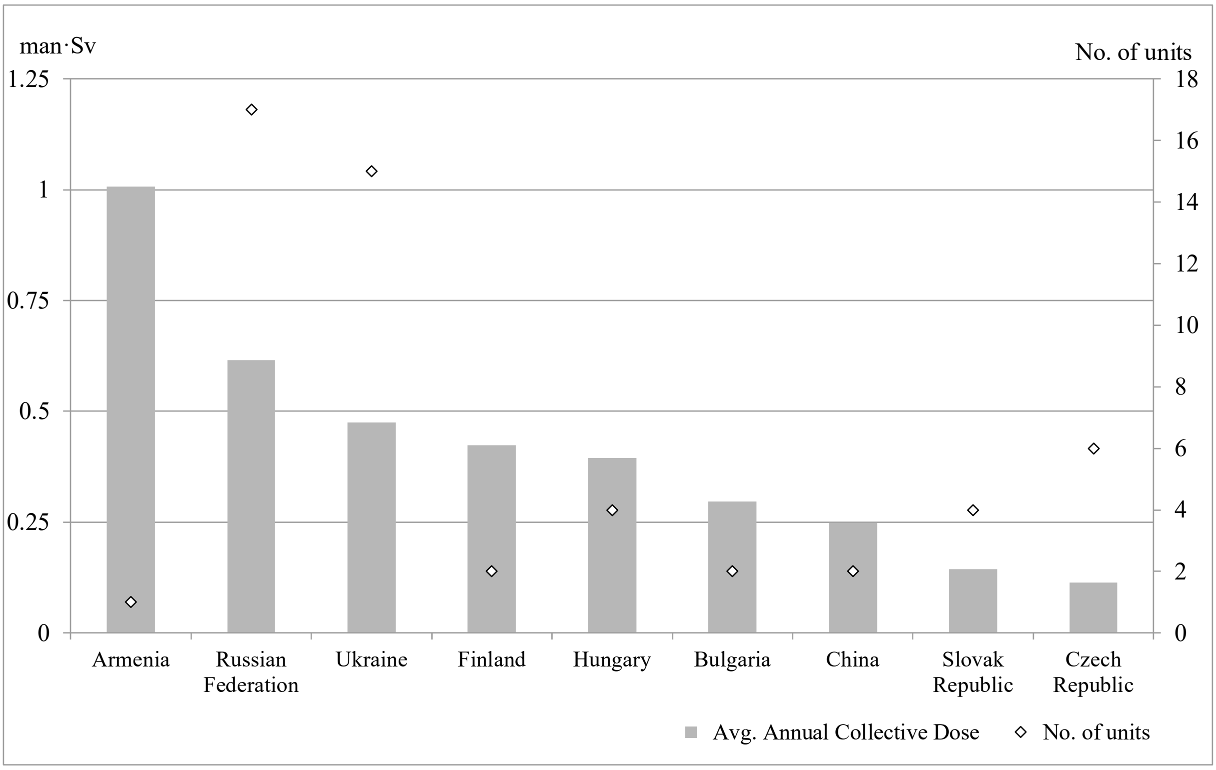


Figure 4. **2014 BWR average collective dose per reactor by country (man·Sv/reactor)**

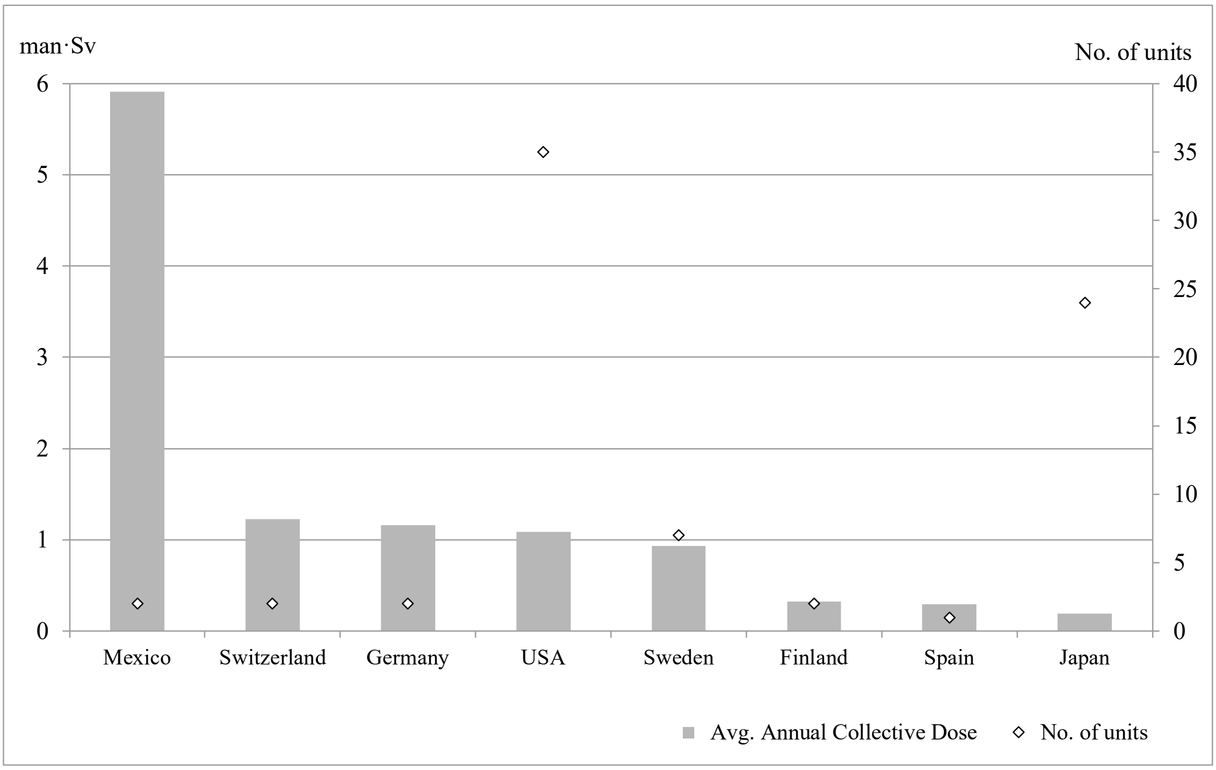
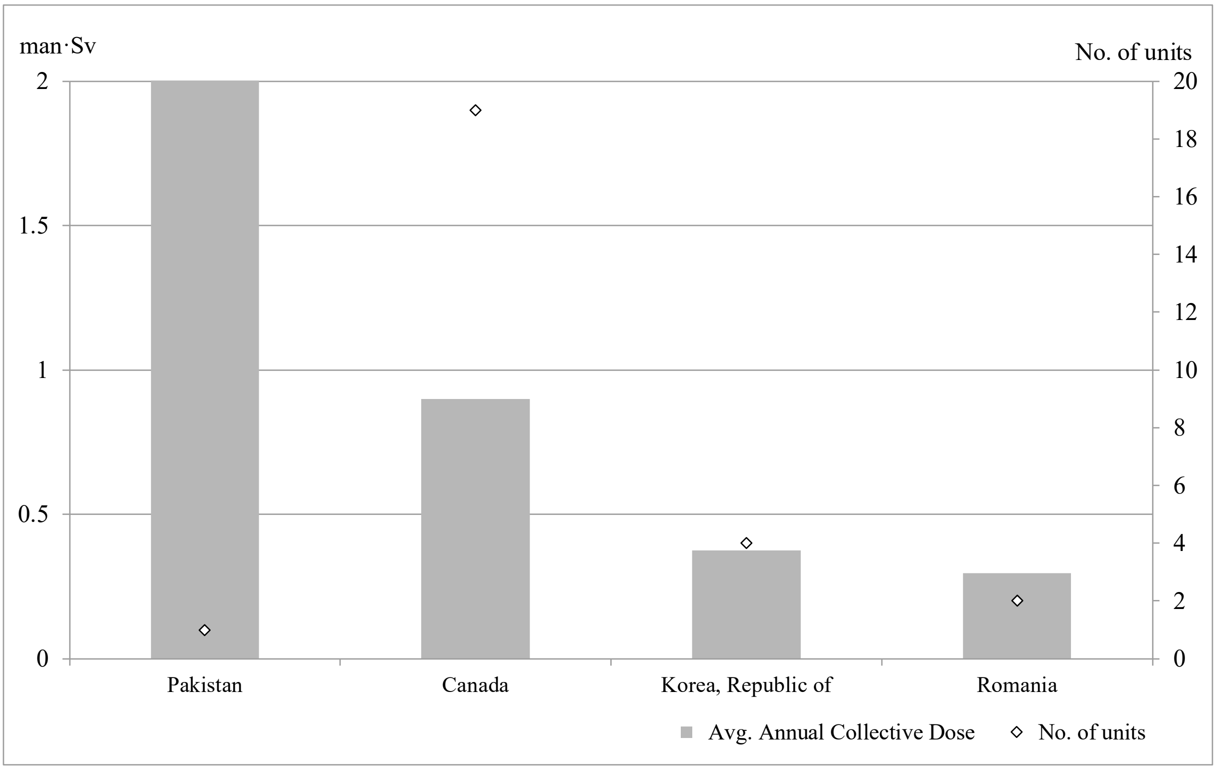


Figure 5. **2014 PHWR average collective dose per reactor by country (man·Sv/reactor)**



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

Table 3 provides information on 3-year rolling average annual collective dose per reactor, by country and reactor type for the period of 2010-2012 to 2012-2014. Figures 6-14 present the 3-year rolling average annual collective dose from 2000 to 2014 in different countries by taking into account the reactor types, including PWR, VVER, BWR and PHWR.

Table 3. **3-year rolling average annual collective dose per reactor, by country and reactor type, 2010-2012 to 2012-2014 (man·Sv/reactor)**

	PWR			VVER			BWR		
	/10-/12	**/11-/13**	**/12-/14**	**/10-/12**	**/11-/13**	**/12-/14**	**/10-/12**	**/11-/13**	**/12-/14**
Armenia				0.97	0.96	0.88			
Belgium	0.33	0.30	0.26						
Brazil	0.32	0.31	0.30						
Bulgaria				0.29	0.23	0.23			
Canada									
China	0.46	0.61	0.59		0.23	0.24			
Czech Republic				0.12	0.12	0.12			
Finland				0.67	0.49	0.51	0.43	0.39	0.33
France	0.67	0.73	0.73						
Germany	0.42	0.32	0.23				0.85	0.92	1.11
Hungary				0.47	0.51	0.45			
Japan	0.88	0.46	0.21				0.85	0.51	0.23
Korea, Republic of	0.47	0.50	0.44						
Mexico							3.37	1.93	3.62
Netherlands	0.41	0.48	0.46						
Pakistan	0.31	0.28	0.40						
Romania									
Russian Federation				0.64	0.60	0.58			
Slovak Republic				0.16	0.15	0.15			
Slovenia	0.60	0.77	0.78						
South Africa, Rep. of	0.61	0.54	0.45						
Spain	0.43	0.45	0.42				0.93	1.50	0.93
Sweden	0.81	0.83	0.59				0.89	0.82	0.77
Switzerland	0.44	0.38	0.35				1.27	1.23	1.28
Ukraine				0.61	0.57	0.53			
United Kingdom	0.28	0.32	0.26						
United States	0.59	0.52	0.49				1.30	1.27	1.16
Average	**0.61**	**0.55**	**0.50**	**0.51**	**0.48**	**0.45**	**1.11**	**0.96**	**0.87**

	PHWR			GCR		
	/10-/12	**/11-/13**	**/12-/14**	**/10-/12**	**/11-/13**	**/12-/14**
Canada	1.35	1.12	1.00			
Korea, Republic of	1.11	0.55	0.50			
Lithuania						
Pakistan	2.59	2.33	1.67			
Romania	0.35	0.30	0.34			
United Kingdom				0.05	0.06	0.06
Average	**1.29**	**1.02**	**0.90**	**0.05**	**0.06**	**0.06**

	/09-/11	**/10-/12**	**/12-/14**
Global Average	**0.74**	**0.61**	**0.55**

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

Figure 6. **3-Year rolling average collective dose by country from 2000 to 2014 for PWRs (1)**

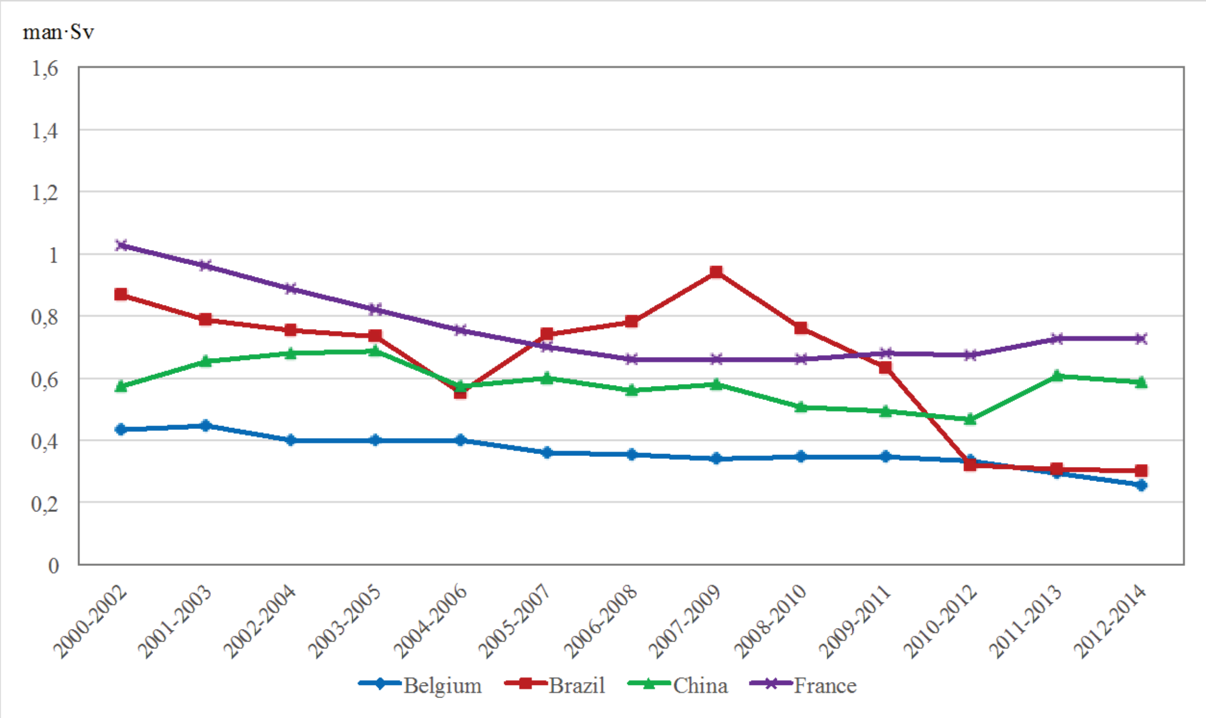


Figure 7. **3-Year rolling average collective dose by country from 2000 to 2014 for PWRs (2)**

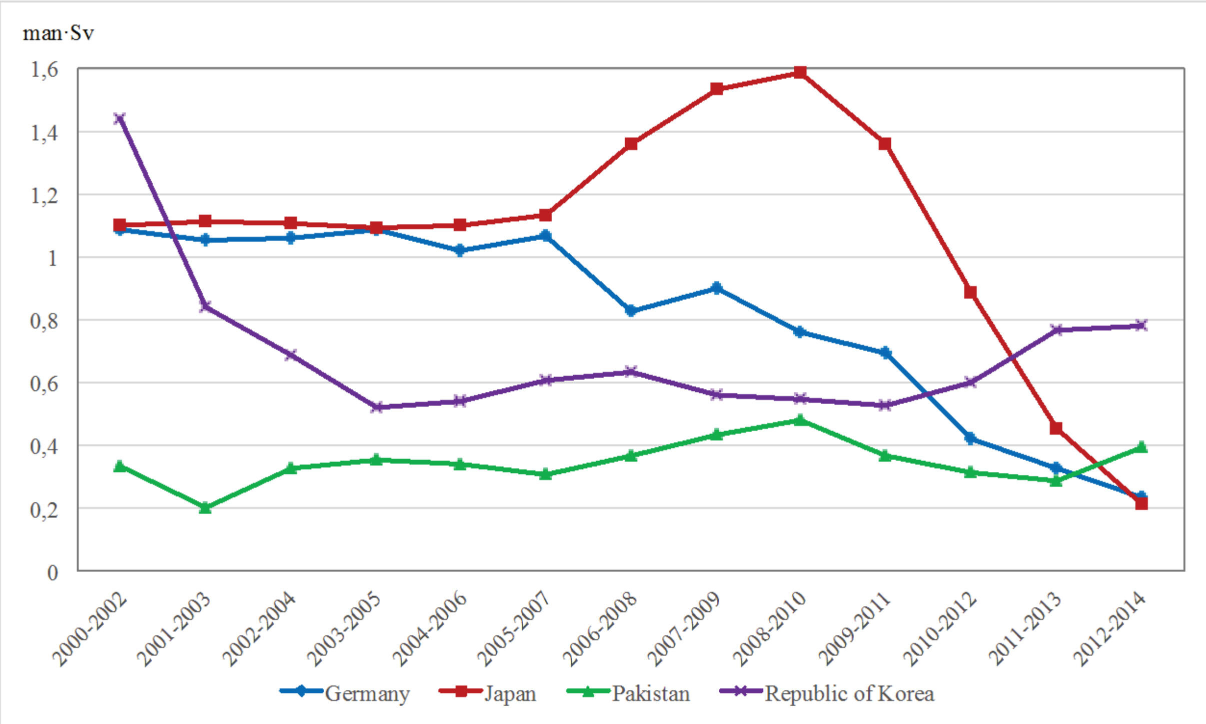


Figure 8. **3-Year rolling average collective dose by country from 2000 to 2014 for PWRs (3)**

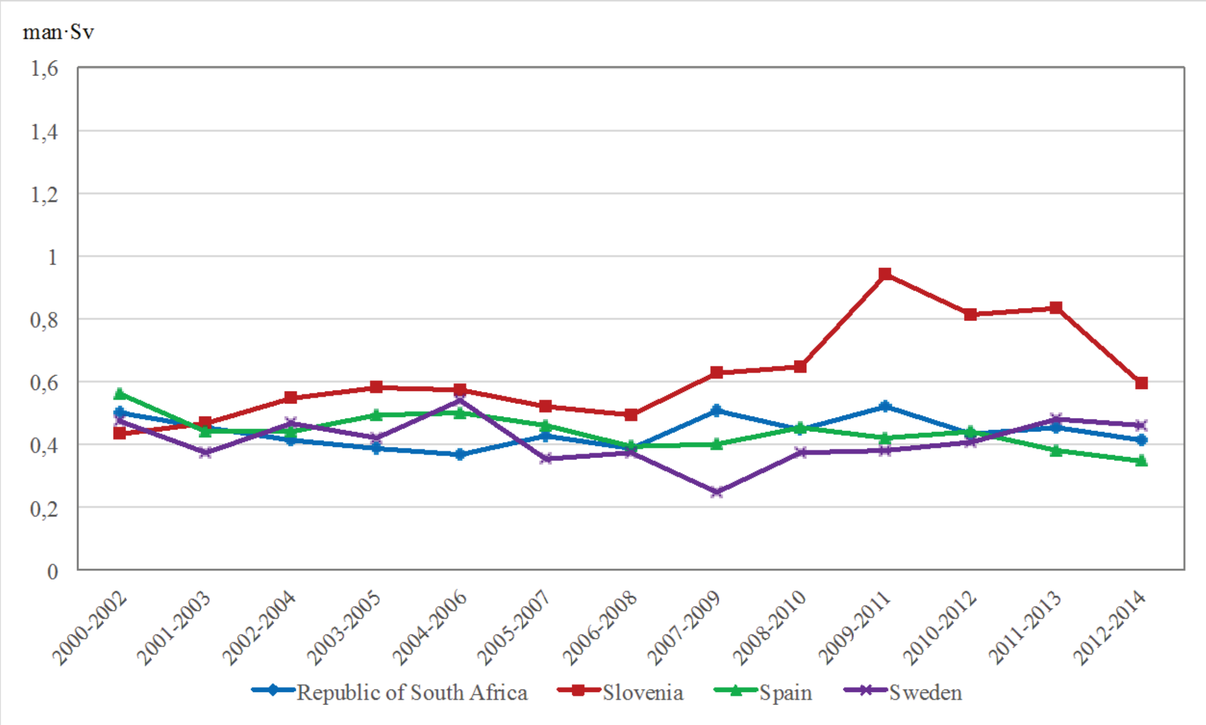


Figure 9. **3-Year rolling average collective dose by country from 2000 to 2014 for PWRs (4)**

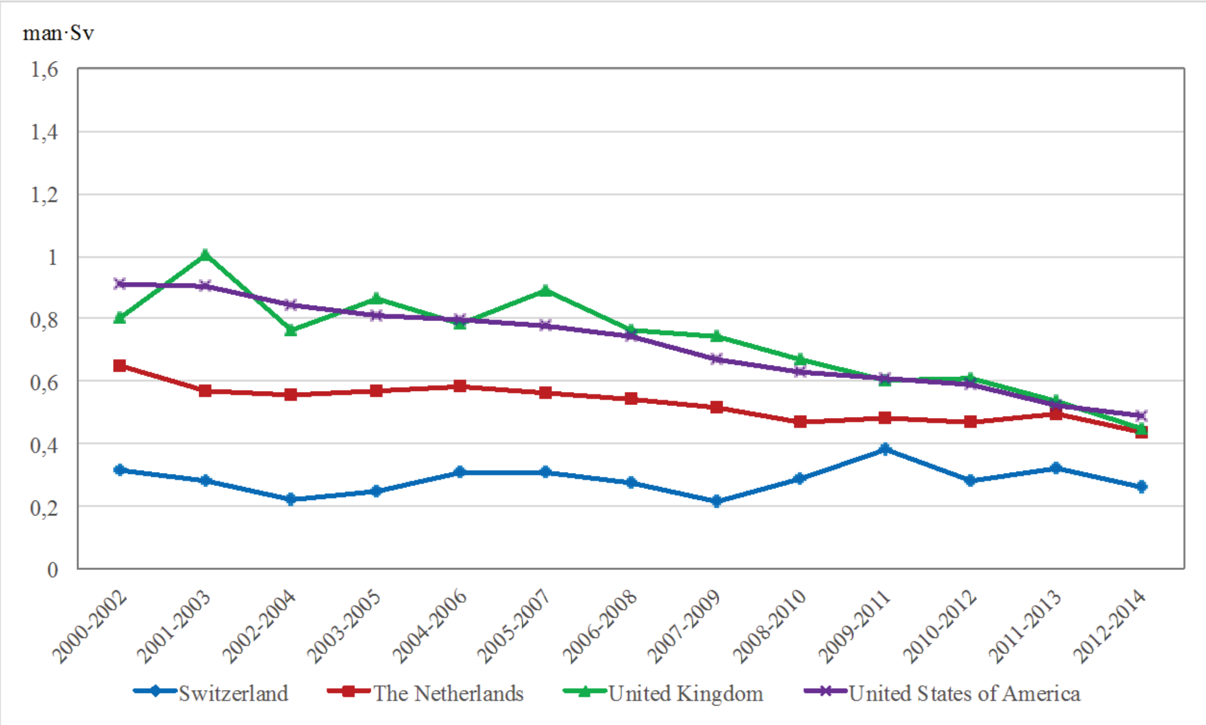


Figure 10. **3-Year rolling average collective dose by country from 2000 to 2014 for VVERs (1)**

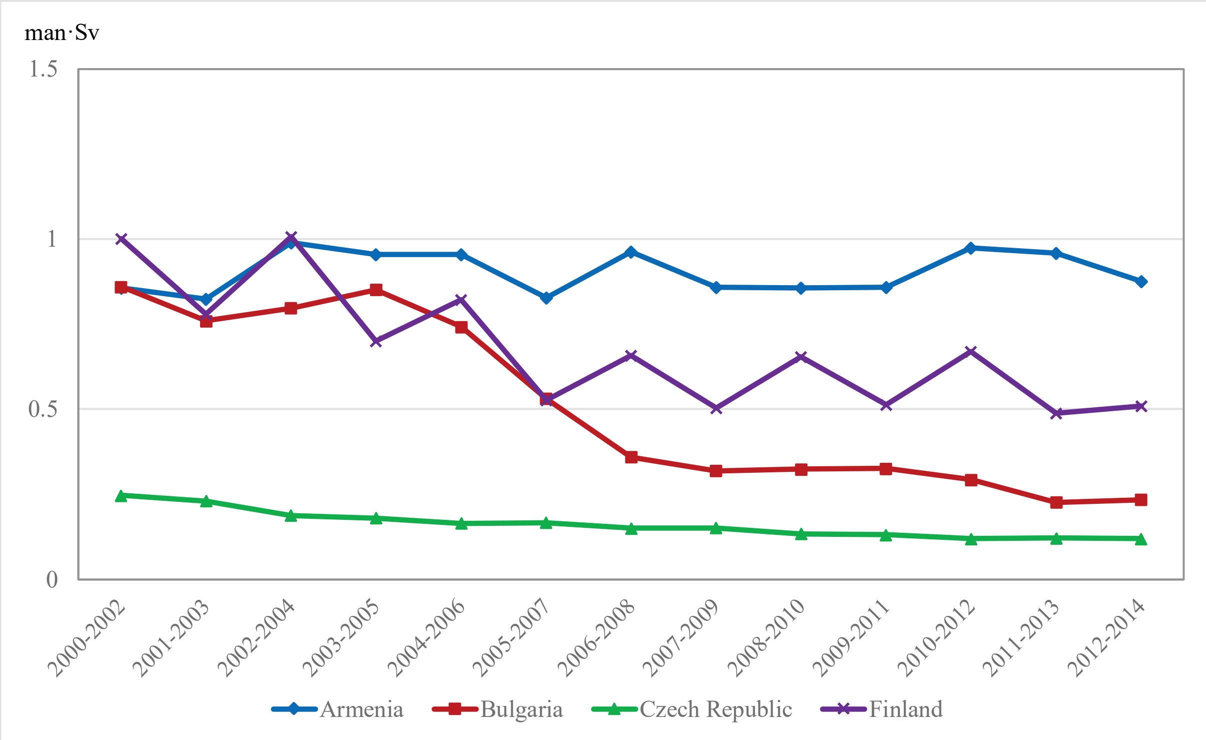


Figure 11. **3-Year rolling average collective dose by country from 2000 to 2014 for VVERs (2)**

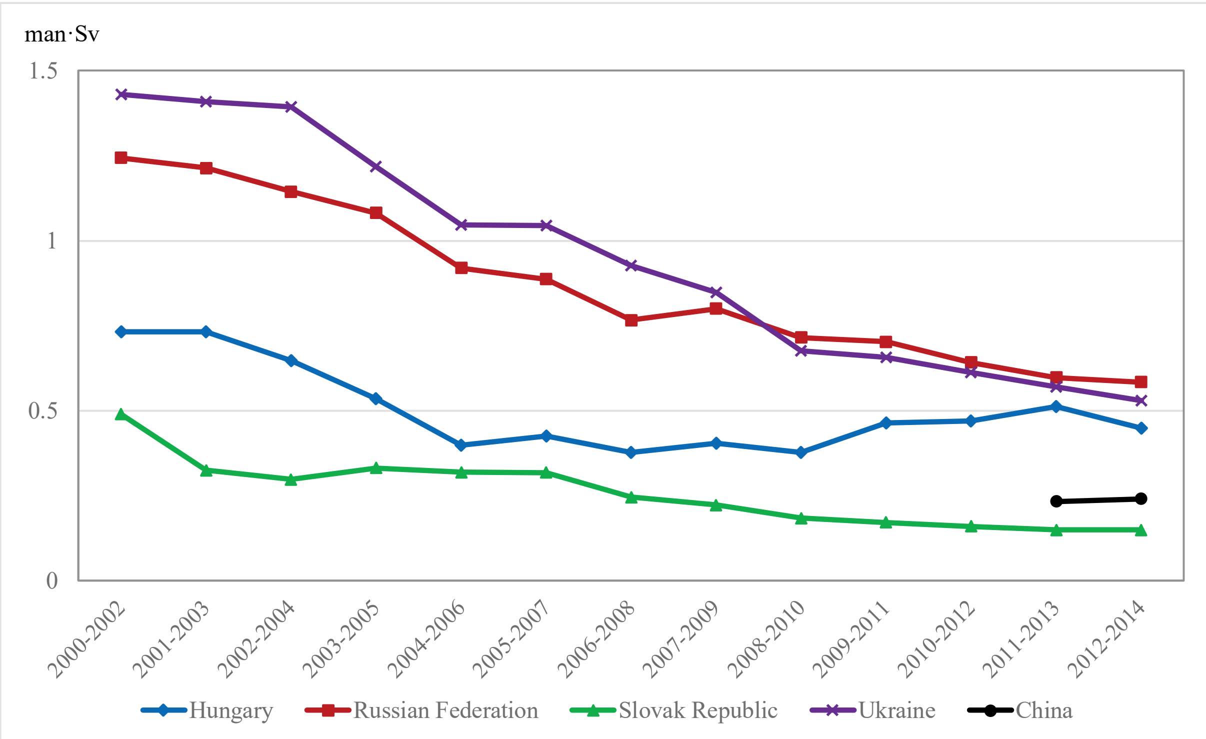


Figure 12. **3-Year rolling average collective dose by country from 2000 to 2014 for BWRs (1)**

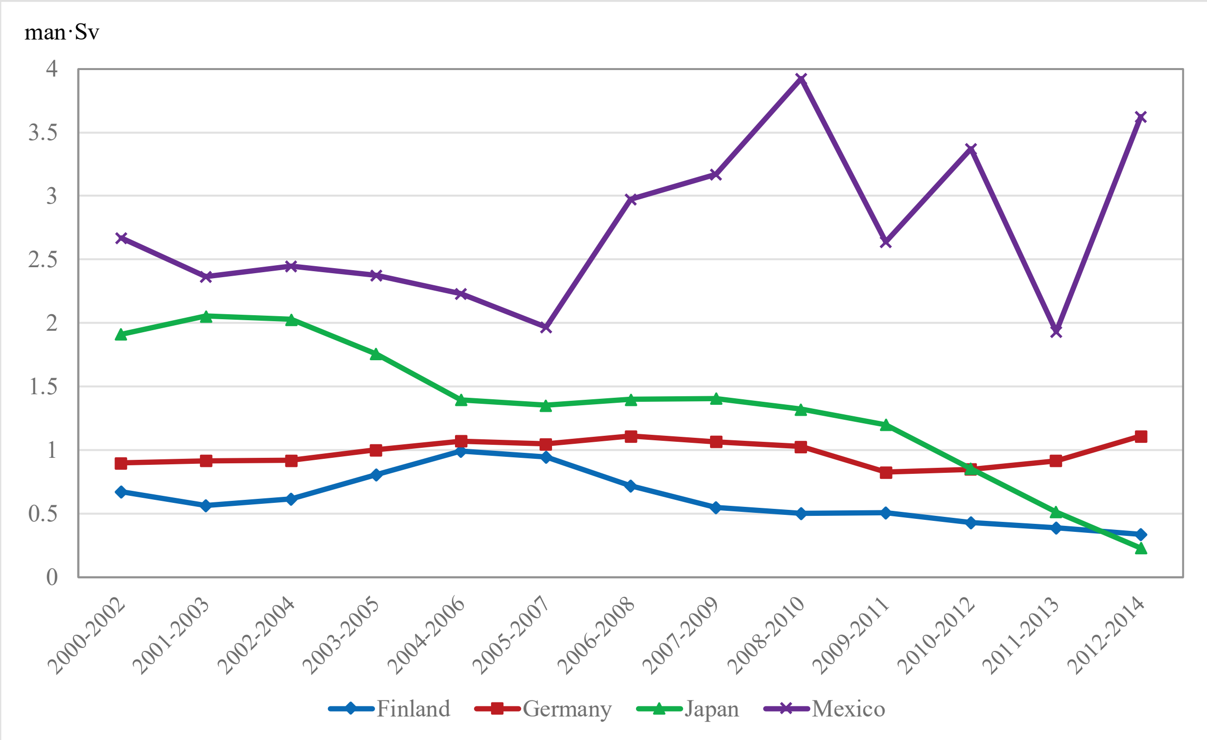


Figure 13. **3-Year rolling average collective dose by country from 2000 to 2014 for BWRs (2)**

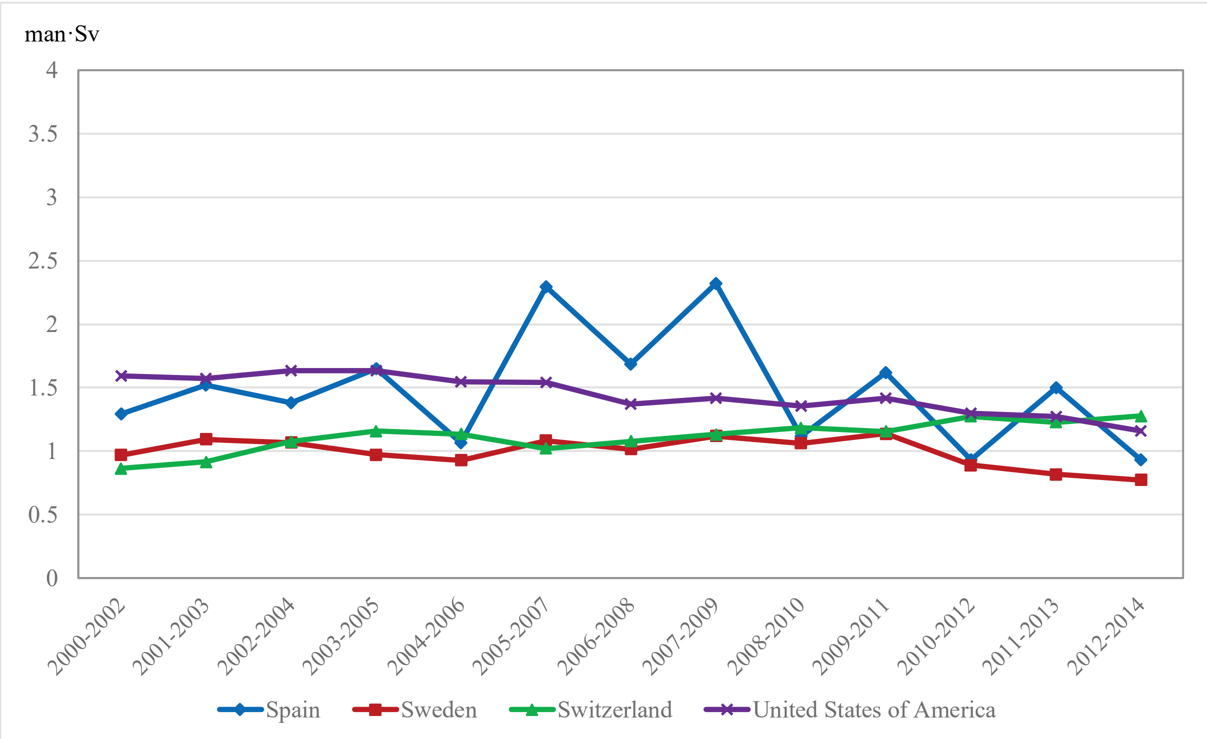
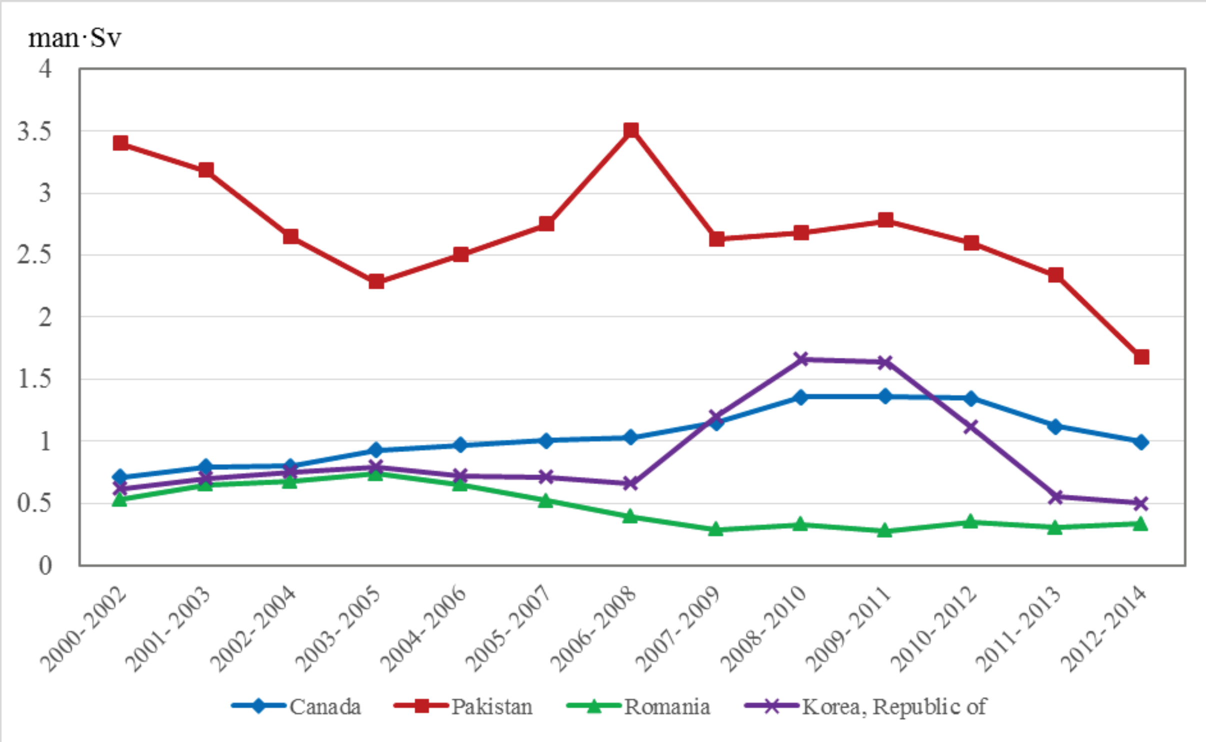


Figure 14. **3-Year rolling average collective dose by country from 2000 to 2014 for PHWRs**



2.2 Occupational exposure trends: Definitely shutdown reactors

In addition to information from operating reactors, the ISOE database contains dose data from 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 2012-2014 period. These reactor units are generally of different type and size, at different phases of their decommissioning programmes, and supply data at various levels of detail. For these reasons, and because these figures are based on a limited number of shutdown reactors, definitive conclusions cannot be drawn. Under the ISOE Working Group on Data Analysis, work continued in 2013 aimed at improving data collection for shut down and decommissioned reactors in order to facilitate better benchmarking.

Table 4 provides average annual collective doses per unit for definitely shutdown reactors by country and reactor type for 2012-2014, 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 2010-2014 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, 2012-2014 (man·mSv/reactor)**

		2012		2013		2014	
		No.	**Dose**	**No.**	**Dose**	**No.**	**Dose**
PWR	France	1	275.6	1	189.3	1	88.8
	Germany	7	130.5	7	139.7	7	159.0
	Italy	1	3.1	1	5.2	1	7.3
	Spain	1	308.0	1	468.9	1	591.3
	United States	6	127.1	12	47.3	10	83.4
	Average	*16*	*141.4*	*22*	*100.4*	*20*	*132.0*
VVER	Bulgaria	4	10.1	4	3.3	4	1.8
	Russian Federation	2	79.2	2	49.6	2	44.7
	Slovak Republic*	2	4.2				
	Average	*8*	*25.9*	*6*	*18.7*	*6*	*16.1*
BWR	Germany	5	98.5	5	80.2	5	61.9
	Italy	2	18.4	2	34.2	2	17.4
	Japan**	2	41.2	2	64.2	2	40.6
	Netherlands	1	0	1	0	1	0
	Spain	-	-	1	31.2	1	102.0
	Sweden	2	20.0	2	3.5	2	3.9
	United States	4	59.1	5	55.7	3	60.6
	Average	*16*	*55.5*	*18*	*50.8*	*16*	*44.8*
GCR	France	6	7.4	6	8.2	6	23.3
	Germany	1	0	1	0	1	0
	Italy	1	0.2	1	2.2	1	7.7
	Japan	1	70.0	1	10	1	0
	Spain	1	0	1	0	1	0
	United Kingdom	19	56.0	19	57.3	19	52.0
	Average	*29*	*40.63*	*29*	*39.66*	*29*	*39.2*
PHWR	Canada	1	0	3	17.3	3	36.3
LWGR	Lithuania	2	264.9	2	304.8	2	304.4
LWCHWR	Japan	1	148.8	1	134.1	1	29.8

* Withdrawal of JAVYS NPP

** without Fukushima Daiichi NPP

Figure 15. **Average annual collective dose by country from 2010 to 2014 for PWRs**

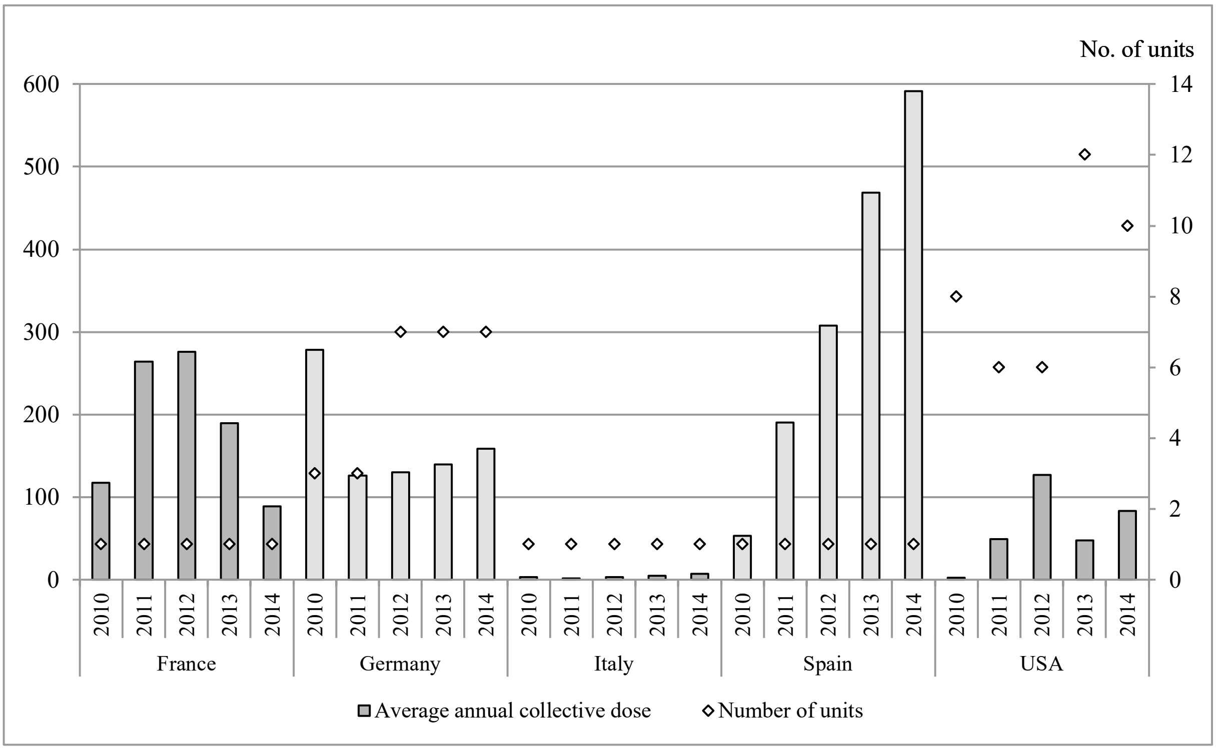


Figure 16. **Average annual collective dose by country from 2010 to 2014 for VVERs**

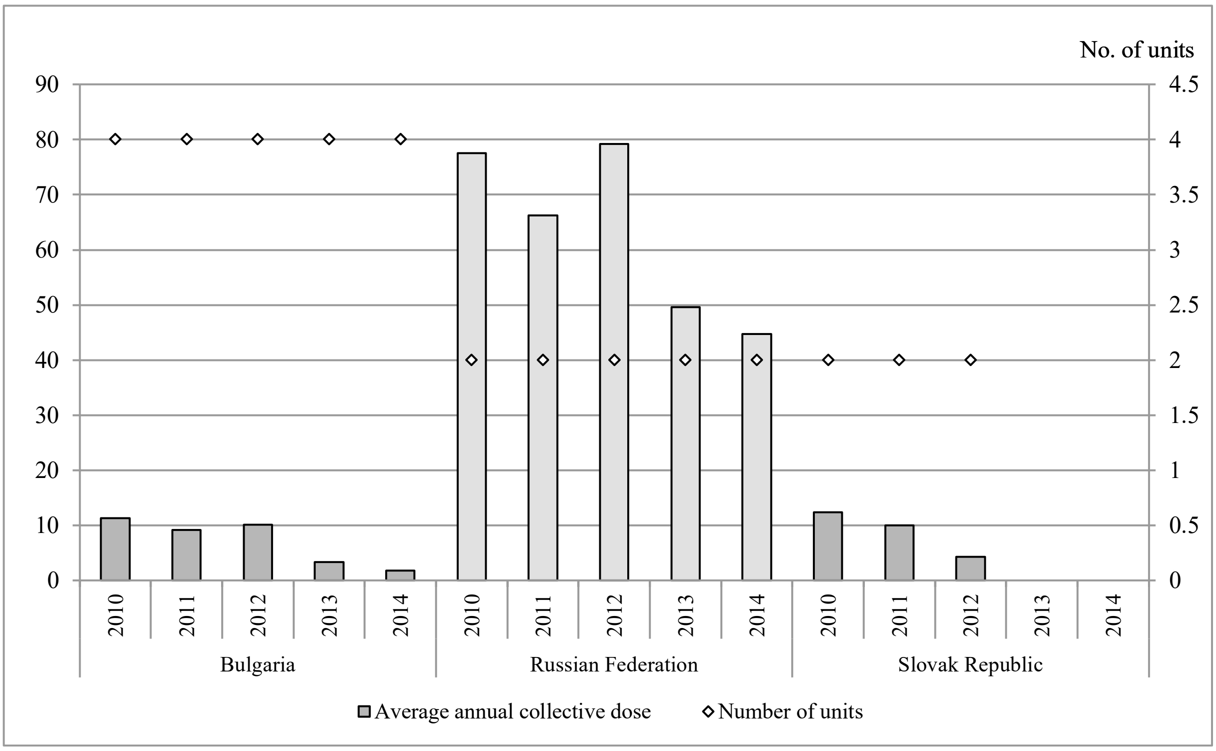


Figure 17. **Average annual collective dose by country from 2010 to 2014 for BWRs**

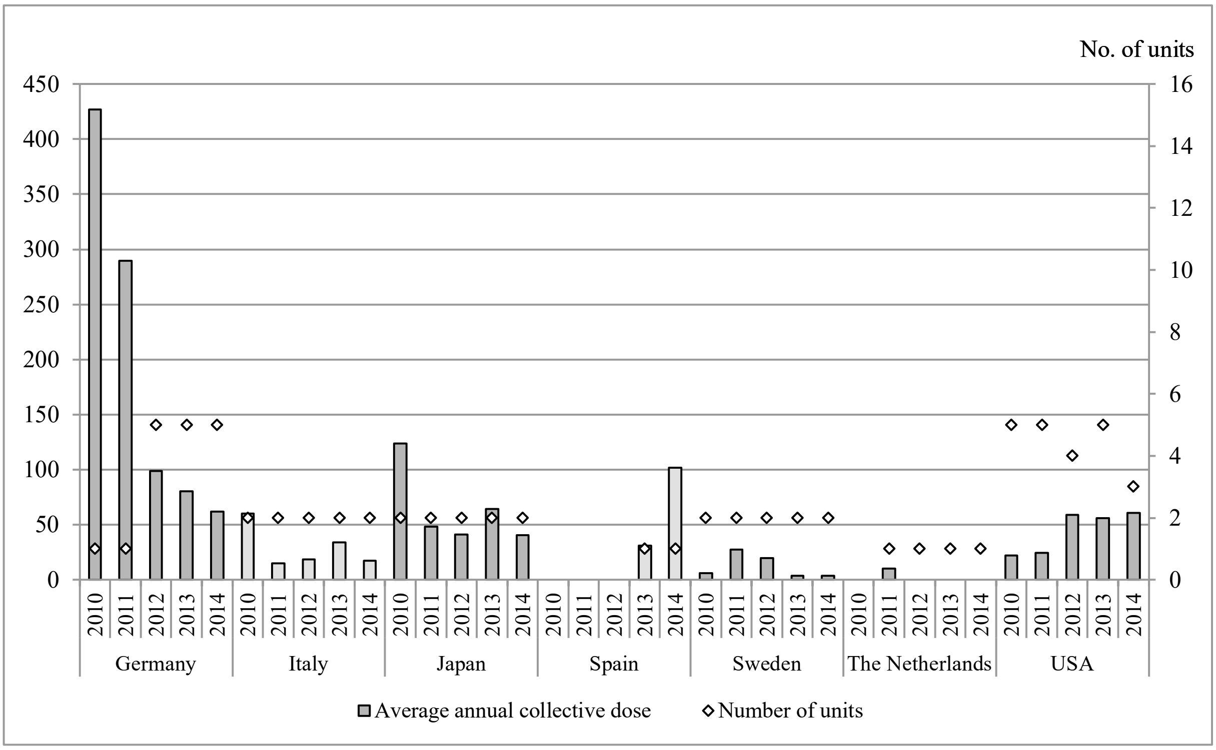
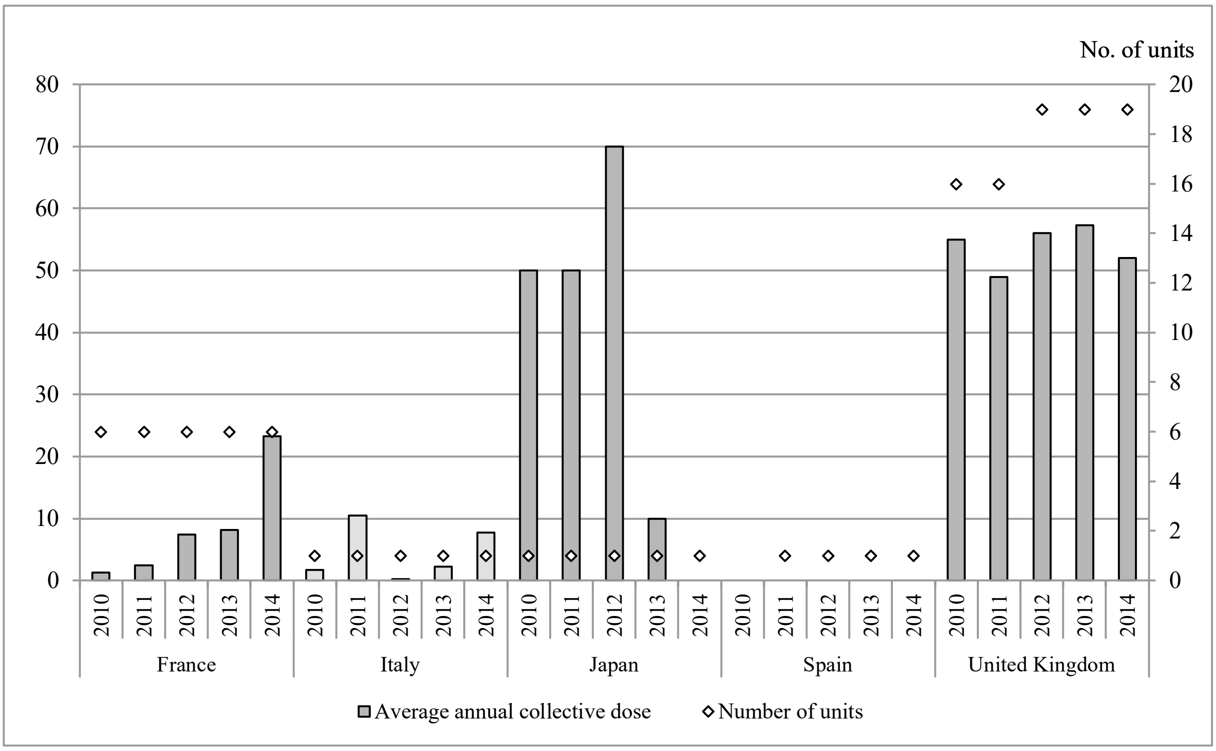


Figure 18. **Average annual collective dose by country from 2010 to 2013 for GCRs**



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 2014. Such information serves to identify broad trends and helps to highlight specific areas where further study might reveal relevant experiences or lessons. However, to help to enhance this numerical data, this section provides a short list of important events which took place in ISOE participating countries during 2014 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.

ARMENIA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	1	1007
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	1	*No separate data is available*

2) Principal events of the year 2014

Summary of national dosimetric trends

For the year 2014, the dosimetric trend at the Armenian NPP was an increase, and that was a result of work in the controlled area, such as work with spent fuel removal and transportation, work with activated material in reactor equipment, nondestructive testing of pipes and other control work during the outage, decontamination work and the work with radioactive wastes. Due to extra repair and maintenance work not planned for 2014 outages, there was an increase in the collective dose up to 1.01Sv for 2014.

1. Due to various national reporting approaches, dose units used by each country have not been standardised.

The maximum individual dose was 18.2 mSv. The collective dose for outside workers was 0.079 man•Sv. The value for outside workers dose is very small, because the facility operator has its own repair workers.
The collective dose for repair and outage was planned in terms of dose constraints, and the real doses constituted 87% of planned doses.

- *Events influencing dosimetric trends*

  No significant events (accidental situations) were registered for the impact on dosimetric trends.

- *Number and duration of outages*

  For 2014, one outage with a 90 (full refuelling) day duration was performed.

- *New plants on line/plants shut down*

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

- *Major evolutions*

  The "Dose reduction program including ALARA culture implementation" for 2014 was established, and improvement of the old radiation control system is almost finished. The new radiation control pass system is already in operation.

- *Component or system replacements*

  During the outage in 2014, no components or systems were replaced.

- *Safety-related issues*

  Some safety-related issues still exist due to medium activity radioactive waste treatment and storage activities. The National Strategy for radioactive waste management in Armenia has been started with EU assistance programs.

- *Unexpected events*

  For the year 2014, no unexpected events were registered.

- *New/experimental dose-reduction programmes*

  No new/experimental dose-reduction programmes were applied for the year 2014.

- *Organisational evolutions*

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

For 2015

- *Issues of concern*

  In 2015, the modification of some safety systems are implemented due to life extension and modernisation program implementation.

- *Technical plans for major work*

Modernisation of the Radiation Control System for airborne and liquid releases; modernisation and safety improvement measures of some safety systems (which are included in LTE programme).

- *Regulatory plans for major work*

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

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

BELGIUM

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	7	257

2) Principal events of the year 2014

- *Events influencing dosimetric trends*

  a) Unplanned shutdown for Doel 3/Tihange 2 on 26 March 2014, due to the unexpected results related to the issue of indications (Hydrogen flakes) in the reactor vessels. The reactors had not been restarted at the end of 2014.

  b) Unplanned shutdown for Doel 4 on 5 August 2014, due to sabotage to the turbine. The reactor was restarted by the end of 2014.

  c) As in 2013, concrete conditioning of the radioactive waste at Doel has been stopped, after the discovery of an unexpected alkali-silicate reaction.

  d) August– September 2014: the risk of black out during the winter of 2014-2015 is outlined by the grid regulator. This induced prompt revision of the outage scope and planning for Tihange 1 in 2014 and Tihange 3 in 2015.

  e) Detailed collective dosimetry (outage information):

2014	Doel 1	Doel 2	Doel 3	Doel 4	Tihange 1	Tihange 2	Tihange 3
Outage dates	3/1 - 20/1	13/6 - 3/7	26/4 - 7/6	14/3 - 12/4	30/8 - 20/10	28/4 - 15/7	*
Outage man.mSv	145.6	128.2	334.9	206.4	469.8	182.0	*
Total man.mSv	335.8		343.0	255.6	512.7	273.0	29.8

- *New/experimental dose-reduction programmes*

  There has not yet been any impact from the Zinc injection in the primary circuit of Doel 3.

- *Organisational evolutions*

  Tihange 3, Oct 2014: test phase of RCA access using the Doel protocol (protective overclothes and not an entire change of clothes). This test phase was successful, such that Tihange has the objective to make it effective for all units in 2015.

- *Regulatory requirements*

  The National Safety Authority kicked off the project to revise the base regulation for protection against ionising radiations, following the publication of the Euratom BSS.

BRAZIL

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	2	342.4

2) Principal events of the year 2014

- *Events influencing dosimetric trends*

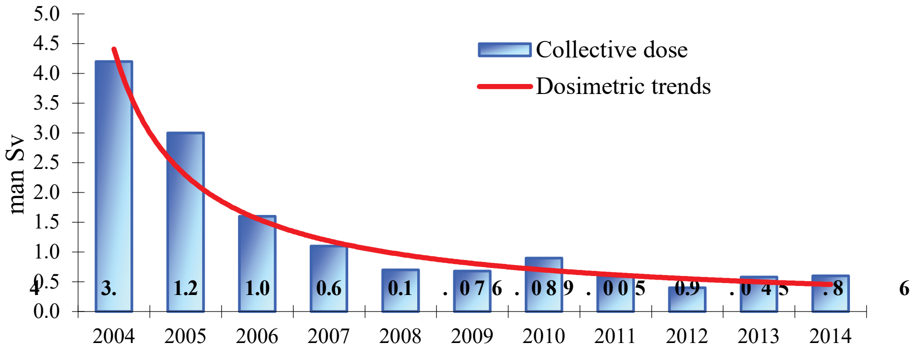
  Replacement of Angra 1 reactor vessel head.

BULGARIA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER-1000	2	297
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER-440	4	1.8

2) Principal events of the year 2014



Unit No.	**Outage duration - days**	**Outage information**
Unit 5	36 d	Refuelling and maintenance activities
Unit 6	39 d	Refuelling and maintenance activities

A modernisation of the steam generators separation system of Unit 6 was performed in 2014. A radiation protection programme for this work has been developed. A mock-up facility for worker training has been built. An ALARA co-ordinator was assigned to control the activities and to help workers during the work. As a result, the actual exposure was 25% lower than the planned exposure.

CANADA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
CANDU	19	900
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
CANDU	3	109*

*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 & Gentilly -2.

2) Principal events in ISOE participating countries

For 2014 national dosimetric trends:

- 17.08 Person-Sv for 19 operating units in 2014;
- Average annual dose per unit 0.90 person-Sv in 2014.

The total collective effective doses and the average collective dose per unit at operating Canadian nuclear plants increased slightly in 2014 (approximately 6%) from 2013. However, the trends remain steady since 2010. The increase in occupational dose reflects the type of scope of work being performed and values are noted to be less than when refurbishment activities were ongoing at Pt. Lepreau and Bruce Power Units 1, 2.

The average calculated dose for 2014 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.

In 2014, approximately 89% of the collective dose was due to outage activities, and most of the radiation dose received by workers came from external exposure. Approximately 11% of the dose received was from internal exposure, with tritium being the main contributor to the internal dose of exposed workers.

The implementation of ALARA initiatives at Canadian Nuclear Power Plants (NPPs) and improved work planning and control, continue to contribute to the reductions in the annual Canadian collective dose. Distribution of annual effective doses to workers at Canadian NPPs showed that approximately 85%of the workers received an annual effective dose below 1 mSv.

3) Principal Events in Canada

Bruce Power

In 2014, all eight units were operational at Bruce Nuclear Generating Station. Bruce A, Units 1-4 had 268 outage days in 2014. Bruce B, Units 5-8 had 133 outage days in 2014.

Bruce A, Units 1-4 routine operations dose for 201 was 0.367 person-Sv and the maintenance outage dose was 3.385 person-Sv (one planned outage and forced outages). The internal dose for Bruce A Units 1-4 was 0.260 person-Sv and the external dose was 3.492 person-Sv. The total collective dose for Bruce A Units 1-4 was 3.752 person-Sv which resulted in an average collective dose 0.938 person-Sv/unit.

Bruce B Units 5-8 routine operations dose was 0.547 person-Sv. The outage dose was 4,632 person-Sv in 2014. The internal dose was 0.228 person-Sv. The external dose was 4,951 person-Sv. The total dose was 5,179 person-Sv which resulted in an average collective dose 1.295 person-Sv/unit.

Darlington Units 1-4

In 2014, all four units were operational at Darlington Nuclear Generating Station with a total of 104 outage days. Outage activities accounted for approximately 82% of the total collective dose at Darlington. Internal dose accounted for approximately 15% of the total collective dose.

Darlington Units 1-4 had routine operations dose of 0.391 person-Sv. The total outage dose was 1.813 person-Sv. The internal dose for 2014 was 0.338 person-Sv. The external dose was 1.866 person-Sv which resulted in an average collective dose 0.551 person-Sv/unit. The outage dose was a decrease from 2013. This was primarily due to fewer planned and forced outages resulting from Darlington's three year unit outage cycle.

Pickering Nuclear

In 2014, Pickering Nuclear Generating Station had six units in operation (Units 1,4,5-8), with a total of 405 outage days. Units 2 and 3 remained in safe storage state.

Outage activities accounted for approximately 87% of the collective dose at Pickering Nuclear Generating Station. Internal dose accounted for approximately 17% of the total collective dose.

The routine collective dose for operational units was 0.721person-Sv in 2014.

The outage dose for the operational units was 4,686 person-Sv. The internal dose was 0.915 person-Sv. The external dose was 4.491 person-Sv. The total dose was 5.406 person-Sv which resulted in an average of collective dose 0.901 person-Sv/unit.

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

Point Lepreau

Point Lepreau is a single unit CANDU station. In 2014, Point Lepreau was fully operation with a total of 66 outage days. Outage activities accounted for approximately 73% of the total collective dose at Pt. Lepreau. Internal dose accounted for approximately 15% of the total collective dose.

The routine collective dose for operational activities was 0.148 person-Sv in 2014.

The internal dose was 0.077 person-Sv. The external dose was 0.468 person-Sv. The total dose was 0.545 person-Sv.

The reduction in the collective dose is attributed to the reduction in the source term due to the installation of new plant components.

Gentilly-2

Gentilly-2 is a single unit CANDU station. In 2014, Gentilly-2 continued transition from operation to safe storage state. The reactor was shut down in December 28, 2012.

The 2014 station collective dose is only attributed to safe storage transition activities.

The total collective effective dose in 2014 was 0.109 man-Sv. This dose was mainly due to draining the moderator and heat transport systems, installation of a liner in the irradiated fuel bay and transfer of purification resins and used fuel).

The internal collective dose in 2014 was 0.038 person. Sv. The external dose was 0.017 person Sv. The total site collective dose in 2014 was 0.109 person Sv.

4) Major 2014 Highlights

- *Regulatory Update*

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

  Maximum individual dose effective dose received at a Canadian NPP in 2014 was 20.17 mSv. Distribution of annual effective dose to workers at Canadian NPPs showed that on the average approximately 85% of workers received an annual dose below 1 mSv.

- *Safety-related issues*

  No safety-related issues were identified in 2014.

- *Decommissioning Issues*

  Gentilly-2 continued decommissioning activities in 2014.

- *New Plants under construction/plants shutdown*

  No Units under construction in 2014.
  No Units were shutdown in 2014.

5) Conclusions

The 2014 average collective dose for the Canadian fleet was 0.90 person-Sv, nearly achieving the CANDU WANO dose target of 0.80 person-Sv. 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.

Outages accounted for approximately 89% of the total collective dose. Internal dose contributed up to 11% of the total collective dose with tritium the main dose contributor.

ALARA initiatives such as improved shielding, source term reduction activities and improved work planning have contributed to an overall reduction in collective dose per unit across the Canadian nuclear industry.

CHINA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	15	409.7
VVER	2	248.5
PHWR	2	360.5

2) Principal events of the year 2014

- *Events influencing dosimetric trends*

  In 2014, there were no INES 2 or above events in any of the operational nuclear power plants. The monitoring index over the year showed that the integrity of three safety barriers remained sound.

  - In operational nuclear power plants, the dose information in the table above is summarised only for 19 reactors operating before the end of 2014. In those reactors, refueling outages were completed for 12 of 15 PWR units, 1 of 2 PHWR units, and 2 of 2 VVER units in 2014.
  - Four new PWR units (Hongyanhe 1-2 and Ningde 1-2) began to operate in 2014.

- *New/experimental dose-reduction programmes*

  In the operation of nuclear power plants, annual collective dose is mainly from outages. The ALARA programme is well implemented in the design and operation of all nuclear power plants. Average annual collective dose per unit decreased slightly in comparison with that for 2013, and stayed at a low level.

- *Regulatory requirements*

  - In December 2014, a Nuclear Safety Culture Policy Statement was jointly issued by National Nuclear Safety Administration (NNSA), National Energy Administration, and State Administration of Science, Technology and Industry for National Defence. It sets forth guidance on establishing and maintaining a positive nuclear safety culture for individuals and organisations.
  - NNSA accelerated the legislation progress of the Nuclear Safety Act by the study and development of related specific subjects.

3) Report from Authority

NNSA Annual Report in 2014 (Chinese) has been drafted and will be published soon.

CZECH REPUBLIC

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	6	113

2) Principal events of the year 2014

- *Events influencing dosimetric trends*

  The main contributions to the collective dose were 6 planned outages.

NPP, Unit	Outage information	CED [man.mSv]
Temelin, Unit 1	64 days, standard maintenance outage with refuelling	115
Temelin, Unit 2	49 days, standard maintenance outage with refuelling	53
Dukovany, Unit 1	26 days, standard maintenance outage with refuelling	86
Dukovany, Unit 2	31 days, standard maintenance outage with refuelling	57
Dukovany, Unit 3	30 days, standard maintenance outage with refuelling	89
Dukovany, Unit 4	34 days, standard maintenance outage with refuelling	95

  The 2014 collective dose (0.419 man.Sv) of Dukovany NPP was the lowest in the last 5 years, mainly due to short refuelling outages.

  CED increased in comparison with the previous year mainly due to implementation of the post-Fukushima National Action Plan during the outage of Unit 1 at Temelin NPP.

  There were no unusual or extraordinary radiation events in the year 2014 at Temelin NPP or Dukovany NPP.

  Very 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 2014 the activities continued of two working groups (WG) established by the RP department in 2013:

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

- *Regulatory requirements*

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

3) Report from Authority

The State Office for Nuclear Safety (SUJB) carried out 50 inspections of radiation protection at NPPs and contractors in 2014. No serious shortcomings were identified.

SUJB continued the evaluation of the implementation of measures set out in the Post-Fukushima National Action Plan. Further, SUJB assessed the number of projects of reconstruction and modernisation planned by company ČEZ for both NPPs, e.g. reconstruction of the radiation monitoring system in all units of the Dukovany NPP or implementation of important measurements into the Post Accident Monitoring System in the Dukovany NPP.

During 2014 SUJB continued in preparation of “New” Atomic Act and its implementing regulations. Draft law was submitted to the Government of the Czech Republic at the end of 2014. Preparation of implementing regulations continues in 2015.

FINLAND

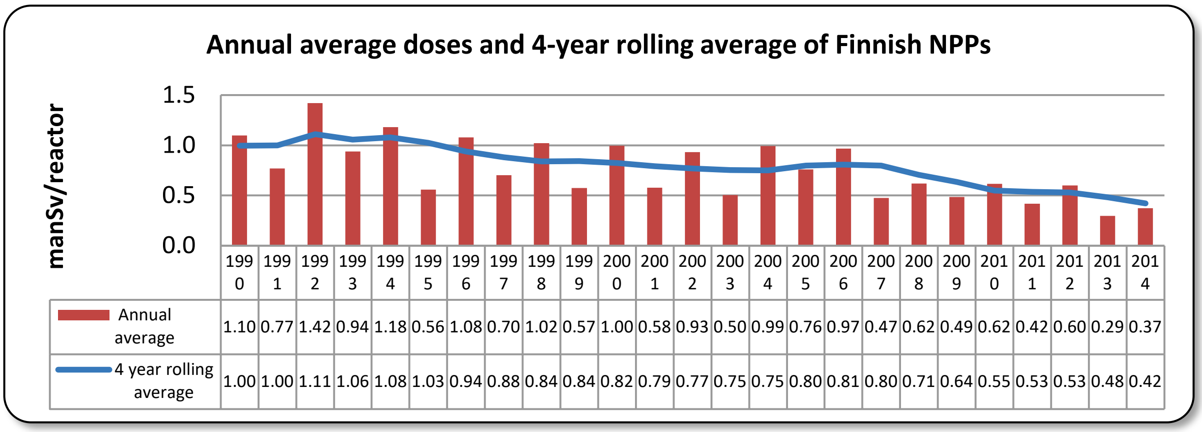
1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	2	423.5
BWR	2	321.5
All types	4	372.5

2) Principal events of the year 2014

Summary of national dosimetric trends

The annual collective dose strongly depends on the length and type of annual outages. The 2014 collective dose (1.49 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.



Olkiluoto

The annual outage of 2014 at the Olkiluoto 1 unit was a maintenance outage. The duration of the outage was about 17 days. In addition to refuelling, some maintenance activities were carried out, including the replacement of low-voltage switchgear in two subsystems, piping modifications in the auxiliary feed water system, installation of a new auxiliary transformer and several other modification and maintenance jobs. Apart from TVO's own personnel, just over 800 subcontractor employees were involved in the OL1 outage. The collective outage dose was 0.327 man.Sv.

The refuelling outage at the Olkiluoto 2 unit took about 8 days including refuelling, maintenance and repair work and some tests. Two main seawater pumps were replaced as well. Some 500 subcontractor employees were involved in the OL2 outage. The collective dose of the short refuelling outage was 0.187 man.Sv.

The maximum personal outage dose was 4.4 mSv.

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

At present, plant modifications are being planned and implemented to prepare the plant units for the renewal of the operating licence in 2018.

Loviisa

At unit 1 the outage was a normal short maintenance outage with a collective dose accumulation of 0.295 man.Sv and duration of about 21 days.

At unit 2 a long inspection outage was performed. The duration of the outage was about 35 days. Collective dose of the outage was 0.508 man.Sv mainly caused by primary side inspections, maintenance work and related auxiliary tasks (insulation, scaffolding, RP and cleaning). As a large modernisation project, the pressure control system of the primary circuit was renewed during the outage.

On both units the collective dose accumulation was the lowest in-plant operating history compared to similar outage types.

Source term reduction: After 5 years of studies, testing and approval, one antimony-free mechanical seal was installed in one of Loviisa 1's six primary coolant pumps in 2012. During the 2013 outage this seal was inspected and approved. Following that approval, all seals on both units were replaced during the outages of 2013 and 2014. Currently, radioactive antimony causes about 50 % of the doses at both units. After the seal replacement the dose rates of primary components are expected to decrease by nearly 50 % during the following three years, as the amount of antimony decreases in the primary coolant.

3) Report from Authority

Revision of the Nuclear Energy Act is in process to broaden STUK’s future legal mandate to issue binding regulations and licence conditions. This is one of the recommendations from the IRRS mission to Finland in 2012. An IRRS follow-up mission will take place in June 2015.

The renewal process of regulatory guides is completed, and the implementation of new requirements was started in 2014. The implementation process of the new BSS directive has also started, and it will require some up-dating of the current legislation.

The power companies of operating plants are planning modernisations as well as safety improvements, some of which are motivated by lessons learned from the Fukushima Daiichi accident. Also a periodic safety review at the Loviisa NPP has started and will be carried out by the end of 2015.

The Olkiluoto 3 unit is nearing commissioning and the operating license phase. Also at least one new unit is planned to enter the construction license phase by mid-2015.

In other sectors of the nuclear cycle there are also activities. One research reactor will be decommissioned, and the final repository for spent fuel is currently in the construction license phase.

FRANCE

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	58	720
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	88.8
GCR	6	23.3
GCHWR	1	11.4
SFR	1	3.4

2) Principal events of the year 2014

For 2014, the average collective dose of the French nuclear fleet (58 PWRs) is 0.72 man.Sv/unit (2014 annual EDF objective: 0.82 man.Sv/unit). The average collective dose for the 900 MWe 3-loop reactors (900 MWe – 34 reactors) is 0.88 man.Sv/unit and the average collective dose for the 4-loop reactors (1300 MWe and 1450 MWe – 24 reactors) is 0.48 man.Sv/unit.

Type and number of outages

Type	Number
ASR – short outage	23
VP – standard outage	18
VD – ten-year outage	7
No outage	10
Forced outage	1

Specific activities

Type	Number
SGR	1
RVHR	0

The outage collective dose represents 81% of the total collective dose. The collective dose received when the reactors were operating represents 19% of the total collective dose. The collective dose due to neutron is 0.261 man.Sv; 79% of which (0.206 man.Sv) is due to spent fuel transport.

Individual doses

In 2014, no worker received an individual dose higher than 16 mSv in 12 rolling months on the EDF fleet. 76% of the exposed workers received a cumulative dose lower than 1 mSv and 99.5% of the exposed workers received less than 10 mSv.

3) Principal events of the year 2014

The main 2014 events with a dosimetric impact are the following:

- Blayais 3 SGR:
  The SGR initially planned for 2014 was postponed to 2015. Unit 3 should operate at the beginning of September 2015 according to the last forecast. This unit has been shut down since 07/25/14.
- Elbow 64A replacement at Dampierre 4:
  Difficulties for this activity associated with a high RCS index (1.10) have led to a collective dose of 350 man.mSv.
  Moreover, 100 man.mSv was accrued for an unplanned thermocouple column C5 replacement.
- Ag100m contamination on Bugey 4 and Bugey 5:
  Chemical decontamination occurred in emergency at Bugey 4 and Bugey 5 due to Ag110m contamination of the CVCS circuit.
- Seismic resistance following a global safety event on the fleet:
  Biologic shielding whose seismic resistance was not proved has been removed. These removals impact the radiological conditions of areas in the nuclear auxiliary building and also for field and radiological protection inspections.
- Maintenance issues on replacing support pin:
  Problems concerning a seized screw and a broken tap lead to 220 more hours in the controlled area at Gravelines.
- Decontamination:
  For 4-loop reactors (1300 MWe), decontamination and cleaning of Solid Waste Treatment System tank and Liquid Waste Treatment system evaporator were undertaken before inspections.

3-loop reactors – 900 MWe

In 2014, Blayais 2, Bugey 3 and Fessenheim 2 had no outage. Chinon B2 had a forced outage for an occupational exposure of 8 man.mSv.

The 3-loop reactors outage program was composed of 15 short outages, 11 standard outages, 5 ten-year outages. Two (2) Steam Generator Replacements were performed, with only one (1) performed in 2014.
Two (2) outages of the 2013 program ended in 2014: the 3rd ten-year outage and steam generator replacement at Blayais 2 for 0.109 man.Sv and the 3rd ten-year outage at Dampierre 3 (collective dose in 2014: 0 man.Sv).
Two (2) outages commencing in 2014 were not finished at the end of 2014: Cruas 2 (end of the short outage for 0 man.mSv) and Blayais 3 (3rd ten-year outage and steam generator replacement for 0.460 man.Sv).

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

- Short outage: 0.157 man.Sv at Chinon B1;
- Standard outage: 0.489 man.Sv at Chinon B4;
- Ten-year outage: 1.709 man.Sv at Tricastin 4;
- SGR: 0.672 man.Sv at Cruas 4.

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

In 2014, 7 units had no outage.

The 4-loop reactors outage program was composed of 8 short outages, 7 standard outages, 2 ten-year outages. Two (2) outages of the 2013 program ended in 2014: a standard outage at Cattenom 3 for 0.005 man.Sv and a short outage at Civaux 2 for 0.004 man.Sv.

No outage remained unfinished at the end of 2014.

The lowest collective doses for the various outage types were:

- Short outage: 0.165 man.Sv at Nogent 2;
- Standard outage: 0.502 man.Sv at Civaux 2;
- Ten-year outage: 1.224 man.Sv at Golfech 2.

Main radiation protection significant events (ESR)

In 2014, 3 events were classified at the INES scale level 1.

- Belleville NPP (rated level 1 at the INES scale)
  1 ESR on unit 2: skin exposure of a worker higher than one quarter of the annual regulatory dose limit during waste management in the nuclear auxiliary building.
- Blayais NPP (rated level 1 at the INES scale)
  1 ESR on unit 4: cheek contamination of a worker with exposure higher than one quarter of the annual regulatory dose limit occurring during replacement of seals of the dummy vessel head.
- Tricastin NPP (rated level 1 at the INES scale)
  1 ESR on unit 1: a worker received a significant dose (5.3 mSv) during the installation of the transfer cover.

Other events in 2014

Significant events for the authority or EDF:

- Cattenom NPP
  On unit 2: Gaps on the setting of alarm thresholds gantry to exit the controlled area.

Concerning red zone

- Dampierre NPP
  1 ESR on unit 1: absence of control means of red zone on classification of a demineraliser.

2015 goals

For 2015, the collective dose objective for the French nuclear fleet is set at 0.79 man.Sv/unit.

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

- 0 workers with a dose > 18 mSv;
- Less than 20 workers with a dose > 14 mSv;
- Less than 370 workers with a dose > 10 mSv.

Future activities in 2015

Collective dose: continuation of the activities initiated since 2012.

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

Forty seven outages are planned for 2015 with 22 short outages, 21 standard outages and 4 ten-year outages, including a ten-year outage on a 4-loop reactor (1300 MWe) combined with a SGR (lead unit).

To be noted:

- The end of the SGR of Blayais 3;
- The beginning of hydrostatic testing on nuclear equipment under pressure on RHRS circuits (Gravelines and Golfech);
- Inspections and special activities (Post Fukushima activities, Authority requests and EDF program of maintenance and modifications).

3) Report from Authority

Evaluation of radiation protection

In 2014, the collective dosimetry per reactor was lower than in 2013 and is below EDF forecasts. This drop is partly due to progress in implementing the ALARA principle and partly due to the limitation of the number of days for which reactor maintenance outages are prolonged.

ASN considers that the average situation of the NPPs in 2014 concerning radiation protection could be improved with regard to a certain number of points:

- after two unsatisfactory years, the control of industrial radiography work is improving but weaknesses persist in the organisation of management and the modification of the drawings used to define the demarcation of the operations zone, as well as in the quality of the walk-downs performed when
- preparing this work;
- rigorousness in the preparation of the work (in particular consideration of hot spots in the risk assessment and the evolution of the forecast dose), monitoring of the integrated doses by persons competent in radiation protection, the implementation of optimisation measures (tele-dosimetry in particular) and the behavior of the workers when faced with electronic dosimeter alarms, are not up to the expected level. These inadequacies are the cause of far too many cases of individual dose targets being exceeded, or even significant exposure of the personnel, in particular when working at the bottom of the pool;
- control of the dispersion of contamination inside the reactor building is progressing but still remains insufficient, especially owing to inadequate behavior or worksite containment shortcomings;
- satisfactory control of limited stay areas is progressing but remains insufficient. Efforts are in particular needed concerning the management of radioactive waste and the identification of the activities concerned.

Significant contamination events

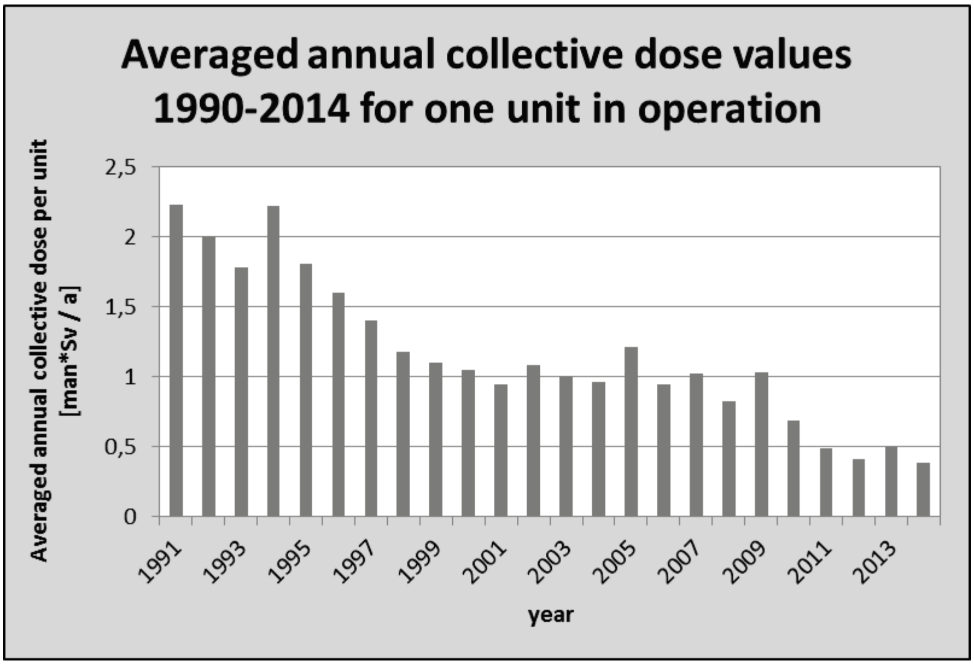
Two significant contamination events (rated level 1 on the INES scale) were notified in the NPPs in 2014. They concern:

- the contamination of the nose of a staff member handling a bag of waste containing used filters from a ventilation system in the Belleville NPP, leading to exposure in excess of one quarter of the regulation limit per square centimeter of skin;
- the contamination of the cheek of a staff member during maintenance on the "dummy closure head" at the Le Blayais NPP, leading to exposure in excess of one quarter of the regulation limit per square centimeter of skin.

GERMANY

1) Dose information for the year 2014

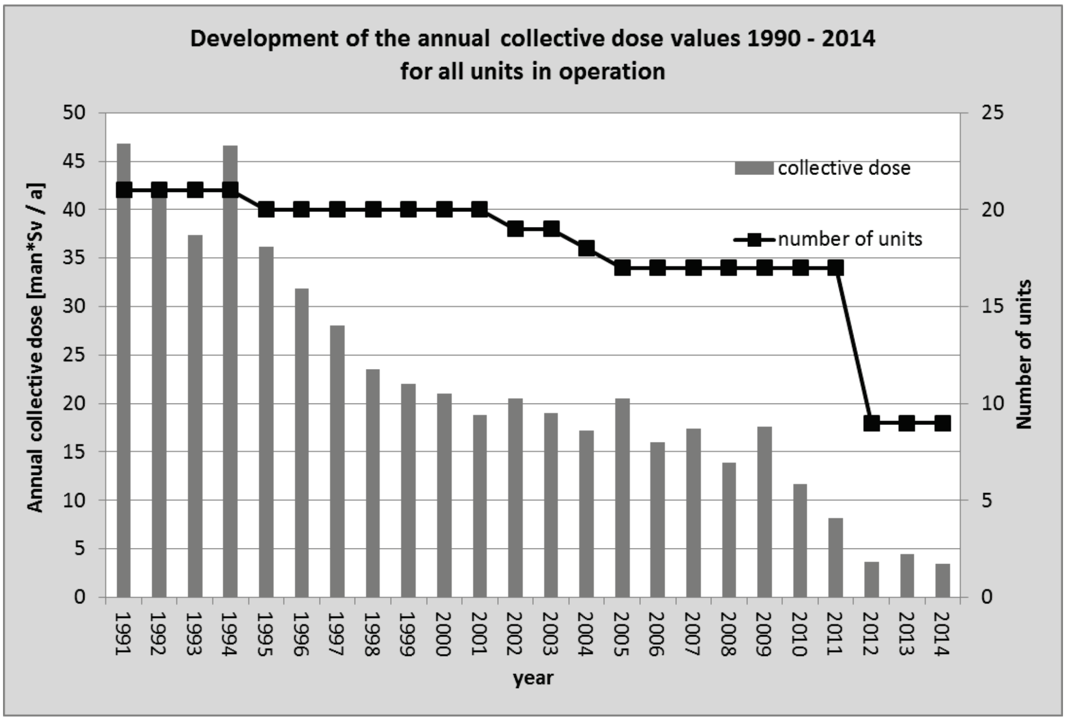
ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	7	159
BWR	2	1160
All types	9	381
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	7	76
BWR	4	75
All types	11	76



Summary of national dosimetric trends

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

In 2014 the average annual collective dose per unit in operation was 381 man·mSv, which is comparable to the value of 492 man·mSv in the year 2013. The trend in the average annual collective dose from 1990 to 2014 is presented in the figure above. For the plants in decommissioning, the value of the average annual collective dose is 76 man*mSv.



HUNGARY

1) Dose information for the year 2014

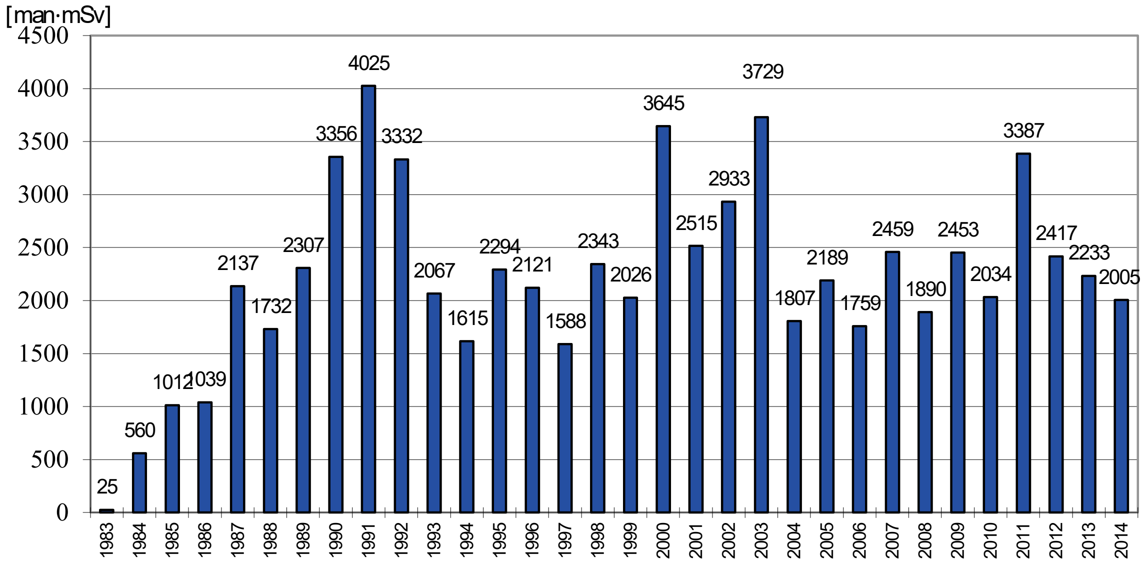
ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	4	521 (with electronic dosimeters) 501 (with TLDs)

2) Principal events of the year 2014

Summary of national dosimetric trends

The results of operational dosimetry show that the collective radiation exposure was 2082 man·mSv for 2014 at Paks NPP (1579 man·mSv with dosimetry work permit and 503 man·mSv without dosimetry work permit). The highest individual radiation exposure was 11.2 mSv, which was well below the dose limit of 50 mSv/year, and our dose constraint of 20 mSv/year.
The collective dose decreased in comparison to the previous year. The lower collective exposures were mainly ascribed to the finding that the collective dose of investment activities was lower in 2014 than in previous years.
The cause of the difference between electronic dosimeter and TLD data was the change in the TLD monitoring by the authorities.

Development of the annual collective dose values at Paks Nuclear Power Plant (using 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 2014. The collective dose of the outage was 725 man mSv on Unit 4.

- *Number and duration of outages*

  The duration of outages were 30 days on Unit 1, 26 days on Unit 2, 32 days on Unit 3 and 55 days on Unit 4.

ITALY

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	**7.33** (1 unit - Trino NPP)
BWR	2	**17.37** (1 unit Caorso NPP [0.96 man·mSv] + 1 unit Garigliano NPP [33.77 man·mSv])
GCR	1	**7.74** (1 unit - Latina NPP)

JAPAN

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit·year]**
PWR	24	231
BWR	24	190
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit·year]**
BWR	8	13,081
GCR	1	0
LWCHWR	1	30

2) Principal events of the year 2014

- *Outline of national dosimetric trend*

  The average annual collective dose for shutdown BWRs increased from 9,696 man·mSv /unit in the previous year (2013) to 13,081 man·mSv /unit for 2014. This is because the collective dose of Fukushima Daiichi NPP has been taken into account beginning this year. The average annual collective dose excluding Fukushima Daiichi NPP this year was 28 man·mSv /unit, and that of Fukushima Daiichi NPP was 17,428 man·mSv /unit.

  The average annual collective dose of operating reactors was almost at the same level as last year. This is because no nuclear reactors have been operating at power for a long time (since about the time of the accident at the Fukushima Daiichi NPP).

- *Operating status of nuclear power plants*

  In FY 2014, no unit operated.

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

  The individual dose distributions at Fukushima Daiichi NPP for cumulative dose until March 2015 and for dose during FY2014 are shown below.

As of July 31,2015

Cumulative dose Classification (mSv)	Number of workers (March 2011 – March 2015)			Fiscal year 2014 (April 2014 – March 2015)		
	TEPCO	Contractor	Total	TEPCO	Contractor	Total
＞250	6	0	6	0	0	0
200 ～ 250	1	2	3	0	0	0
150 ～ 200	26	2	28	0	0	0
100 ～ 150	117	20	137	0	0	0
75 ～ 100	293	196	489	0	0	0
50 ～ 75	331	1,363	1,694	0	0	0
20 ～ 50	620	5,701	6,321	11	997	1,008
10 ～ 20	596	5,380	5,976	60	2,599	2,659
5 ～ 10	494	5,011	5,505	158	2,775	2,933
1 ～ 5	828	9,057	9,885	637	5,313	5,950
≦1	1,117	11,470	12,587	822	7,358	8,180
Total	4,429	38,202	42,631	1,688	19,042	20,730
Max. (mSv)	678.80	238.42	678.80	29.50	39.85	39.85
Ave. (mSv)	23.16	11.05	12.31	2.30	5.29	5.04

* TEPCO use integrated value of APD data that was measured every time when enter into the facilities under control area.
These data sometimes deviate due to replacing these data to monthly dose data measured by an integral dosimeter.
* 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, but no plant had obtained approval at the end of FY 2014.

3) Report from Authority

Revision of regulation for radiation exposure for emergency workers

At the time of the accident at Fukushima Daiichi, the dose limit for emergency response staff was changed from 100mSv to 250mSv temporarily. Although the dose limit has been returned to 100mSv now, preparation is important for an accident that might require an individual dose beyond 100mSv. Therefore, NRA started an investigation into radiation exposure measures for emergency workers on 30 July 2014. NRA approved the revision of the regulation and ordinance on 5 August 2015.

Point of revision of regulation for emergency workers

Emergency work is limited to radiation workers who are provided with information about the risks of working in radiation situations, have training regarding radiation protection measures, and express willingness to carry out the emergency work.

An effective dose limit of 250 mSv for an accident that has a high probability of radioactive materials being released outside the facility is added to the current dose limit of 100mSv for emergency workers.

The dose limit of 250 mSv is related to the Act on Special Measures Concerning Nuclear Emergency Preparedness to strengthen the number and effectiveness of countermeasures in the unlikely case of a nuclear disaster, e.g. NPP, nuclear fuel cycle facility, radioactive material transport, to address a severe accident like that at Fukushima Daiichi NPP, and the needs of nuclear disaster prevention staff.

Considering the reference level of IAEA or ICRP recommendations, necessary action is ordered by NRA of the operator based on law in case of unnecessary radiation exposure, even if considering risk of the public, or exposure exceeding the limit due to inappropriate radiation protection.

As a practical measure, the radiation dose for emergency work and planned work are managed separately only if the specialty of the workers is necessary to keep the damaged facility safe or operate other nuclear facility safely, although an accumulated lifetime dose should not exceed 1000 mSv.

KOREA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	19	377.82
PHWR	4	286.50
All types	23	361.94

2) Principal events of the year 2014

Summary of national dosimetric trends

For the year 2014, 23 NPPs were in operation; 19 PWR units and 4 PHWR units. The average collective dose per unit for 2014 was 361.94 man·mSv. The dominant contributor to the collective dose for 2014 was work carried out during the outages, resulting in 85.7 % of the total collective dose. 14,260 people were engaged in radiation work, and the total collective dose was 8,325 man·mSv.

- *Number and duration of outages*

  Overhauls were performed at 15 PWRs and 3 PHWRs. The total duration for the outages was 896 days for PWRs and 147 days for PHWRs. Total outage duration was decreased compared to that for 2013.

- *Component replacements*

  - High energy piping, including RCS piping, was replaced at Kori 1 during the outage, resulting in 42.4 man·mSv of total collective dose.
  - The Reactor Vessel Head was replaced at Hanbit 3 from October 2014 to March 2015 during the outage, resulting in 65.25 man·mSv.
  - Two steam generators were replaced at Hanul 3 in 2014, resulting in 453.25 man·mSv.

- *New dose-reduction programmes*

  A trial application of zinc injection to reduce source term has been applied to Hanul 1 since 2010 and as a result of this programme, there was about 30% to 40% decrease in radiation exposure rate at RCS piping and steam generator chambers. KHNP is planning to extend zinc injection to other reactors. Zinc injection is scheduled to be applied to 2 NPPs (Kori 3 and Kori 4) beginning in 2016 and 8 NPPs (Kori 2, Hanbit 1, Hanbit 2, Hanbit 3, Hanbit 4, Hanul 2, Hanul 3 and Hanul 4) beginning in 2017.

LITHUANIA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
LWGR	2	318.77

2) Principal events of the year 2014

- *Events influencing dosimetric trends*

  In 2014, the occupational doses at the Ignalina NPP (INPP) were maintained as low as possible, taking into account all economic, social and technological conditions: 521 man·mSv in 2010, 631 man·mSv in 2011, 587 man·mSv in 2012, 655 man·mSv in 2013 and 638 man·mSv (55% of planned dose) in 2014. The collective dose for INPP personnel was 612.9 man·mSv (62% of planned dose) and for outside workers was 24.7 man·mSv (15% of planned dose). The external dosimetry system used was Thermoluminescence dosimeters (TLD).

  The 20 mSv individual dose wasn't exceeded. The highest individual effective dose for INPP staff was 11.66 mSv, and for outside workers – 4.22 mSv. The average effective individual dose for INPP staff was 0.36 mSv, and for outside workers – 0.03 mSv.

  The main work that contributed to the collective dose during technical service and decommissioning of Units 1 and 2 at the INPP were fuel handling; repairing of the hot cell; maintenance work 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; in-service inspection of DN800 pipeline; and isolation of the main circulation circuit.

  In 2014 no Component or system replacements were performed. In 2014 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 continuously implementing programs of introducing ALARA principle during work activities. The evaluation and upgrading of the level of safety culture, extension and support to the effectiveness of the quality improvement system are very important.

- *Organisational evolutions*

  Year 2014 was significant for Ignalina Nuclear Power Plant; much essential work for safe and world unique project implementation was performed.

  Significant progress in the implementation of decommissioning projects was achieved this year: work on the installation of the unloading-loading machine and modernisation of cranes in the spent fuel storage pool hall was started, work continued on producing shock absorbers and installing already manufactured shock absorbers, the construction of the Interim Spent Fuel Storage Facility was finally finished and cold testing was started.

According to the INPP experience and international experience in the field of decommissioning, a new Final plan of INPP decommissioning was designed and approved.

The first stage of changing the INPP structure was implemented at the end of the year – the new Activity Planning and Finance Department was established. Projects Management Service will ensure the effective implementation of projects management and harmonisation principles.

In 2014 the dismantling work was continued, with about 7 thousand tonnes of equipment dismantled that year.

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. INPP is implementing the world unique decommissioning project using in-house staff experience, during which new challenges and tasks having no analogue in the world practice are faced constantly.

3) Report from Authority

In 2014 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, work permit procedure for dose intensive work and emergency preparedness.

Inspections results showed that Ignalina NPP activities were carried out in accordance with the established radiation protection requirements. During the inspection of application of clearance levels, areas for improvement were identified, and recommendations regarding review of the corresponding Ignalina NPP procedures were provided. The corrective measures were implemented in due time.

In 2015 VATESI will continue supervision and control of nuclear safety of the decommissioning of INPP, management of radioactive waste, including the construction and operation of new nuclear facilities, as well as the radiation protection of these activities and at the facilities. To enhance the level of radiation protection during decommissioning of the INPP, VATESI will continue to review radiation protection requirements established in legal documents.

MEXICO

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	2	5910

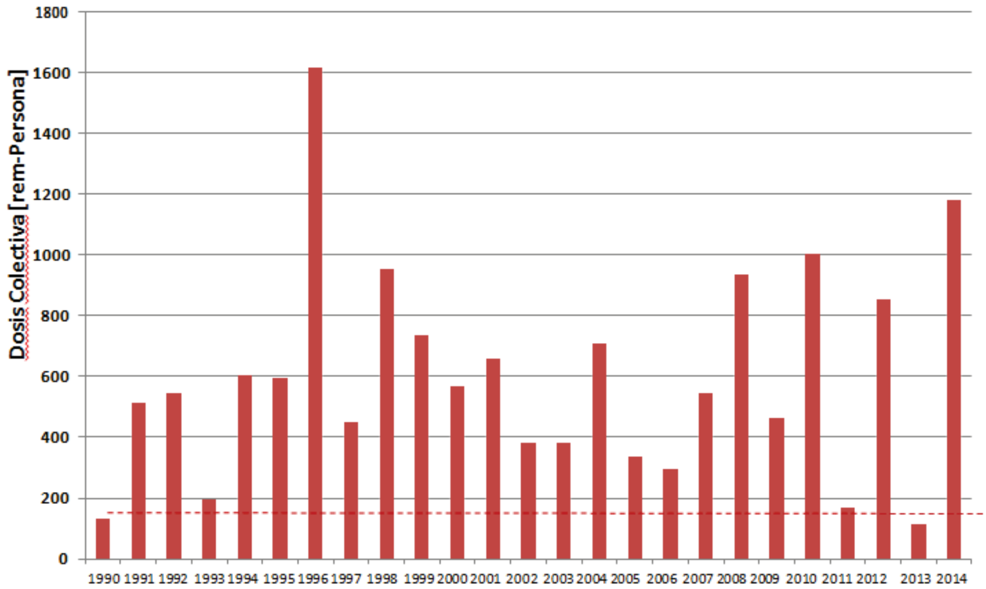
2) Principal events of the year 2014

Summary of national dosimetric trends

The nuclear reactors existing in Mexico are two BWR/GE units at the Laguna Verde Nuclear Power Station located in Laguna Verde, State of Veracruz, Mexico.
Laguna Verde's historical collective dose both on line and during refuelling outages is higher than the BWRs average. On line collective dose is high because of failures or shortcomings in equipment reliability. Some examples are steam leaks, reactor water clean-up system pumps failures, radwaste treatment systems failures. Refuelling outage collective dose is high mainly because the relatively high radioactive source term (Co-60) caused high radiation areas.
The collective dose of normal operation was high in 2014, mostly because of reactor water clean-up system failures during the first quarter (emergent work).

- *Events influencing dosimetric trends*

  a) Increase of radioactive source term: this factor was originated by the reactor water chemical instability induced in turn by the application of noble metals and hydrogen since 2006 to prevent the stress corrosion cracking of reactor internals. This factor is still strongly influencing dose rates at the plant and specifically in the drywell during refuelling outages. Since 2011 LV's Chemistry Manager has taken the responsibility for hydrogen injection, iron control in feed water and any other condition that can result in a chemical instability inside the reactor vessel.
  During the next outage on both units, chemical decontamination will be performed on three systems: RRC, RWCU and RHR.
  The trend of the collective dose behaviour is shown in the graph (rem-P):



- *Number and duration of outages*

  - Refuelling outages:
    - 16 RFO Unit 1 (from March 23th to May 10th) collective dose 5.089 man- Sv;
    - 13 RFO Unit 2 (from June 5th to August 8th) collective dose 5.69 man-Sv.
  - From October 14th to October 20th - a forced outage in Unit 2, collective dose 0.05735 man-Sv.
  - Form October 20th to November 01st - a forced outage in Unit 2, collective dose 0.00945 man-Sv.

- *Major evolutions*

  Dryer reinforcement to allow a power up-rate for unit 2.

- *New/experimental dose-reduction programmes*

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

  Control and optimisation of reactor water chemistry plays a fundamental role in the control and eventual reduction in the source term. The main strategies / actions aimed at source term control are:
  - On Line Noble Metal Chemistry (OLNC);
  - Cobalt selective removal resins – continuous application to reactor water;
  - Continued application of Zinc to the reactor water;
  - Iron concentration control in feed water;
  - Reactor Water Cleanup System (RWCU) – continuous operation;

- Optimising continuity and availability of Hydrogen injection to the reactor;
- CRUD pump usage with high flows (600 gpm) during the outages (2015);
- Portable demineraliser use during the outages (2015);
- RWCU system modifications to improve its efficiency;
- Chemical decontamination of recirculation loops during refuelling outages;
- Plans to change–out of components to those without satellite.

For 2015

Issues of concern in 2015

Refuelling outage 17 RFO Unit 1.

Technical plans for major work in 2015

Chemical decontamination in unit 1.

Dryer reinforcement to allow for power up-rate for unit 1.

RANGOS DE DOSIS ANUAL [mSv]	NÚMERO DE INDIVIDUOS EN CADA RANGO	DOSIS TOTAL PARA CADA RANGO [mSv-PERSONA]
NO MEDIDA (<0.05)	1520	0
<0.25	400	56.6
0.25 - 0.50	304	108.1
0.50 - 0.75	192	117.2
0.75 - 1.00	139	120.7
1.00 - 2.50	485	805.5
2.50 - 5.00	356	1288.7
5.00 - 7.50	198	1210.4
7.50 - 10.00	146	1266.8
10.00 - 20.00	371	5281.1
20.00 - 30.00	62	1458.0
30.00 - 40.00	3	91.0
40.00 - 50.00		
50.00 - 60.00		
60.00 - 70.00		
70.00 - 80.00		
80.00 - 90.00		
90.00 - 100.00		
NUMERO TOTAL DE PERSONAL REPORTADO	4176	DOSIS TOTAL: 11804.17

DOSIS MAS ALTA:30.76 mSv (3.076 rem)

NETHERLANDS

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	248
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	1	0

2) Principal events of the year 2014

For the single unit in operation, dose during outage was 194 man.mSv; during normal operation, the dose was 54 man.mSv.

PAKISTAN

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PHWR	1	2012.55
PWR	2	597.377

2) Principal events of the year 2014

- *Events influencing dosimetric trends*
  - PHWR 8 Outages, 240.60 days
  - PWR (Chashma -1) 8 Outages, 55.31 days
  - PWR (Chashma -2) 5 Outages, 50.67 days

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

    Replacement of inlet/outlet headers of Process Salt Water Heat Exchangers
    Replacement of 5000 condenser tubes

  - PWR

    No specific report

ROMANIA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
CANDU	2	296

2) Principal events in the year 2014

Summary of national dosimetric trends

Occupational exposure at Cernavoda NPP			
Year	**Internal effective dose [man·mSv]**	**External effective dose [man·mSv]**	**Total effective dose [man·mSv]**
2014 (2 units)	160.3	432	592.3

- *Events influencing dosimetric trends*

  Normal operation of the plant (U1 & U2)

  At the end of 2014:

  - there are 159 employees with individual doses exceeding 1 mSv; 11 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 since the beginning of the year is 7.511 mSv;
  - the contribution of internal dose due to tritium intake is 27%.

  Planned Outage

  A 30 day planned outage was done at Unit#1 between May 10th and June 06th 2014. Activities with major contribution to the collective dose were as follows:

  - Fuelling machine bridge components - preventive maintenance;
  - Reactor Building Leak Rate Test;
  - Feeder – yoke clearance measurements and correction;
  - Inspection for tubing and supports damage in the feeder cabinets;
  - Planned outage systematic inspections;
  - Feeder thickness measurements, feeder clearance measurements, feeder - yoke measurements, elbow UT examination;
  - Snubber inspection; piping supports inspection.

  Total collective dose at the end of the planned outage was 310.4 man mSv (229 man mSv external dose and 81.4 man mSv internal dose due to tritium intakes).

  Finally, this planned outage had a 52% contribution to the collective dose of 2014.

Planned Outages dose history

Year	Unit	Interval	External collective dose received man mSv	Internal collective dose (^{3}H intakes) received man mSv	Total collective dose received man mSv
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

Unplanned outages

Unit 2 – December 24-25: Unit was orderly shutdown in order to repair D2O leakage on Shut Down System line 68334 3/8 11H (7.32 man mSv external dose).

Radiation protection-related issues

Good practices for individual dose optimisation, identified during Planned Outage:

- Using Teledosimetry system for high dose rate jobs (fuel channel inspection);
- Mandatory usage of respiratory protection for entering reactor building;
- Prompt detection of increased level of tritiated water vapour in the air of the Reactor Building using Tritium-in-Air-Monitoring (TAM) system allowed us to stop the jobs and evacuate the area;
- Using wireless communication system in order to prevent removing the tritium mask during the job.

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

The purpose of this improvement is to connect the on line radiation monitoring equipment to a computerised interface system that allows remote monitoring, limited remote control capability and maintaining an integrated short and long-term database. Thus the collective dose of the operating personnel will decrease (by avoiding entrance into high radiation hazard areas), and radiation hazard control will be improved for the normal operation of the plant (where real time radiation hazard information will be available).

This project will be finished in September 2015.

Issues of concern in 2014

The main concerns for 2014 were important work with high radiological impact, performed during the Planned Outage of Unit 1.

For 2015

Issues of concern in 2015

The main concerns for 2015 are activities with high radiological impact, to be performed during the Planned Outage of Unit 2:

- Steam Generator ECT inspection;
- Fuelling machine bridge component preventive maintenance;
- Feeder – yoke clearance measurements and correction;
- Inspection for tubing and supports damage in the feeder cabinets;
- Planned outage systematic inspections;
- Feeder thickness measurements, feeder clearance measurements, feeder – yoke measurements, elbow UT examination;
- Snubber inspection; piping supports inspection;
- Engineering changes implementation.

RUSSIA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	17	615.8
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	2	44.7

2) Principal events of the year 2014

Collective doses

In 2014, the total effective annual collective dose of utility employees and contractors at seventeen operating VVER type reactors was 10467.8 man·mSv. This value presents 1661.3 man·mSv (18.9%) increase from the year 2013 total collective dose of 8806.5 man·mSv.

Comparative analysis shows a considerable difference between average annual collective doses for the groups of VVER-440 MWe and VVER-1000 MWe reactors. In 2014, the results were as follows:

- 709.4 man·mSv/unit with respect to the group of 6 operating VVER-440 reactors;
- 564.7 man·mSv/unit with respect to the group of 11 operating VVER-1000 reactors.

- *Events influencing dosimetric trends*

  As the result of 18 month fuel campaigns at all Russian units with VVER-1000 (except the unit № 5 of Novovoronezh NPP), there is a considerable difference in planned outage total numbers for 10 operating VVER-1000 reactors from one year to another.

  In 2013, the planned outages were not implemented at four VVER-1000 units (Balakovo 1, Kalinin 1 and 2, Rostov 1). The planned outage at Balakovo 2 was just started at the end of December 2013 (10 days) and was finished in 2014. The total planned outage duration for all Russian VVERs-440 and VVERs-1000 was 641 days (without considering the initial 10 days of the Balakovo 2 outage), which provided a value of 7444.6 man·mSv for the total planned outage collective dose.

  In 2014, the planned outages were performed at all seventeen VVER-440 and VVER-1000 units (the Balakovo 2 outage was finished, and the Balakovo 3 outage was started). The total planned outage duration for all Russian VVERs was 912 days – a 271 day increase (42.3%) in comparison to 2013. The registered total collective dose during the planned outages was 9364.1 man·mSv. This value is higher by 1919.5 man·mSv (25.8%) than it was in 2013.

  Thus, the 2014 total effective annual collective dose increase was entirely determined by the increase of the total number and duration of planned outages as compared to 2013.

Individual doses

In 2014, individual effective doses of utility employees and contractors did not exceed the control dose level of 18.0 mSv per year at VVER-440 and VVER-1000 reactors.

The maximum recorded individual dose was 16.4 mSv. This dose was gradually received by a worker of the Novovoronezh NPP maintenance department during the repair of reactor component equipment at Units 3-5 during the full year.

The maximum annual effective individual doses at other plants with VVER type reactors in 2014 were:

- Balakovo – 15.9 mSv;
- Kalinin – 15.4 mSv;
- Kola – 15.5 mSv;
- Rostov – 6.3 mSv.

Annual individual doses over 10.0 mSv were received by 196 persons (76 persons at Balakovo, 41 persons at Kalinin, 44 persons at Kola, 35 persons at Novovoronezh). This value is higher by 37 persons (23.3%) than in 2013. The principal factor is the increase of the planned outage number and duration at the Balakovo and Kalinin plants in 2014.

Nobody exceeded 10.0 mSv level and only 3 persons exceeded 5.0 mSv at Rostov NPP.

Planned outage duration and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Balakovo 1	71	1031.0
Balakovo 2	55 (completion of outage which was started in 2013)	544.3
Balakovo 3	39 (beginning of outage with completion in 2015)	528.2
Balakovo 4	67	692.9
Kalinin 1	109	1084.0
Kalinin 2	75	620.0
Kalinin 3	54	321.0
Kalinin 4	37	109.8
Kola 1	37	465.5
Kola 2	40	399.8
Kola 3	45	577.0
Kola 4	97	916.3
Novovoronezh 3	32	639.1
Novovoronezh 4	35	567.0
Novovoronezh 5	40	586.5
Rostov 1	48	203.3
Rostov 2	31	78.4

Unplanned outage duration and collective dose

Reactor	Duration [days]	Collective dose [man·mSv]
Kola 1	15	48.8

Issues of concern in 2014

Documents, manuals and models were developed:

- Estimation of NPP personal radiation risk coefficients. Development of ARMIR programme based on individual and generic risk.
- Development and certification of optimised set of standard sources (phantoms) for whole body monitor calibration based on gamma radiation efficiency registration factor.
- Preparation of the Programme of radiation protection optimisation at Concern Rosenergoatom NPPs for the period 2015 – 2019.

SLOVAK REPUBLIC

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	4	126.175
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	2	Not included in ISOE
GCR	1	Not included in ISOE

2) Principal events of the year 2014

- *Events influencing dosimetric trends*
  - Bohunice NPP (2 units): The total annual effective dose in Bohunice NPP in 2014 calculated from legal film dosimeters was 193.626 man.mSv (employees 95.527 man.mSv, outside workers 98.099 man.mSv). The maximum individual dose was 2.478 mSv (NPP's employee). Without internal contamination. Without anomalies in radiation conditions.
  - Mochovce NPP (2 units): The total annual effective dose in Mochovce NPP in 2014 evaluated from legal film dosimeters and E50 was 311.074 man.mSv (employees 127.377 man.mSv, outside workers 183.697 man.mSv). The maximum individual dose was 4.044 mSv (NPP's employee).

- *Outage information*

  Bohunice NPP:
  - Unit 3 – 21.1 day standard maintenance outage. The collective exposure was 97.454 man.mSv from electronic operational dosimetry.
  - Unit 4 – 18.6 day standard maintenance outage. The collective exposure was 94.316 man. mSv from electronic operational dosimetry.

  Mochovce NPP:
  - Unit 1 – 20.5 day standard maintenance outage. The collective exposure was 96.563 man. mSv from electronic operational dosimetry.
  - Unit 2 – 38.25 day major maintenance outage. The collective exposure was 168.936 man.mSv from electronic operational dosimetry.

- *Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown*
  - Mochovce NPP – start of upgrade of central radiological computerised system; the finish is expected in 2015.

SLOVENIA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	106

2) Principal events of the year 2014

- *Events influencing dosimetric trends*

  Calendar year 2014 included the usual operating cycle with no outage.

- *Regulatory requirements*

  Technical Plans:

  Preparation for reactor vessel up-flow conversion project in the 2015 outage, to avoid future fuel rod failures.

SOUTH AFRICA

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	2	281.367

2) Principal events of the year 2014

- *Number and duration of outages*

  One refuelling outage, with a duration of 53 days

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

  No component or system replacements. No unexpected events/incidents. No new reactors came on line.

- *Reactors definitively shutdown*

  No reactors were definitively shut down.

- *New/experimental dose-reduction programmes*

  Dose reduction initiatives implemented during 2014 included zinc Injection.

- *Regulatory requirements*

  No new requirements were issued by the South African regulatory authorities.

SPAIN

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	6	393.73
BWR	1	290.04
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	591.33
BWR	1*	101.7
GCR	1	0

*SM Garoña – temporary shutdown

2) Principal events of the year 2014

- *Number and duration of outages*

Almaraz NPP

21st outage of ALMARAZ Unit 2:

- Duration: 63 days.
- Beginning: November 24th, 2013.
- Ending: January 25th, 2014.
- Collective dose: 541.948 man.mSv.
- Maximum individual dose: 4.449 mSv.

23rd outage of ALMARAZ Unit 1:

- Duration: 58 days.
- Beginning: June 22nd, 2014.
- Ending: August 20th, 2014.
- Collective dose: 437.825 man.mSv.
- Maximum individual dose: 3.085 mSv.

Santa María De Garoña NPP

Date	**Event**	**Mean activity (if it exists)**	**Collective Dose (man.mSv)**
October 17th to November 11th	Control rod drive (CRD) removal and maintenance.	--	14.439
November 10th to December 12th	100% inspection reactor vessel and internals.	IVVI over the core. UT base material and circumferential welds.	11.560

Ascó NPP

23rd outage of Ascó 1

- Duration: 56 days.
- Collective dose: 663.356 man.mSv.
- Maximum individual dose: 5.073 mSv.

22nd outage of Ascó 2

- Duration: 44 days.
- Collective dose: 632.423 man.mSv.
- Maximum individual dose: 3.880 mSv.

Relevant activities from the RP point of view performed during both outages

- Steam Generator secondary cycle chemical cleaning;
- Pressuriser safety valve hydraulic seal elimination;
- RHR alternative injection design modification;
- Vessel's head conic seals substitution;
- Design modification of the RCS pump oil level system.

Cofrentes NPP

- Maintenance activities in nuclear steam sensitive areas have been performed to take advantage of power reductions to restructure control rod map.
- Maintenance activities have been accomplished to the reactor water clean-up pumps.

- *Component or system replacement:*

Almaraz NPP

- Motor of reactor coolant pump in 21st outage of unit 2.
- Motor of reactor coolant pump in 23th outage of unit 1.
- Replacement of nuclear instrumentation system and its associated wiring in both outages.

- *New/experimental dose-reduction programmes:*

Almaraz NPP

- Reduction of 16.6% in the maximum individual dose objective during outage.
- Degreasing of the cavity walls and floor with solvent during the 23rd outage of ALMARAZ Unit 1. This cleaning will be applied periodically in the future.
- Continuous improvement of the dose optimisation program and of the radiation protection procedures and measures.

Cofrentes NPP

- Temporary and permanent shielding.
- The shielding program has been continued with the installation of permanent shielding in different areas of the plant, with an approximate weight of 53.5 tons of lead.
- In 2014 temporary shielding was installed in different locations in the plant with an approximate weight of 3.5 tons of lead.

- *Regulatory requirements*

Santa María de Garoña NPP

- Application for start-up, May 27th.
- Regulatory start-up conditions, July 30th.

SWEDEN

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	3	805
BWR	7	959
All types	10	913
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	2	2

2) Principal events of the year 2014

Forsmark

In 2014 the collective dose for the whole site was 1 737 man.mSv and the maximum individual dose was 10.7 mSv. Forsmark 1 and 2 have had continuously low moisture level in the steam which has resulted in additional decrease in activity levels in the turbine system. Forsmark 2 still has increased dose rates in the residual heat removal system (since 2012). Forsmark 2 has entered normal operation at 120% power (previously on trial operation). Forsmark 3 stopped in April 2014 to replace damaged fuel prior to the outage.
During 2014 routines for the new EPD-system that was installed at the end of 2013/beginning of 2014 at Forsmark was put in place. That includes work-specific alarm levels and a new teledosimetry system.

During the outage of Forsmark 2, lift of a shaft belonging to a main circulation pump was performed as routine. Unexpectedly, personnel working at lower levels were exposed to higher dose rates due to the shaft being placed on a hatch. This was unforeseen and therefore an investigation was conducted.

Due to upcoming new dose limits for the lens of the eye, additional measurements of dose to the lens of the eye were performed. This was comprised of 74 measurements of the dose to the eye lens with a maximum registered dose of 2.64 mSv.

Ringhals

Ringhals 1 performed a chemical decontamination on the RH (Residual Heat) and RWCU (Reactor Water Clean-Up) systems with a very good result of DF=20 on average. In many critical areas with heavy workload and potentially high collective doses, the DFs were in many cases as high as a factor of > 100.

Ringhals 2 detected a leak in the containment steel liner when performing the scheduled ILRT (Integrated Leak Rate Test). In order to find the leak a major part of the concrete floor in containment had to be removed. (The repair work was still going on in June 2015.)

Ringhals 3 and 4 performed a quite large number of projects as a part of modernisation, lifetime extension and regulatory requirements.

During 2014 Ringhals reactor units showed 4 different types of radionuclide dominance. Ringhals 1 is still a Co-60 station with some small changes due to modification to FPHD (Forward Pumped Heat Drain). In Ringhals 2, 2014 was the year of Sb-124 dominance in the CS and RH systems. The cause has not yet been analyzed/ determined. At Ringhals 3 there was still some Ag-110m in the CS system that contributes to the outage dose. The cause has been determined to be leaking CRs, and the CR management program has been modified. Finally, Ringhals 4 is a Co-58 dominated station primarily due to the SG replacement in 2011. Because of the different nuclide dominant in each unit, station staff have to use different nuclide vectors for release of material, depending on the origin of use.

Oskarshamn

Modernisation and preparation for power uprate is still ongoing at Oskarshamn 2 from the 1th of June 2013 to the end of December 2015. The predicted collective dose budget is 4408 man.mSv and the outcome was 2900 man.mSv at the end of 2014. The extent of the project includes among other things exchange of internals, reheaters, shell valves, heat exchangers and a new control room including all cables.

At Oskarshamn 3 containment electrical penetration assemblies and cables were exchanged in a 40 day period. The resulting collective dose was 400 man.mSv. ALARA measures taken were: system decontamination of the RHR and RWCU systems with a decontamination factor of 10, laser scanning of containment with the resulting database used for visualizing cable routes for prefabrication of cables, use of electronic document handling by using iPads and training of personnel in a mock-up facility.

Barsebäck

Barsebäck 1 and 2 are definitively shut down. Decommissioning will start in 2020.
Ongoing activities are planning for segmentation of internals and planning for building an intermediate storage facility for internals on site.

3) Report from Authority

The Swedish Radiation Safety Authority (SSM) is working on a draft of a new radiation protection law, and a complete set of radiation protection legislation framework below the law. The regulations include nuclear safety, radiation protection, security and safeguard and will be completed in 2017.

The SSM process of supervising the nuclear facilities in Sweden is being evaluated internally and the process will be updated, included carrying out follow-ups and checks of activities related to all identified issues.

A joint effort by the Nordic countries radiation protection authorities has been done to produce a handbook for handling a nuclear or radiological accident. Planning for decommissioning of several nuclear installations is ongoing. This includes cooperation with the Ministry of Environment.

SWITZERLAND

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	3	258
BWR	2	1196

2) Principal events of the year 2014

- *Events influencing dosimetric trends*

NPP Beznau Unit 1
A refuelling outage from 01.04.2014 until 14.04.2014 caused a collective dose of 113 man·mSv (planned collective dose target 106 man·mSv). Additionally, due to repair of an identified leakage (PRW) from 16.06.2014 until 2.07.2014, a collective dose of 54 man·mSv was reported. During operation, a collective dose of 39 man·mSv led to the annual collective dose of 206 man·mSv for the unit.

NPP Beznau Unit 2: A refuelling outage from 11.08.2014 until 25.08.2014 caused a collective dose of 45 man·mSv (planned collective dose target 62 man·mSv). During operation, a collective dose of 40 man·mSv led to the annual collective dose of 85 man·mSv for the unit.

The highest individual dose in the Beznau NPPs was 5.2 mSv.

NPP Gösgen
The outage of 30 days resulted in 425 man·mSv (planned collective dose target 433 man·mSv). The highest individual dose was 6.6 mSv. No incorporation into or permanent contamination of any person was detected. Because of tramp uranium due to old fuel leaks in the years 2007-2010, additional control over iodine aerosols was still necessary while opening the primary cooling circuit. During operation, a collective dose of 57 man·mSv led to the annual collective dose of 482man·mSv for the unit.

Since applying Zn injection, the dose rates detected at components of the primary circuit have decreased about 58%.

NPP Leibstadt
Shortly before the outage, operation with failed fuel was noticed. Fortunately there was no washed-out fuel in the water. The outage of 32 days resulted in 1080 man·mSv. The highest individual dose was 12.2 mSv. No incorporation into or permanent contamination of any person was detected. During operation, a collective dose of 398 man·mSv led to the annual collective dose of 1478man·mSv for the unit.

The reactor was shut down according to the “Soft Shutdown” procedure to avoid contamination of the residual heat removal system. Details were presented at the ISOE Symposium in January 2015.

NPP Mühleberg
The outage of 28 days led to 630 man·mSv (planned collective dose target 842 man·mSv). The highest individual dose was 9.4 mSv. No incorporation into or permanent contamination of any person was detected. During operation, a collective dose of 284 man·mSv led to the annual collective dose of 914 man·mSv for the unit.

Beside the prevention of stress corrosion cracking, the water chemistry with noble chem and continuous hydrogen injection resulted in a reduction of the dose rate levels on the recirculation loops. For the segmentation of 151 used fuel channels (September-December) a collective dose rate of 77.5 man·mSv was planned. The work reported an actual total of 23.5 man·mSv, mostly due to the fact that no mechanical failures of the equipment needed to be repaired.

UKRAINE

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	15	490

UNITED KINGDOM

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	366.5
GCR	15(1)	77.52
All types	16	95.58
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
GCR	19(2)	52.02

Notes
(1) 14 Advanced Gas-Cooled Reactors and 1 Magnox Reactor.
(2) 19 Magnox Reactors.

2) Principal events of the year 2014

The Collective Radiation Exposures for the Advanced Gas-Cooled Reactors, operated by EDF Energy, were generally low, ranging from 13 man.mSv for Heysham 2 NPP to 524.5 man.mSv for Heysham 1 NPP. (All UK gas reactor sites have two reactors.) The highest collective radiation doses were recorded by the Advanced Gas-Cooled Reactor at Heysham 1 which had to undertake extensive inspection and repairs of a boiler spine inside the Reactor Vessel. The doses at Heysham 1 were the principal reason for the increased average collective dose for the operating gas-cooled reactors.

Sizewell B, the only PWR, recorded an annual collective radiation exposure of 366.5 man.mSv. The plant carried out its thirteenth refuelling outage, with a duration 48 days, in the autumn of 2014. Around 90% of the annual collective radiation exposure was recorded during this refuelling outage.

Of the first generation gas-cooled reactors in the United Kingdom there is now only one Magnox reactor left operating, Wylfa Unit 1. The reactor is currently licensed to operate until the end of 2015. The majority of the Magnox reactor sites are now completely defuelled and are at various stages of decommissioning.

EDF Energy continues to progress with plans to build twin EPRs at Hinkley Point and Sizewell. By the end of 2014 all necessary regulatory approvals and political agreements had been received. The final investment decision is expected in 2015, after the UK General Election. There are also proposals for nuclear new build by other consortia, based upon the Advanced Boiling Water Reactor design and the Westinghouse AP1000. These proposals are undergoing generic design assessment by the UK regulators.

UNITED STATES

1) Dose information for the year 2014

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	61	545.31
BWR	35	1085.16
All types	96	742.13
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	7	80.73
BWR	3	91.77

2) Principal events of the year 2014

Summary of national dosimetric trends

The USA PWR and BWR occupational dose averages for 2014 reflected a continued emphasis on dose reduction initiatives at the 96 operating commercial reactors: Also, four PWRs units continued transition to the SAFSTOR/ decommissioning phases.

Reactor Type	Number of Units	Total Collective Dose	Avg Dose per Reactor
PWR	61	33,263.97 person mSv	0.545 person Sv/unit
BWR	35	37,980.63 person mSv	1.085 person Sv/unit

The total collective dose for the 96 reactors in 2014 was 71,244.6 person mSv, a increase of 5. 5% from the 2013 total collective dose of 67,521.29 person mSv from 100 operating reactors. The resulting average collective dose per reactor for USA LWR was 742 person mSv/unit or a 9.9% increase from 2013 (675 person mSv/reactor unit). Thirty-three individuals received between 20-30 mSv at a US PWR site in 2014.

US PWRs
The total collective dose for US PWRs in 2014 was 33,263.97 person mSv for 61 operating PWR units. The 2014 PWR total collective dose was 45% higher than the 2013 US PWR total collective dose of 23,002.77 person mSv. The 2014 average collective dose per reactor was 545 person mSv/PWR unit. US PWR units are generally on 18-month refueling cycles. The US PWR refueling frequency can create fewer refueling outages in certain years in the US, for example 2013, 2016 and 2019.

The US PWR sites that achieved annual site doses of under 150 person mSv in 2014 were:

- Harris 12 person mSv
- Three Mile Island 1 125 person mSv
- Fort Calhoun 51 person mSv

US BWRs

The total collective dose for US BWRs in 2014 was 37,980.63 person mSv for 35 operating BWR units. The 2014 BWR total collective dose was 15% lower than the 2013 US BWR total collective dose of 44,518.52 person mSv for 35 operating BWR units. The 2014 average collective dose per reactor was 1085 person mSv/BWR unit.

Most US BWR units are on 24-month refueling cycles. The highest 2014 annual US BWR site dose was 4,309 person mSv at Peach Bottom 2,3. The lowest US BWR annual dose in 2014 was River Bend with 161 person mSv. US BWRs have faced occupational dose challenges due to power up-rates and water chemistry at some US BWR units in 2014.

- *New plants on line/plants shut down*

  Watts Bar 2, a TVA Westinghouse Ice Condenser unit, is being prepared to commence initial operations in early 2016. Southern Company is continuing the construction of two new PWRs at the Vogtle site in Georgia. South Carolina Electric & Gas is constructing two new PWRs on the V.C.Summer site. Upon completion of these reactors, the US may be operating 101 reactors in the near future, if there are no permanent shutdowns of any other sites.

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

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

- *Major evolutions*

  Four US PWRs continued their transition to decommissioning status, with their definitive shut down dates listed in the following: Crystal River on February 20, 2013 (containment concrete issues), Kewaunee on May 7, 2013 (low regional electricity prices due to natural gas competition), and San Onofre 2,3 on June 7, 2013 (due to new steam generator engineering design errors). The 2014 occupational dose for selected US units undergoing SAFESTOR or decommissioning are as follows:

  - Crystal River 6.96 person mSv
  - San Onofre 2, 3 13.69 person mSv
  - Kewaunee 19.64 person mSv
  - Humboldt Bay 123.81 person mSv
  - Zion 1,2 787.30 person mSv

- *New/experimental dose-reduction programmes*

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

Technical plans for major work in 2014

PWRs continue to perform MSIP treatments (piping squeeze to relief metallurgical stresses) on plant piping. Boric acid leak remediation is also an on-going emphasis at US PWRs. Prairie Island 1 replaced Steam Generators in 2014.

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. Loading of spent fuel assemblies into dry casks continued in 2014. US BWRs continue to replace dryers in the upper reactor internals.

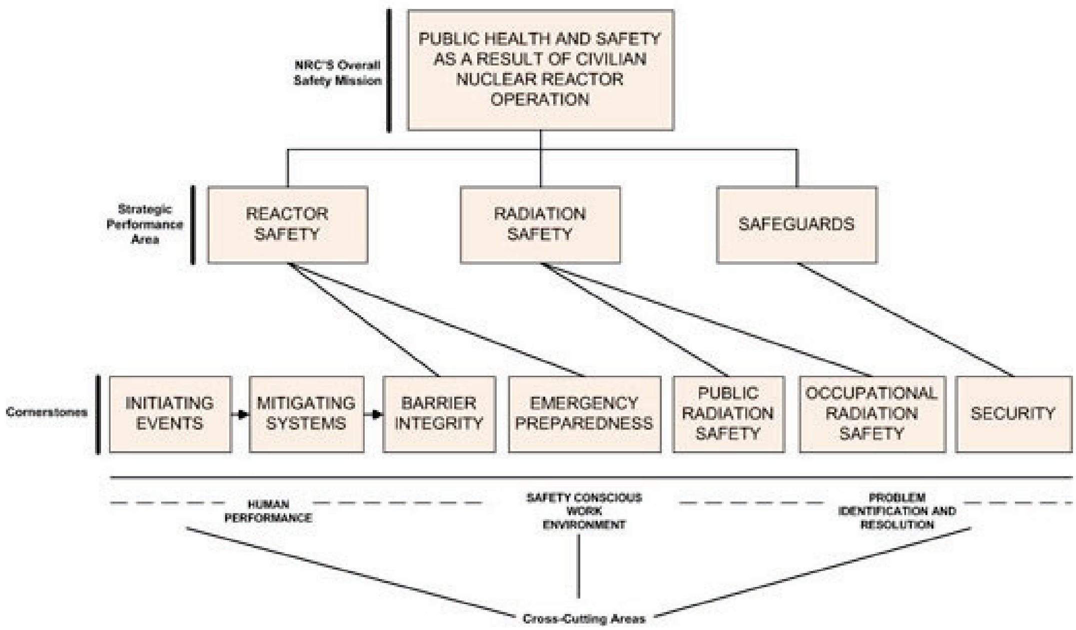
Regulatory plans for major work in 2014

NRC's Reactor Oversight Program – Regulatory Framework

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

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

REGULATORY FRAMEWORK



Occupational Radiation Safety Cornerstone and 2014 Results

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

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

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

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

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

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

Those units that do not cross the thresholds receive a green finding or no findings. Of the 103 units evaluated in 2013 only one unit in the first quarter received an elevated finding due to findings found in 2012. The latest ROP Performance Indicator Findings can be found at www.nrc.gov/NRR/OVERSIGHT/ASSESS/pi_summary.html.

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

4. ISOE EXPERIENCE EXCHANGE ACTIVITIES

While ISOE is well known for its occupational exposure data and analyses, the programme's strength comes from its efforts to share such information broadly amongst its participants. The combination of ISOE symposia, ISOE Network and technical visits provides a means for radiation protection professionals to meet, share information and build links between ISOE regions to develop a global approach to occupational exposure management. This section provides information on the main information and experience exchange activities within ISOE during 2014.

4.1 ISOE ALARA Symposia

ISOE Regional ALARA Symposium

North American Symposium

The 2014 ISOE North American ALARA Symposium was held 13-15 January 2014 at Fort Lauderdale, United States. The symposium was organised by the North American Technical Centre (NATC) and was attended by 100 registered participants. A distinguished paper was selected by the participating technical centres:

- *Fermi 2 BWR Outage Dose Reduction Achievements*, D. LaBurn, Fermi NPP, United States

European Symposium

The 2014 ISOE North American ALARA Symposium was held 9-11 April 2014 in Bern/Switzerland. The symposium was organised by the European Technical Centre (ETC), in collaboration with Mühleberg NPP and the Swiss Federal Nuclear Safety Inspectorate (ENSI) and was attended by 156 registered participants from 22 countries. Distinguished papers selected by the participating technical centres included:

- *High Pressure Water Decontamination at the Nuclear Power Plant Philippsburg,* M. Hellmann (Philippsburg NPP), Germany
- *ALARA Management Measures and Experience in Post Handling of Replaced Pressurizer from Ringhals 4,* E. Hernvall, T. Svedberg (Ringhals NPP), Sweden

And a distinguished poster:

- *Modelling the Relation between the Activity of a PWR Primary Circuit and the Occupational Dose,* S. Schneider, A. Artmann (GRS), Germany

In connection with the symposium, the participants had the opportunity to participate in technical visits at Mühleberg NPP and Mont Terri Rock Laboratory on 11 April.

Asian Symposium

The 2014 ISOE Asian ALARA Symposium was held 23-24 September 2014 in Gyeongju/Republic of Korea. The symposium was organised by the Asian Technical Centre (ATC) and was attended by 117 registered participants from 4 countries. Distinguished papers selected by the participating technical centres included:

- *Radiation Protection Management in Fukushima Daiichi NPS and Post-Accident Measures,* S. Takahira, TEPCO, Japan
- *Decreasing costs and increasing efficiency by reusing Lead vests for reduction of waste materials,* D.K. Yun, KHNP, Republic of Korea

In connection with the symposium, the participants had the opportunity to participate in technical visits at Wolsong NPP and Gyeongju LILW Disposal Site on 25 September.

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

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

The ISOE website 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 website, containing both public and members-only resources, provides participants with access to a broad and growing range of ALARA resources, including ISOE publications, reports and symposia proceedings, web forums for real-time communications amongst participants, members address books, and online access to the ISOE occupational exposure database.

ISOE Occupational Exposure Database

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

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 2014, eleven 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. The following types of documents are 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 website. In addition to a common user group for all members, the forum contains a dedicated regulators group and a common utilities group. All questions and answers entered in the RP Forum are searchable using the website search engine, increasing the potential audience of any entered information.

4.3 ISOE benchmarking visits

To facilitate the direct exchange of radiation protection practice and experience, the ISOE programme supports voluntary site benchmarking visits amongst the Participating Utilities in the four technical centre regions. These visits are 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 website in order to facilitate the broader distribution of this information within ISOE. Highlights of visits conducted during 2014 are summarisd below.

Benchmarking visits organised by ETC

In 2014, two benchmarking visits have been organised by ETC for the French Utility EDF, using ISOE contacts, but no ISOE/ETC resources. The French team was composed of representatives of EDF and CEPN.

— May 2014: Visit to Diablo Canyon NPP, United States.
  The visit took place from 19^{th} to 22^{nd} May 2014.
  The main topic discussed was:
  - 4-loop Steam Generator Replacement
    (EDF will perform the first 4-loop SGR at Paluel NPP in 2015)

— October 2014: Visit to Almaraz NPP, Spain.
  The visit took place on 7th and 8th October 2014.
  The main topics discussed were:
  - RP organisation
  - Training
  - RP Performance indicators
  - Optimisation process

Benchmarking visits organised by NATC

A benchmarking visit was conducted by the NATC.

— November 2013: benchmarking trip to Prairie Island NPP, United States.

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 2014, including:

ISOE Meetings	**Date**
ISOE Bureau	Apr. 2014; Nov. 2014
Working Group on Data Analysis (WGDA)	Nov. 2014
24^{th} ISOE Management Board Meeting	Nov. 2014
Expert Group on Occupational Radiation Protection in Severe Accident Management and Post-Accident Recovery (EG-SAM)	Apr. 2014; June. 2014

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 2014 and approving the programme of work for 2015. The 2014 mid-year meeting of the ISOE Bureau focused on the status of the ISOE activities for 2014, the status of the renewal of the ISOE Terms and Conditions, planning for the ISOE annual session 2014.

ISOE Working Group on Data Analysis

The Working Group on Data Analysis (WGDA) met in November 2014, 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 Expert Group on Water Chemistry and Source-Term Management (EGWC)

The EGWC published a report on April 2014 on "Radiation Protection Aspects of Primary Water Chemistry and Source-term Management". It reflects the current state of knowledge, technology and experience on primary water chemistry and source-term management issues directly related with radiation protection. According to its mandate, after the publication of the report, the working group has been disbanded.

ISOE Expert Group on Occupational Radiation Protection in Severe Accident Management and Post-accident Recovery (EG-SAM)

The expert group develop a preliminary report by the end of 2013. The content of the report is thus based on current reflections and action plans undertaken by the ISOE participating utilities and regulatory authorities to improve the emergency response plans in the event of a severe nuclear accident from the point of view of occupational radiation protection. A specific attention has been given to the analysis of past nuclear accidents (TMI-2, USA-1979; Chernobyl, USSR-1986 and Fukushima Daiichi, Japan-2011) and to the integration of the occupational radiation protection lessons learned from these accidents into the various chapters of the report.

To finalise the report, an international workshop was organised in June 2014 to present and discuss the content of the interim version and share national experiences on best occupational RP management practices and protocols for optimum RP job coverage during severe accident, initial response and recovery.

The report on "Occupational Radiation Protection in Severe Accident Management" has been finalised end of 2014 and published on January 2015. According to its mandate, after the publication of the report, the working group has been disbanded.

Annex 1

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

Note: This annex provides the status of ISOE official participation as of December 2014

Officially Participating Utilities: Operating reactors

Country	**Utility**[4]	**Plant name**	
Republic of Armenia	Armenian Nuclear Power Plant (CJSC)	Medzamor 2	
Belgium	Electrabel (GDF– SUEZ)	Doel 1, 2, 3, 4	Tihange 1, 2, 3
Brazil	Electrobras Eletronuclear S.A.	Angra 1, 2	
Bulgaria	Kozloduy NPP Plc.	Kozloduy 5, 6	
Canada	Bruce Power	Bruce A1, A2, A3, A4	Bruce B5, B6, B7, B8
	New Brunswick Electric Power Commission	Point Lepreau	
	Ontario Power Generation	Darlington 1, 2, 3, 4	Pickering 1, 4 Pickering 5, 6,7, 8
China	Daya Bay Nuclear Power Operations and Management Co., Ltd.	Daya Bay 1, 2 Ling Ao 1, 2, 3, 4	
	CNNC Nuclear Power Operations Management Co., Ltd.	Qinshan 1	
	CNNP Jiangsu Nuclear Power Corporation	Tianwan 1, 2	
Czech Republic	CEZ A.S.	Dukovany 1, 2, 3, 4 Temelin 1, 2	
Finland	Fortum Power and Heat Oy	Loviisa 1, 2	
	Teollisuuden Voima Oyj	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
Germany	E.ON Kernkraft GmbH	Brokdorf Grafenrheinfeld	Grohnde Isar 2
	EnBW Kernkraft GmbH	Philippsburg 2	Neckarwestheim 2
	RWE Power AG	Emsland	Gundremmingen B, C
Hungary	Magyar Villamos Muvek Zrt	Paks 1, 2, 3, 4	

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

Country	Utility[4]	Plant name	
Japan	Chubu Electric Power Co., Inc.	Hamaoka 3, 4, 5	
	Chugoku Electric Power Co. Inc.	Shimane 1, 2	
	Hokkaido Electric Power Co. Inc.	Tomari 1, 2, 3	
	Hokuriku Electric Power Co.	Shika 1, 2	
	Japan Atomic Power Co.	Tokai 2	Tsuruga 1, 2
	Kansai Electric Power Co., Inc.	Mihama 1, 2, 3 Ohi 1, 2, 3, 4	Takahama 1, 2, 3, 4
	Kyushu Electric Power Co., Inc.	Genkai 1, 2, 3, 4	Sendai 1, 2
	Shikoku Electric Power Co., Inc.	Ikata 1, 2, 3	
	Tohoku Electric Power Co., Inc.	Onagawa 1, 2, 3	Higashidori 1
	Tokyo Electric Power Co.	Fukushima Daiichi 5, 6 Fukushima Daini 1, 2, 3, 4	Kashiwazaki Kariwa 1, 2, 3, 4, 5, 6, 7
Korea, Republic of	Korean Hydro and Nuclear Power Co. Ltd. (KHNP)	Kori 1, 2, 3, 4 Shin-Kori 1, 2 Hanbit 1, 2, 3, 4, 5, 6	Hanul 1, 2, 3, 4, 5, 6 Wolsong 1, 2, 3, 4 Shin-Wolsong 1
Mexico	Comision Federal de Electricidad	Laguna Verde 1, 2	
Pakistan	Pakistan Atomic Energy Commission (PAEC)	Chasnupp 1, 2	Kanupp
Romania	Societatea Nationala Nuclearelectrica	Cernavoda 1, 2	
Russian Federation	Rosenergoatom Concern OJSC	Balokovo 1, 2, 3, 4 Kalinin 1, 2, 3, 4 Kola 1, 2, 3, 4	Novovoronezh 3, 4, 5 Rostov 1, 2
Slovak Republic	Slovenské Electrárne A.S.	Bohunice 3, 4	Mochovce 1, 2
Slovenia	Nuklearna Elektrarna Krško	Krško 1	
South Africa	ESKOM	Koeberg 1, 2	
Spain	UNESA	Almaraz 1, 2 Asco 1, 2 Cofrentes	Trillo 1 Vandellos 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	BKW FMB Energie AG	Mühleberg	
	Kernkraftwerk Gösgen-Däniken AG	Gösgen	
	Kernkraftwerk Leibstadt AG	Leibstadt	
	Axpo AG	Beznau 1, 2	
Netherlands	N.V. EPZ	Borssele	
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	

Country	Utility[4]	Plant name	
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 Nuclear Corporation	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
	First Energy Nuclear Operating Co.	Beaver Valley 1, 2 Davis Besse 1	Perry 1
	Luminant Generation Company, LIc.	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	
	Public Service Electric & Gas Co.	Hope Creek 1	
	PPL Susquehanna, LIc.	Susquehanna 1, 2	
	South Carolina Electric & Gas Co.	Virgil C. Summer 1	
	South Texas Project Nuclear Operating Co.	South Texas 1, 2	
	Southern Nuclear Operating Company, Inc.	Hatch 1, 2 Farley 1, 2	Vogtle 1, 2
	Tennessee Valley Authority (TVA)	Browns Ferry 1, 2, 3 Sequoyah 1, 2	Watts Barr 1
	Wolf Creek Nuclear Operation Corp.	Wolf Creek	
	XCel Energy	Monticello	Prairie Island 1, 2

Officially Participating Utilities: Definitively shutdown reactors

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

Participating Regulatory Authorities

Country	Authority
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	Ministry of Infrastructure and the Environment, Human Environment and Transport Inspectorate
Slovak Republic	Public Health Authority of the Slovak Republic
Slovenia	Ministry of Health, Slovenian Radiation Protection Administration (SRPA) Slovenian Nuclear Safety Administration (SNSA)
Spain	Consejo de Seguridad Nuclear (CSN) – Nuclear Safety Council
Sweden	Swedish Radiation Safety Authority (SSM)
Switzerland	Swiss Federal Nuclear Safety Inspectorate (ENSI)
United Kingdom	The Office for Nuclear Regulation (ONR)
United States	U.S. Nuclear Regulatory Commission (US NRC)

Country – Technical Centre affiliations

Country	Technical Centre*	Country	Technical Centre
Armenia	IAEATC	Mexico	NATC
Belgium	ETC	Netherlands	ETC
Brazil	IAEATC	Pakistan	IAEATC
Bulgaria	IAEATC	Romania	IAEATC
Canada	NATC	Russian Federation	ETC
China	IAEATC	Slovak Republic	ETC
Czech Republic	ETC	Slovenia	ETC
Finland	ETC	South Africa, Rep. of	IAEATC
France	ETC	Spain	ETC
Germany	ETC	Sweden	ETC
Hungary	ETC	Switzerland	ETC
Italy	ETC	Ukraine	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)	Japan Nuclear Energy Safety Organisation (JNES) Tokyo, Japan www.jnes.go.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, U.S.A. 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

	2009 2010	2011 2012	2013 2014
Chairperson (Utilities)	SIMIONOV, Vasile Cernavoda NPP ROMANIA	ABELA, Gonzague EDF FRANCE	HARRIS, Willie EXELON UNITED STATES
Chairperson Elect (Utilities)	ABELA, Gonzague EDF FRANCE	HARRIS, Willie EXELON UNITED STATES	HWANG, Tae-Won KHNP REPUBLIC OF KOREA
Vice-Chairperson (Authorities)	HOLAHAN, Vincent US Nuclear Regulatory Commission UNITED STATES	DJEFFAL, Salah Canadian Nuclear Safety Commission CANADA BROCK, Terry US Nuclear Regulatory Commission UNITED STATES	JAHN, Swen-Gunnar ENSI SWITZERLAND
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Annex 3

ISOE MANAGEMENT BOARD AND NATIONAL CO-ORDINATORS (2013-2014)

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

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PYUSKYULYAN Konstantin	Medzamor 2 NPP
AVETISYAN, Aida	Armenian Nuclear Regulatory Authority
BELGIUM	
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SCHRAYEN, Virginie	FANC – Federal Agency for Nuclear Control
BRAZIL	
do AMARAL, Marcos Antônio	Angra NPP
GROMANN DE ARAUJO GOES, Alexandre	CNEN – National Nuclear Energy Commission
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CANADA	
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PRITCHARD, Colin	Bruce Power
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ZHANG, Jintao	China National Nuclear Corporation
CZECH REPUBLIC	
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FUCHSOVA, Dagmar	SUJB – State Office for Nuclear Safety
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BUJTAS, Tibor	PAKS NPP
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SUZUKI, Akiko	Nuclear Regulation Authority (NRA)
YAMATO, Aiji	Nuclear Safety Research Association (NSRA)
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TUMOSIENE Kristina	VATESI – State Nuclear Power Safety Inspectorate
PLETNIOV, Victor	Ignalina NPP

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DELGADO, José Luis	Comisión Nacional de Seguridad Nuclear y Salvaguardias
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MEIJER, Hans	Borssele NPP
BREAS, Gerard	Ministry of Infrastructure and the Environment
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MUBBASHER, Makshoof A.	Chasnupp NPP
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JUG, Nina	Slovenian Radiation Protection Administration
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JUTLE, Kasturi	Council for Nuclear Safety
SPAIN	
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SWITZERLAND	
TAYLOR Thomas	Mühleberg NPP
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RYAZANTSEV, Viktor	SNRCU – State Nuclear Regulatory Committee of Ukraine
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RENN, Guy	Sizewell B NPP
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UNITED STATES OF AMERICA	
MILLER, David	D.C. Cook Plant (NATC)
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NOBLE, Douglas	Davis Besse NPP

Annex 4

ISOE WORKING GROUPS (2014)

Working Group on Data Analysis (WGDA)

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FARNIKOVA, Monika	Temelin NPP
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COUASNON, Olivier	Autorité de Sûreté Nucléaire (ASN)
D'ASCENZO, Lucie	CEPN (ETC)
MICHELET, Marie	EDF
ROCHER, Alain	EDF
SCHIEBER, Caroline	CEPN (ETC)
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JENTJENS, Lena	VGB PowerTech
STAHL, Thorsten	Gesellschaft für Anlagen-und Reaktorsicherheit (GRS) mbH
STEINEL, Dieter	Philippsburg NPP
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BESSHO, Yasunori	Nuclear Regulation Authority (NRA)
SUZUKI, Akiko	Nuclear Regulation Authority (NRA)
KOREA (REPUBLIC OF)	
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JUNG, Kyu-Hwan	Korea Institute of Nuclear Safety (KINS)
KIM, Byeong-Soo	Korea Institute of Nuclear Safety (KINS)
KONG, Tae Young	Korea Hydro and Nuclear Power Corporation Ltd. (KHNP)
LEE, Tearyong	Korea Hydro and Nuclear Power Corporation Ltd. (KHNP)
MEXICO	
ARMENTA, Socorro	Laguna Verde NPP
ROMANIA	
SIMIONOV, Vasile	Cernavoda NPP
RUSSIAN FEDERATION	
GLASUNOV, Vadim	Russian Research Institute for Nuclear Power Plant Operation (VNIIAES)
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BREZNIK, Borut	Krsko NPP
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HENNIGOR, Staffan	Forsmark NPP
SVEDBERG, Torgny	Ringhals NPP
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UNITED STATES OF AMERICA	
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HAGEMEYER, Derek	Oak Ridge Associated Universities (ORAU)
HARRIS, Willie O.	Exelon Nuclear
MILLER, David W.	D.C. Cook Plant (NATC)
PERKINS, David	Electric Power Research Institute (EPRI)
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MA, Jizeng	IAEA
OKYAR, Halil Burçind	NEA

Expert Group on Water Chemistry and Source-Term Management (EGWC)

Chair: ROCHER, Alain (France)

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ROCHER, Alain	EDF
VAILLANT, Ludovic	CEPN (ETC)
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SMIEŠKO, Ivan	Bohunice NPP
SWEDEN	
BENGTSSON, Bernt	Ringhals NPP
OLSSON, Mattias	Forsmark NPP
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WELLS, Daniel M.	Electric Power Reasearch Institute (EPRI)

Expert Group on Occupational Radiation Protection in Severe Accident Management & Post-Accident Recovery (EG-SAM)

Chair: ANDERSON, Ellen (United States)

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PRITCHARD, Colin	Bruce Power
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BELTRAMI, Laure-Anne	CEPN – ISOE ETC
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SUZUKI, Akiko	Nuclear Regulation Authority (NRA)
KOREA (REPUBLIC OF)	
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KONG, Tae Young	KHNP Central Research Institute
ROMANIA	
SIMIONOV, Vasile	Cernavoda NPP
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GLASUNOV, Vadim	Russian Research Institute for Nuclear Power Plant Operation (VNIIAES)
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GRUBEL, Stefan	Slovenské elektrárne, a.s.
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ROSELL HERRERA, Borja	Almaraz NPP
LABARTA, Teresa	Consejo de Seguridad Nuclear (CSN)
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FRITIOFF, Karin	Vattenfall Research & Development AB
SWITZERLAND	
JAHN, Swen-Gunnar	Swiss Federal Nuclear Safety Inspectorate (ENSI)
WOENKHAUS, Jürgen	Beznau NPP
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VITALIEVICH, Zubov Sergei	South Ukraine NPP
UNITED KINGDOM	
RENN, Guy	Sizewell B NPP

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HARRIS, Willie	Exelon Nuclear
MILLER, David W.	DC Cook NPP – ISOE NATC
TARZIA, James P.	Radiation Safety & Control Services Inc.

JOINT SECRETARIAT

MA, Jizeng	IAEA
OKYAR, Halil Burçind	NEA

Annex 5

LIST OF ISOE PUBLICATIONS

Reports

- *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.
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- *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.
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- *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.
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- *ISOE – Nuclear Power Plant Occupational Exposures in OECD Countries: 1969-1991,* OECD, 1993.

ISOE News

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. 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
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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
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No. 20: Oct. 2003	Japanese dosimetric results: FY2002 data and trends
No. 19: Oct. 2002	Korea, Republic of; Summary of National Dosimetric Trends
No. 18: Oct. 2002	Japanese occupational exposure during periodic inspection at PWRs and BWRs ended in FY 2001
No. 17: Oct. 2002	Japanese dosimetric results: FY2001 data and trends
No. 16: Oct. 2001	Japanese occupational exposure during periodical inspection at PWRs and BWRs ended in FY 2000
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No. 14: Sept. 2000	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1999
No. 13: Sept. 2000	Japanese Dosimetric Results: FY 1999 Data and Trends
No. 12: Oct. 1999	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1998
No. 11: Oct. 1999	Japanese Dosimetric Results: FY 1998 Data and Trends
No. 10: Nov. 1999	Experience of 1st Annual Inspection Outage in an ABWR
No. 9: Oct. 1999	Replacement of Reactor Internals and Full System Decontamination at a Japanese BWR
No. 8: Oct. 1998	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1997
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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. 56: Dec. 2012 European dosimetric results for 2011

No. 55: Nov. 2012 Man-Sievert Monetary Value Survey (2012 Update)

No. 54: Feb. 2012 European dosimetric results for 2010

No. 53: Feb. 2011 European dosimetric results for 2009

No. 52: Apr. 2010 PWR Outage Collective Dose: Analysis per sister unit group for the 2002-2007 period

No. 51: Dec. 2009 European dosimetric results for 2008

No. 50: Sep. 2009 Outage duration and outage collective dose between 1996 – 2006 for VVERs

No. 49: Sep. 2009 Outage duration and outage collective dose between 1996 – 2006 for BWRs

No. 48: Sep. 2009 Outage duration and outage collective dose between 1996 – 2006 for PWRs

No. 47: Feb. 2009 European dosimetric results for 2007

No. 46: Oct. 2007 European dosimetric results for 2006

No. 44: July 2006 Preliminary European dosimetric results for 2005

No. 43: May 2006 Conclusions and recommendations from the Essen Symposium

No. 42: Nov. 2005 Self-employed Workers in Europe

No. 41: Oct. 2005 Update of the annual outage duration and doses in European reactors (1994-2004)

No. 40: Aug. 2005 Workers internal contamination practices survey

No. 39: July 2005 Preliminary European dosimetric results for 2004

No. 38: Nov. 2004 Update of the annual outage duration and doses in European reactors (1993-2003)

No. 37: July 2004 Conclusions and recommendations from the 4th European ISOE workshop on occupational exposure management at NPPs

No. 36: Oct. 2003 Update of the annual outage duration and doses in European reactors (1993-2002)

No. 35: July 2003 Preliminary European dosimetric results for 2002

No. 34: July 2003 Man-Sievert monetary value survey (2002 update)

No. 33: March 2003 Update of the annual outage duration and doses in European reactors (1993-2001)

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

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

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

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

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

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

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

No. 25: June 2000	Conclusions and recommendations from the 2nd EC/ISOE workshop on occupational exposure management at nuclear power plants
No. 24: June 2000	List of BWR and CANDU sister unit groups
No. 23: June 2000	Preliminary European Dosimetric Results 1999
No. 22: May 2000	Analysis of the evolution of collective dose related to insulation jobs in some European PWRs
No. 21: May 2000	Investigation on access and dosimetric follow-up rules in NPPs for foreign workers
No. 20: April 1999	Preliminary European Dosimetric Results 1998
No. 19: Oct. 1998	ISOE 3 data base – New ISOE 3 Questionnaires received (since Sept 1998)
No. 18: Sept. 1998	The Use of the man-Sievert monetary value in 1997
No. 17: Dec. 1998	Occupational Exposure and Steam Generator Replacements, update
No. 16: July 1998	Preliminary European Dosimetric Results for 1997
No. 15: Sept. 1998	PWR collective dose per job 1994-1995-1996 data
No. 14: July 1998	PWR collective dose per job 1994-1995-1996 data
No. 12: Sept. 1997	Occupational exposure and reactor vessel annealing
No. 11: Sept. 1997	Annual individual doses distributions: data available and statistical biases
No. 10: June 1997	Preliminary European Dosimetric Results for 1996
No. 9: Dec. 1996	Reactor Vessel Closure Head Replacement
No. 7: June 1996	Preliminary European Dosimetric Results for 1995
No. 6: April 1996	Overview of the first three Full System Decontamination
No. 4: June 1995	Preliminary European Dosimetric Results for 1994
No. 3: June 1994	First European Dosimetric Results: 1993 data
No. 2: May 1994	The influence of reactor age and installed power on collective dose: 1992 data
No. 1: April 1994	Occupational Exposure and Steam Generator Replacement

IAEA Technical Centre

No. 9: Aug. 2003	Preliminary dosimetric results for 2002
No. 8: Nov. 2002	Conclusions and Recommendations from the 3rd European ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants
No. 7: Oct. 2002	Information on exposure data collected for the year 2001
No. 6: June 2001	Preliminary dosimetric results for 2000
No. 5: Sept. 2000	Preliminary dosimetric results for 1999
No. 4: April 1999	IAEA Workshop on implementation and management of the ALARA principle in nuclear power plant operations, Vienna 22-23 April 1998
No. 3: April 1999	IAEA technical co-operation projects on improving occupational radiation protection in nuclear power plants
No. 2: April 1999	IAEA Publications on occupational radiation protection
No. 1: Oct. 1995	ISOE Expert meeting

North American Technical Centre

2014-2: Aug. 2014	Kewaunee PWR Low Dose Outage Worker Study
2014-1: July 2014	North American Pressurized Water Reactor (PWR) 2013 Occupational Dose Benchmarking Charts
2012-13: Sept. 2012	2011 CANDU Occupational Dose Benchmarking Charts
2012-12: July 2012	North American Boiling Water Reactor (BWR) 2008 Occupational Dose Benchmarking Charts
2012-11: July 2012	North American Pressurized Water Reactor (PWR) 2008 Occupational Dose Benchmarking Charts
2012-10: July 2012	North American Boiling Water Reactor (BWR) 2007 Occupational Dose Benchmarking Charts
2012-9: July 2012	North American Pressurized Water Reactor (PWR) 2007 Occupational Dose Benchmarking Charts
2012-8: Sept. 2012	North American Boiling Water Reactor (BWR) 2011 Occupational Dose Benchmarking Charts
2012-7: Sept. 2012	North American Pressurized Water Reactor (PWR) 2011 Occupational Dose Benchmarking Charts
2012-6: Sept. 2012	North American Pressurized Water Reactor (PWR) 2011 Occupational Dose Benchmarking Charts
2012-5: July 2012	North American Pressurized Water Reactor (PWR) 2010 Occupational Dose Benchmarking Charts
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2012-1: July 2012	North American Pressurized Water Reactor (PWR) 2006 Occupational Dose Benchmarking Charts
2010-14: June 2010	NATC Analysis of Teledosimetry Data from Multiple PWR Unit Outage CRUD Bursts
2003-8: Aug. 2003	U.S. PWR - Reactor Head Replacement Dose Benchmarking Study
2003-5: July 2003	North American BWR - 2002 Occupational Dose Benchmarking Charts
2003-4: July 2003	U.S. PWR - 2002 Occupational Dose Benchmarking Chart
2003-2: July 2003	3-Year rolling average annual dose comparisons – U.S. BWR 2000-2002 Occupational Dose Benchmarking Charts
2003-1: July 2003	3-Year rolling average annual dose comparisons – U.S. PWR 2000-2002 Occupational Dose Benchmarking Charts
2002-5: July 2002	U.S. BWR – 2001 Occupational Dose Benchmarking Chart
2002-4: July 2002	U.S. PWR – 2001Occupational Dose Benchmarking Chart
2002-2: July 2002	3-Year rolling average annual dose comparisons – U.S. BWR 1999-2001 Occupational Dose Benchmarking Charts
2002-1: Nov. 2002	3-Year rolling average annual dose comparisons – U.S. PWR 1999-2001

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

ISOE International and Regional Symposia

Asian Technical Centre

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

European Technical Centre

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

IAEA Technical Centre

Oct. 2009 (Vienna, Austria)	2009 ISOE International ALARA Symposium

North American Technical Centre

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