2017

INFORMATION SYSTEM ON OCCUPATIONAL EXPOSURE

[ISOE Country Reports]

Rev. 9, 26/01/2023

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.

This special edition of country reports presents dose information and principal events of 2017 in 29[*] out of 31 ISOE countries and will be incorporated into the Twenty-Seventh Annual Report of the ISOE Programme.

[*] Dose info and principal events of 2017 are not presented for Belarus and United Arab Emirates which do not have NPPs in operation (or decommissioning).

TABLE OF CONTENTS

INTRODUCTION

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 special edition of country reports presents dose information and principal events of 2016 from 29[†] out of 31 ISOE countries and will be incorporated into the Twenty-Seventh Annual Report of the ISOE Programme.

ISOE is jointly sponsored by the OECD NEA and IAEA, and its membership is open to nuclear electricity utilities and radiation protection regulatory authorities worldwide who accept the programme's Terms and Conditions. The ISOE Terms and Conditions for the period 2016-2019 came into force on 1 January 2016. As of 15 December 2017, the ISOE programme included 76 Participating Utilities in 26 countries (345 operating units; 55 shutdown units; 8 units under construction), as well as the regulatory authorities in 26 countries. The ISOE database includes occupational exposure information for over 400 units in 29 countries, covering over 75% 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.

In addition to information from operating reactors, the ISOE database contains dose data from over 100 reactors which are shut down or in some stage of decommissioning. As these reactor units are generally of different type and size, and at different phases of their decommissioning programmes, it is difficult to identify clear dose trends. However, work continued in 2017 to improve the data collection for such reactors in order to facilitate better benchmarking.

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 2017, 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 2017 included: the ISOE North-American ALARA Symposium organised by the North American Technical Centre in Fort Lauderdale (USA) on 9-11 January and the ISOE ATC Benchmarking Exchange for Radiation Protection organised by the Asian Technical Centre and Nuclear Research Association (NSRA) in Kyoto (Japan) on 25-27 October. 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.

[†] Dose info and principal events of 2017 are not presented for Belarus and United Arab Emirates which do not have NPPs in operation (or decommissioning).

PRINCIPAL EVENTS IN PARTICIPATING COUNTRIES

ARMENIA

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	1	1058.235
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	1	N/A

2) Principal events of the year 2017

Outage information

The main contributions to the collective dose in 2017 were planned outage.

Collective doses during the 2017 outage

Outage number	Outage dates	Personal collective dose (man·mSv)		
		ANPP		Outside workers
		Planned	Received	Received
2017	10.05.17 - 07.07.17	899	824.635	114.116

Maximum personal doses during the 2017 outage

Outage number	Outage dates	Maximum personal dose (mSv)	
		ANPP	Outside workers
2017	10.05.17 - 07.07.17	17.337	5.005

- *Organisational evolutions*

With the purpose of the ALARA principle further implementation at the Armenian NPP the “Program of the Armenian NPP Radiation protection for 2017” was developed which sets the objectives and tasks for minimization of the radiation impact and ensuring the effective radiation protection for the Armenian NPP personnel.

The tasks were the following:

- Non exceeding of annual personnel collective dose above 1.31 man·Sv;
- Non exceeding of personnel collective dose during outage above 917 man·Sv;
- Non exceeding annual individual dose above 20 mSv.

3) Report from Authority

The Law of the RA on Safe Utilization of Atomic Energy for Peaceful Purposes (Atomic Law) is in the process of updating taking into account IAEA's recommendations, EU directives and IRRS mission recommendations. Revised Law will be submitted to the Government's approval by the end of 2018.

Following regulatory documents are under revision:

- Decree № 1489-N as of 18.08.2006 on approval of radiation safety rules;
- Decree № 1219-N as of 18.08.2006 on approval of radiation safety norms.
- Inspections procedures with Check lists.

BELGIUM

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	7	320.9 man·mSv/unit

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

Unit	Doel 4	Tihange 2	Doel 2	Doel 1	Tihange 1	Doel 3
Outage, 2017	March-May	April-May	May-June	June-July	September-November	September-November
Objective [man·mSv]	190	500	278	261	250	438
Total collective dose [man·mSv]	**225**	**460**	**371**	**360**	**185**	**416**

a) At the Doel 1 and 2 outages in 2017, the dose objectives were exceeded due to the rather unique LTO project for replacing the primary legs Safety Pressure relief Shielding.
b) At Tihange 1 and 2 the dose rates of the primary circuit are slightly elevated due to activation of silver. However, this does not pose a problem to obtain the dose objectives.
c) The personal contamination monitors at the exits of the RCA are being replaced by Argos portals by Mirion.

- *New/experimental dose-reduction programmes*

a) At Doel 3, a slight reduction in the ambient dose rate was measured, meaning that the zinc injection project is beginning to bear fruit.

- *Organisational evolutions*

a) Local RP-staff is being reinforced by experts from the corporate nuclear safety department

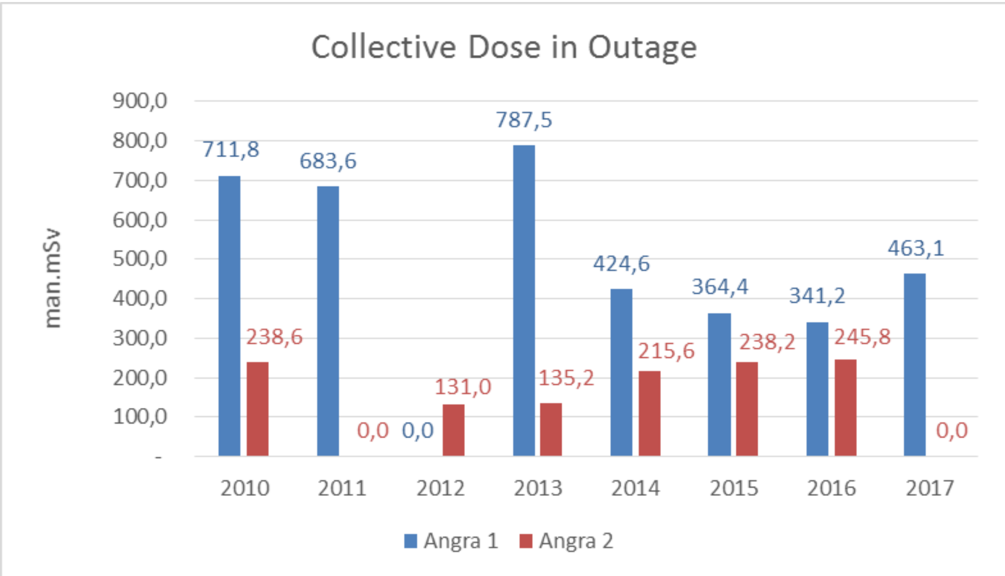
BRAZIL

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	2	Angra 1: 487.42 Angra 2: 12.48

2) Principal events of the year 2017

The main driver for the increased collective dose in 2017 is the outage duration of 57 days in Angra 1, influenced by the unexpected increase on the scope, mainly related to the turbine findings. Angra 2 had no refuelling outage, and the online collective dose presented 12.5 man·mSv, a good result.



Unit	Days of outage	Outage information
Angra 1	57	Refuelling and maintenance activities
Angra 2	-	There was no outage in 2017

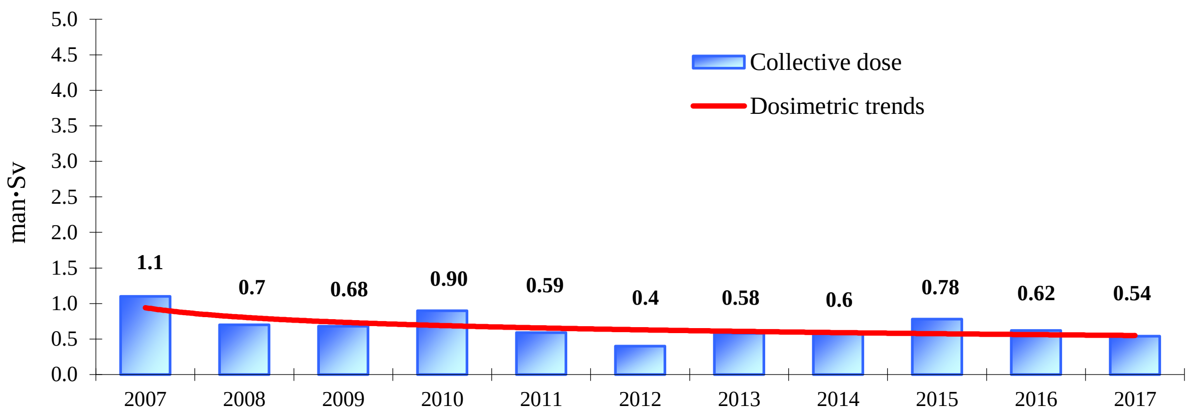
BULGARIA

1) Dose information for the year 2017

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	251
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	9.3

2) Principal events of the year 2017

Summary of dosimetric trends



Unit No.	Outage duration - days	Outage information
Unit 5	49 d	Refuelling and maintenance activities
Unit 6	41 d	Refuelling and maintenance activities

- *Events influencing dosimetric trends*

The main contributors to the collective dose in the year 2017 were the works carried out during the outages. The outage activities resulted in more than 93% of the total collective dose. Most of the higher radiation risk refurbishment activities started several years ago and aimed at increasing of the thermal power and life time extension of units 5&6. They were successfully completed in the previous year. That's why in 2017 in the RCA a large number of low and medium radiation risk activities were performed, which contributed to the collective dose. As examples could be given the following:

- systems and components investigation related to the life time extension project of Unit 5;
- steam generator separation system modernization (the last two steam generators of Unit 5);
- visual control of the reactor and reactor shaft;

- replacement of the main circulation pump aggregates;
- increased volume of radiography control;
- thermal insulation replacement.

The modernization of the steam generator separation system of Units 5&6 (8 SG in total) has been implemented during four outage campaigns. The collective dose gathered during the first campaign was up to 150 man·mSv and the collective dose gathered during the last campaign in 2017 was twice lower. This positive trend was defined by the experience that has been already gained.

CANADA

1) Dose information for 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [person·mSv/unit]**
CANDU	18*	750*

REACTORS IN COLD SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv]**
CANDU	3**	9**

*Darlington Unit 2 initiated a major refurbishment project in October 2016. In 2017 the Unit 2 refurbishment dose was 10,034 person·Sv. The Darlington Unit 2 2017 dose is not included in the 18 operating unit 2017 Canadian annual dose.
**Includes only that shutdown reactor that reports occupational dose separate from operating reactor units or other licensed activities, i.e., Gentilly-2. The remaining two shutdown units report their dose together with the operating Pickering units (Units 1,4,5,6,7,8).

2) Principal events of the year 2017

Summary of national dosimetric trends

- 13.340 person·Sv for 18 operating units in 2017
- Average annual dose per unit: 0.741 person·Sv in 2017

The total collective effective doses and the average collective dose per unit at operating Canadian nuclear plants decreased in 2017 (approximately 17.6 percent) from 2016. It is also noted that Darlington Unit 2 started major feeder tube refurbishment activities in October 2016.

The average calculated dose for 2017 includes eighteen (18) operating 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. The dose is included under the operational Pickering Units. Gentilly-2 transitioned from an operational site to safe storage in 2013. Gentilly-2 annual dose is reported separate from the operating units.

In 2017, approximately 83 percent of the collective operating units' dose was due to outage activities, and most of the radiation dose received by workers came from external exposure. Approximately 17 percent of the dose received was from internal exposure, with tritium being the main contributor to the internal dose of exposed workers.

The implementation of dose reduction initiatives at Canadian Nuclear Power Plants (NPPs) and improved work planning and control, continue to contribute to keeping worker doses ALARA (As Low As Reasonably Achievable) at the 18 operating units.

Bruce A

In 2017, all four units were operational at Bruce A Nuclear Generating Station. Bruce A, Units 1-4 completed planned and forced outages days in 2017 as listed below:

- Bruce A Unit 1 forced outage F1712 due to PHT shutdown during P-Trip SST. Bruce A Unit 1 forced outage F1711 due to unit removed from service for Hydro One maintenance. Forced outage was extended for SDS2 valve repairs for a total of 3.4 days.
- Bruce A Unit 2 experienced forced outage F1744 due to Heat Transport System leak with a duration of 5.6 days
- Bruce A Unit 2 experienced forced outage F1721 due Feedwater leak with a duration was 2.8 days.
- Bruce A Unit 3 planned defuel outage for 59 days in 2017
- Bruce A Unit 4 experienced Forced Outage F1744 due to degraded PHT Pump seal. Bruce A Unit 4 experienced Forced Outage F1743 due to a transient. Bruce A Unit 4 experienced Forced Outage F1742 due to a SBG outage. Bruce A Unit 4 experienced Forced Outage F1761 due to repair of 41120-MV6.

Bruce A, Units 1-4 routine operations dose for 2017 was 0.389 Person·Sv and the maintenance outage dose was 0.884 Person·Sv. The total collective dose for Bruce A Units 1-4 was 1.273 Person·Sv which resulted in an average collective dose 0.318 Person·Sv/unit.

Bruce B

Bruce B, Units 5-8 were operational in 2017 with planned outages in Units 5 & 6. Outage activities accounted for approximately 90 percent of the total collective dose. Routine operations accounted for approximately 10 percent of the total station collective dose. The 2017 maintenance outage results are provided below:

- Bruce B Unit 5 completed planned outage B1751 in 96.5 days. Bruce B Unit 5 experienced forced outage F1751 due to turbine issues.
- Bruce B Unit 6 completed planned outage B1761 in 65 days. Bruce B Unit 6 experienced a forced outage F1762 due to a turbine trip. Bruce B Unit 6 also experienced a forced outage F1761 due to ECI valve repair.
- Bruce Unit 7 experienced 4 forced outages for a total of 17 days.

Bruce B, Units 5-8 routine operations dose was 0.504 Person·Sv. The outage dose was 4.509 Person·Sv in 2017. The total dose was 5.012 Person·Sv which resulted in an average collective dose 1.253 Person·Sv/unit.

In 2017, approximately 11 percent of the total worker dose was due to internal dose. Tritium is the primary source of internal dose.

Darlington Units 1, 3, 4

Darlington Units 1, 3, 4 had routine operations dose of 0.429 person·Sv in 2017. Routine operations accounted for approximately 17 percent of the total collective dose. The total outage dose was 2.033 person·Sv. The internal dose for 2017 for Units 1, 3, 4 was 0.346 Sv. The external dose for 2017 for Units 1, 3, 4 was 2.116 Sv.
Outage scope included single fuel channel replacement, feeder inspections, pressure tube scrape, steam generator inspections. Also, moderator heat exchanger inspection, valve repair and pump seal replacement. Finally, ACU Coil replacement, shield tank over-pressure tie-in. The average 2017 effective dose for the 3 units was 0.821 person·Sv per unit. The total collective dose for Units 1, 3, 4 was 2.463 person·Sv.

Darlington Unit 2

Darlington Unit 2 commenced a refurbishment outage to replace feeder tubes and other components on October 15, 2016. Darlington Unit 2 continued the major refurbishment project in 2017. Scope included replacement of 960 feeder tubes, 960 end-fittings, 480 fuel channels (consisting of calandria tubes and pressure tubes) replacing horizontal and vertical flux detectors, cleaning steam generators, rehabilitating moderator valves, overhauling heat exchangers and pumps. The remaining 3 units will also undergo refurbishment in subsequent years. The 2017 refurbishment internal dose for Darlington Unit 2 was 0.195 Sv. The 2017 refurbishment external dose for Darlington 2 was 9.838 Sv. The total Unit 3 refurbishment dose was 10.034 person·Sv.

Pickering Nuclear

In 2017, Pickering Nuclear Generating Station had six units in operation (Units 1, 4, 5-8). Units 2 and 3 continued to remain in a safe storage state. Outage activities accounted for approximately 82 percent of the collective dose at Pickering Nuclear Generating Station. Routine operations accounted for approximately 18 percent of the total collective dose. The routine collective dose for operational units was 0.719 person·Sv in 2017. The outage dose for the operational units was 3.310 person·Sv. The total dose was 4.028 person·Sv which resulted in an average of collective dose 0.671 man·Sv/unit. The Pickering outages are summarized below:

- Pickering Unit 1 had a planned maintenance outage P1711 from August 21, 2017 to January 4, 2018. Pickering Unit 1 also experienced two forced outages in the 2nd and 3rd quarters for 6 days.
- Pickering Unit 4 had 1 planned maintenance outage P1741. Unit 4 had one forced outage in 2017.
- Pickering Unit 5 had one planned maintenance outage P1751 for 125 days.
- Pickering Unit 7 had one planned maintenance outage P1671 for 13 days. Pickering Unit 7 had one forced outage.
- Unit 7 experienced a 34 day forced outage in the fall, 2017.
- Pickering Unit 8 had one planned unbudgeted maintenance outage for 32 days.

The total external dose for all 6 operating Pickering Units was 324.625 Person rem in 2017 or 76 percent of the total annual dose. The total internal dose for all 6 operating Pickering Units was 78.179 person-rem in 2017 or 24 percent of the total annual dose.

The dose associated with radiological activities performed at Pickering Units 2 & 3 (in safe storage since 2010) is reported with the workers of the other 6 Pickering units. The dose from Units 2 and 3 is negligible, so including it in the dose of the operating units has negligible impact on the overall result.

Point Lepreau

Point Lepreau is a single unit CANDU station. In 2017, Point Lepreau was fully operational with a planned maintenance of 29 days. The outage dose was 0.361 person·Sv. Outage activities accounted for approximately 64 percent of the total collective dose at Pt. Lepreau.

The station maintenance outage was in April 2017. The station experienced a 3 day unplanned outage in August. The activity with the forced outage resulted in a total dose of less than 0.25 person·Sv. The planned outage involved work on heavy water systems including moderator system work on a main moderator pump, local air cooler replacements in the reactor vaults and work performing maintenance on the fueling machine bridge.

The routine collective dose for operational activities was 0.204 person·Sv in 2017. Routine collective dose accounted for approximately 36 percent of the total collective dose at Pt. Lepreau in 2017. Internal dose accounted for approximately 20 percent of the total collective dose. This increased dose contribution from tritium was due in part to a leaking fitting on the primary heat transport system.

The total unit dose in 2017 was 0.565 Person·Sv.

Gentilly-2

Gentilly-2 is a single unit CANDU station. In 2017, Gentilly-2 continued transition into the decommissioning phase. The reactor was shut down in December 28, 2012.

There was a decrease in the collective doses at Gentilly-2 because the majority of radiological work activities with the transition form an operational unit to a safe storage state occurred in 2014. The 2017 station collective dose is only attributed to safe storage transition activities

Number of individuals monitored in 2017 at Gentilly-2 was 735. The highest individual dose in 2017 was 1.16 mSv. The total site collective dose in 2017 was 0.009 person·Sv.

Regulatory Update Highlights

Canadian Nuclear Power Plant (NPPs) operated safely during 2017. Canadian NPP licensees were determined to have made adequate provision for the protection of the health safety and security of persons and the environment from the use of nuclear energy and took the measures required to implement Canada's international obligations. Radiation doses to workers and members of the public, and any radiological releases to the environment were all below regulatory limits. The implementation of radiation protection programs at Canadian Nuclear Power Plants (NPPs) met all applicable regulatory requirements and doses to workers and members of the public were maintained below regulatory dose limits.

Safety-related issues

No safety-related issues were identified in 2017.

Decommissioning Issues

Gentilly-2 continued to transition to safe storage in 2017.

New Plants under construction/plants shutdown:

No Units under construction in 2017.
Darlington Unit 2 continued refurbishment activities in 2017.

Conclusions

The 2017 average collective dose per operating unit for the Canadian fleet was 0.75 person·Sv/unit, achieving the CANDU WANO dose target of 0.80 person·Sv/unit.
Various initiatives were implemented at Canadian units to keep doses ALARA. Initiatives included improved shielding, source term reduction activities, use of CZT 3D isotopic mapping systems and improved work planning

CHINA

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	33	407.4
VVER	2	163.0
PHWR	2	351.0
All types	37	391.2

2) Principal events of the year 2017

- *Summary of national dosimetric trends*

  Two new PWR units (FUQING-4 and YANGJIANG-4) began commercial operation in 2017. For the 37 reactors, refueling outages were performed for 23 of 33 PWR units, 1 of 2 PHWR units, and 1 of 2 VVER units in 2017.

  The total collective dose for the Chinese nuclear fleet (33 PWR units, 2 VVER units and 2 PHWR units) in 2017 was 14.473 man·Sv. The resulting average collective dose was 391.2 man·mSv/unit. No individuals received a dose higher than 10 mSv in 2017.

  In the operation of nuclear power plants, annual collective dose is mainly from outages. The ALARA programme is well implemented during the design and operation of all nuclear power plants. The average annual collective dose per unit of 391.2 man·mSv/unit varied slightly in comparison with the year 2016 (364.7 man·mSv/unit).

  In 2017, there were no radiological events threatening the safety of people and the environment at the operational nuclear power plants. The monitoring index over the year showed that the integrity of three safety barriers was in sound status.

- *Regulatory requirements*

  In Feb. 2017, the Thirteenth Five-year Plan and 2025 Perspective Plan on Nuclear Safety and Prevention & Control of Radioactive Pollution was approved by the State Council of the People's Republic of China.

  In Sep. 2017, the Nuclear Safety Act of the People's Republic of China was issued.

  The National Information System on Occupational Radiation Exposure by NNSA is under construction in 2017, and will be finished by the end of 2018.

3) Report from Authority

The NNSA Annual Report in 2017 (Chinese) has been drafted and will be published soon.

CZECH REPUBLIC

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	6	167

2) Principal events of the year 2017

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

NPP, Unit	Outage information	CED [man·mSv]
Temelin, Unit 1	87 days since 12/9/2017 to 3/1/2018, prolonged maintenance outage with refuelling	33 (only the year of 2017 was included)
Temelin, Unit 2	87 days, prolonged maintenance outage with refuelling	79
Dukovany, Unit 1	124 days, prolonged maintenance outage with refuelling	146
Dukovany, Unit 2	182 days since 9/17/2016 to 3/18/2017, prolonged maintenance outage with refuelling	57 (only the year of 2017 was included)
Dukovany, Unit 3	141 days, prolonged maintenance outage with refuelling	342
Dukovany, Unit 4	119 days, prolonged maintenance outage with refuelling	165

CED remained stable in comparison with the previous year, but increased in comparison with years before mainly due to the main stream generator collector welding during outage of Unit 3 at Dukovany NPP. CED was also affected by excessive weld radiography and pipe welding at Dukovany NPP (all units).

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.

FINLAND

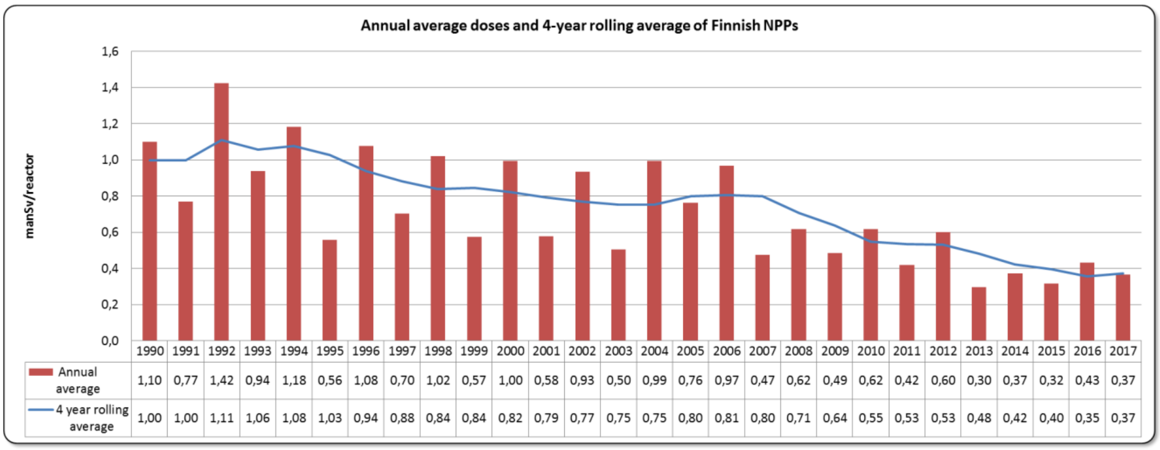
1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	2	257
BWR	2	475
All types	4	366

2) Principal events of the year 2017

- *Summary of national dosimetric trends*

The annual collective dose strongly depends on the length and type of annual outages. The 2017 collective dose (1.464 man·Sv) of Finnish NPPs was the 3rd lowest in the operating history, mainly due to short refuelling outages at three of four reactors. The 4-year-rolling average of collective doses showed a slight increase compared to previous year's result but in the long run the trend has been decreasing since the early 1990's.



<u>Olkiluoto 1 and 2</u>

The annual maintenance outage at unit OL1 included refuelling and standard annual outage work. The length of the outage was 10.5 days. Fuel leakage from previous operating cycle was still visible and caused the increased need to use personal protective gear. The effect of fuel leakage on collective dose is very hard to evaluate, but most likely the effect was less than 0.01 man·Sv. The collective dose was 0.118 man·Sv.

At the OL2 unit the outage was the longest annual outage in the history of TVO with a duration of 64.5 days (planned length 40.5 days). In addition to normal refuelling and maintenance work several big projects were implemented, such as SAFEND (Repair of flaws in RPV safe-end nozzles), ACIS (a new AC independent water injection system), FECO (renewal of reactor internal pumps frequency exchangers), JPD (diversifying of residual heat removal systems), LATE (renewal of high pressure side condense pumps and preheaters), RIP (renewal of Reactor Internal pumps) TICON (renewal turbine condenser tube assemblies and ejectors), TIP (renewal of neutron flux measuring calibration system). Also ASME inspections and repair of heat exchangers in reactor coolant purification system were significant in radiation protection point of view. There were several reasons for prolonging the outage, but the main reasons were related to SAFEND-project. The collective outage dose was 0.657 man·Sv.

In June, based on an increase in the levels of activity in the off-gas system, a fuel leak was detected at OL1. The leak rate increased rapidly and indications of secondary damage were detectable already during the first week. It was considered impossible to complete the operating cycle, as the fuel leak continued to progress at an increasing rate. OL1 was brought to shut down for a refuelling outage in October, when the fuel leak had continued for three months. The leaking fuel assembly was removed from the reactor core. The fuel leak caused significant contamination at the plant and the estimated amount of total dissolved uranium was ca. 23 g. The fuel leak will result in increased radiation doses in upcoming years and in delays in work due to increased need for protective equipment and decontamination. The length of the unexpected refuelling outage was about 10 days and the collective dose of this outage was about 0.05 man·Sv.

Olkiluoto 3

The arrival of fresh nuclear fuel began to the OL3 unit, which is under construction/commissioning. The first radiologically controlled areas were established to the fuel storage. The radiation exposure at OL3 is negligible so far.

Loviisa

On both units the 2017 outages were short refuelling outages with durations of some 19 days per unit. The collective outage doses were among the lowest in plant operating history; 0.186 (LO1) and 0.239 man·Sv (LO2). Main contributors to collective dose accumulation were reactor related tasks (disassembly, assembly), cleaning/decontamination and auxiliary work such as radiation protection, insulation and scaffolding.

Source term reduction:

- During the outages in 2012-2014 an antimony reduction project took place at both plant units. During the project, antimony-bearing gaskets of primary coolant pumps were replaced by antimony free ones. The project has resulted in reduced dose rates in the vicinity of primary components.

- Primary coolant purification system (TC) will be modified in 2019 to enable coolant purification during outages. In the current setup the filtration operates by the pressure difference created by primary coolant pumps, thus the filtration is not operable when the pumps are shut down. The modification consists of installation of a new circulation pump and piping in the steam generator confinement.

Other

Due to the new Hp(3) dose limits, both utilities performed studies on eye dose monitoring during outage periods. The aim was to investigate whether there is a need for wide-range Hp(3) monitoring in the future. Both studies came to the same conclusion that in normal exposure situations the whole body dosimetry results represent eye dose relatively well. Thus eye dose monitoring is required only in some specific tasks where the radiation field is less uniform.

3) Report from Authority

In order to meet the updated IAEA regulations and new European Directives a process to update the Nuclear Energy Act, the Radiation Act and the YVL-guides continued during 2017.

The operating license renewal including a periodic safety review was carried out for the Olkiluoto NPP. TVO submitted an application to the Government for continuing the operating licence for 20 years. The Ministry of Economic Affairs and Employment (MEAE) preparing the matter has requested STUK to issue a statement regarding TVO ’s application.

Finland has one NPP unit under construction (Olkiluoto 3 EPR). The Olkiluoto 3 project has moved from the construction phase to the commissioning phase. The oversight of trial operations constituted a large part of oversight work carried out by STUK in 2017. The oversight includes the inspection of test plans and results, as well as the oversight of different tests.

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

The Finnish Government granted on 12th November 2015 a construction license for Olkiluoto Spent Nuclear Fuel encapsulation plant and disposal facility. Posiva (operator) continued the construction of the disposal facility.

One research reactor has entered in to the decommissioning phase. VTT, Technical Research Centre of Finland (operator) submitted the operating licence application regarding decommissioning to the Government in June 2017, and at the same time also submitted the first set of decommissioning documentation to STUK for inspection.

FRANCE

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	58	610
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	55.3
PHWR	1	2.2
GCR	6	1.33
FNR	1	0.3

2) Principal events of the year 2017

Summary of national dosimetric trends

For 2017, the average collective dose of the French nuclear fleet (58 PWR) is 0.61 man·Sv/unit (as compared to the 2017 annual EDF objective of 0.68 man·Sv/unit). The average collective dose for the 3-loop reactors (900 MWe - 34 reactors) is 0.66 man·Sv/unit and the average collective dose for the 4-loop reactors (1300 MWe and 1450 MWe - 24 reactors) is 0.54 man·Sv/unit.

Type and number of outages

Type	Number
ASR – short outage	19
VP – standard outage	23
VD – ten-year outage	3
No outage	13
Forced outage	4 (*)

(*): dose > 20 man·mSv

Specific activities

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

The outage collective dose represents 81 % of the total collective dose. The collective dose received when the reactor is in operation represents 19 % of the total collective dose. The collective dose due to neutron is 0.235 man·Sv; 74 % of which (0.172 man·Sv) is due to spent fuel transport.

Individual doses

In 2017, no worker received an individual dose higher than 16 mSv in 12 rolling months on the EDF fleet. 78 % of the exposed workers received a cumulative dose lower than 1 mSv and 99.8 % of the exposed workers received less than 10 mSv.

The main 2017 events with a dosimetric impact are the following:

- Paluel 2 Steam Generator Replacement (SGR)
  Fall of a used SG (March 2016), no immediate radiological impact but extension of outage during all the year and until the end of the first half of 2018.
- Belleville 2 Control Rod hazard
  Mechanical failure of the H8 control rod. Extension of outage until April 2018 (instead of the end of 2017).

3-loop reactors – 900 MWe

2017 was an atypical year for Tricastin NPP:

- 1 Standard outage for Tricastin 2
- 1 Short outage for Tricastin 3
- 1 standard outage postponed to 2018 for Tricastin 4
- 2 outages ended in 2017 for Tricastin 1 and 4 (due to the carbon segregation problem)
- A 36 day outage for fuel economy for Tricastin 1
- 2 forced outages for Tricastin 1 and 4 (54 days) to strengthen the dike

The 3-loop reactors outage program was composed of 14 short outages, 13 standard outages, 1 ten-year outage (Cruas 2 started in 2017) and 1 Steam Generator Replacement for Cruas 1 (0.441 man·Sv).

One outage of the 2015 program will continue until end of July 2017: Bugey 5.

One outage started in 2016 continued in 2017 and should end in April 2018 (Fessenheim 2: carbon segregation).

The lowest collective doses for the various outage types were:

- Short outage: 0.145 man·Sv at Chinon B4
- Standard outage: 0.522 man·Sv at Gravelines 6
- Ten-year outage: not ended in 2017

4-loop reactors – 1300 MWe and 1450 MWe

In 2016, 8 units had no outage. The 4-loop reactors outage program was composed of 5 short outages, 9 standard outages and 2 ten-year outages.

One outage was not finished at the end of 2017: the 3rd ten-year outage with SGR of Paluel 2 (fall of the SG in 2016) began in 2015 and the end of the outage is planned at the end of first half 2018.

The lowest collective doses for the various outages types were:

- Short outage: 0.175 man·Sv at Golfech 2
- Standard outage: 0.629 man·Sv at Golfech 1
- Ten-year outage: 1.292 man·Sv at Saint-Alban 1

Main radiation protection significant events (ESR)

In 2017, 3 events have been classified level 1 at the INES scale (5 in 2016). They all concern skin or extremity dose.

- Blayais NPP

  1 event on unit 2 in April 2017: Contamination on the face by Co-60 of activity estimated at 390 kBq. The skin dose was estimated to be higher than one quarter of the annual limit.

- Fessenheim NPP

  1 event in June 2017: Contamination during the maintenance of the press to compact the waste. The skin dose was estimated to be higher than one quarter of the annual limit.

- Cattenom NPP

  1 event in August 2017: Contamination behind the right ear during an activity on the fuel handling machine in the reactor building. The skin dose was estimated to be higher than one quarter of the annual limit.

2018 goals

The collective dose objective for 2018 for the French nuclear fleet is set at 0.69 man·Sv/unit.

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

- Number of workers > 10 mSv over 12 rolling months ≤ 160
- Number of workers > 14 mSv over 12 rolling months ≤ 0

Future activities in 2018

For individual dose: nothing to report.

Collective dose: continuation of the activities initiated since 2012.

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

45 outages are planned for 2018 with 20 short outages, 21 standard outages and 4 ten-year outages. 3 outages that have begun in 2015, 2016 and 2017 are planned to end in 2018: the ten-year outage combined with a SGR started in 2015 at Paluel 2 (fall of SG), the standard outage started in 2016 in Fessenheim 2 (carbon segregation) and the short outage (started in 2017) at Belleville 2 (Control Rod hazard).

For 2018, hydrotests on RHRS circuits are expected: Blayais 3, Bugey 5, Civaux 2, Cattenom 2, Flamanville 1, Saint-Alban 2, Saint-Laurent 2 and Tricastin 4.

3) Report from the Authority

In 2017, ASN carried out 27 radiation protection inspections.

ASN considers that the radiation protection situation of the NPPs in 2017 could be improved more particularly on the following points:

- The organisation of control of the dispersal of contamination inside the reactor building must be improved, notably with regard to the confinement of worksites.
- On several sites, the ASN inspectors found a lack of radiation protection culture on the part of certain workers.
- Weaknesses remain in the control of industrial radiography sites: ASN more specifically identified several events involving overstepping of operation areas demarcation lines or the presence of workers inside the exclusion zone demarcation lines. Progress is required in the preparation of the worksites, more specifically multiple contractor activities and the quality of the installation walkdowns carried out when preparing these worksites.
- The radiation protection optimisation approach falls short of that in previous years. ASN more particularly identifies relatively unambitious reactor outage predicted dose targets. Progress is also expected in the drafting of the risk assessments for the work and the integration of contingencies.
- Control of radiological zoning and the associated provisions remains vulnerable. More specifically the risk assessments for the work do not always identify the risk of entering a specially regulated area.
- Shortcomings in the operational dosimetry alarms analysis process and in the assessment of the significant nature of these events were brought to light during ASN inspections in 2016 and 2017, which led EDF to notify a generic significant radiation protection event.

Shortcomings in the process to care for and treat contaminated personnel were identified in several NPPs. This can lead to delays in treatment, difficulties with dose evaluation and is conducive to inappropriate behaviour on exiting zones with a contamination risk.

The conditions for caring for and treating contaminated personnel are monitored by ASN, notably through simulation exercises. The shortcomings observed are the subject of requests for corrective action.

In several NPPs, ASN observes the positive impact of allocating "zone managers" for radiation protection of workers during reactor outages.

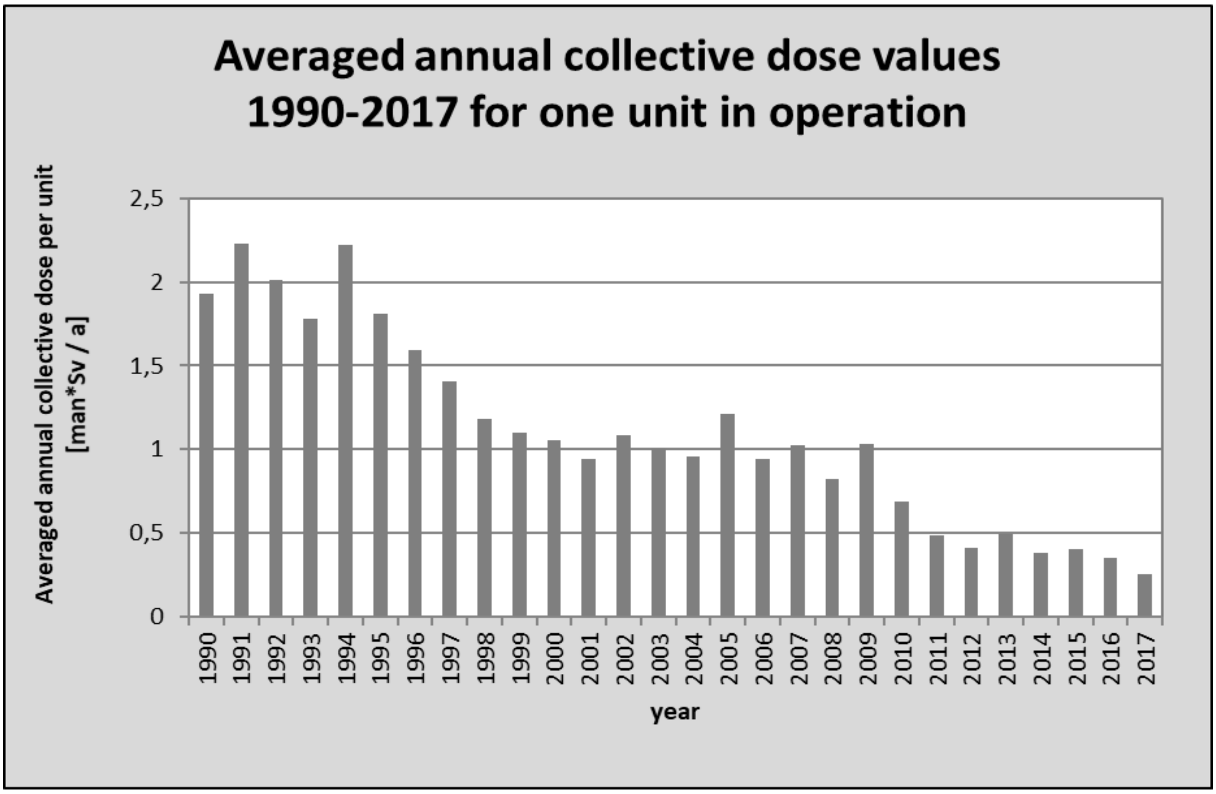
GERMANY

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	6	134.4
BWR	2	625.2
All types	8	257.1
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	8	73.9
BWR	4	74.5

2) Principal events of the year 2017

Summary of national dosimetric trends

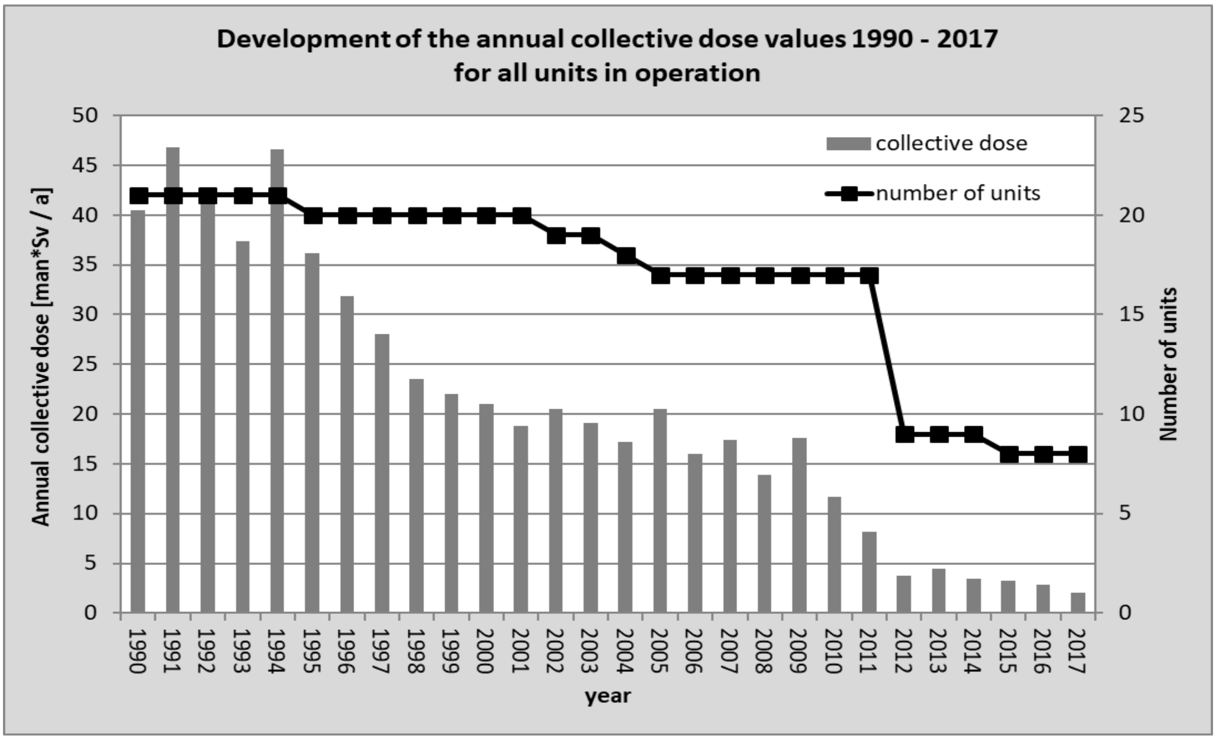


After the accident in Fukushima, Germany decided to terminate the use of nuclear power for the commercial generation of electricity. This was enforced by an amendment of the Atomic Energy Act on 6

August 2011, where further operation of eight nuclear power plants (Biblis A, Biblis B, Brunsbüttel, Isar 1, Krümmel, Neckarwestheim 1, Philippsburg 1 and Unterweser) was terminated. With this amendment, the remaining nine nuclear power plants in operation will be permanently shut down step by step by the end of the year 2022, one plant each at the latest by the end of 2017 (Gundremmingen B) and 2019 (Philippsburg 2) and another three each at the end of 2021 and of 2022. In this course, the nuclear power plant Grafenrheinfeld was shut down on 27 June 2015. Decommissioning of five of the switched off nuclear power plants has started in 2017 (Biblis A, Biblis B, Isar 1, Neckarwestheim 1 and Philippsburg 1). The remaining four nuclear power plants, which were currently switched off, were in the post-operational phase; to none of them a decommissioning licence was issued until the end of the year 2017.

The trend in the average annual collective dose for all units in operation from 1990 to 2017 is presented in the figure above. The decrease observed in the years 2011 and 2012 is based on the shutdown of the eight nuclear power plants. These plants belong to older construction lines which generally showed a higher annual collective dose compared to later construction lines. In 2017, the average annual collective dose per unit in operation (6 PWR, 2 BWR) was 0.26 man·Sv, whereas the PWR achieving 0.13 man·Sv and the value for the BWR was 0.63 man·Sv. A similar trend is obtained for the total annual collective dose, which is presented in the figure below.

For the plants in decommissioning, the value of the average annual collective dose is even lower, at 0.07 man·Sv. Here the four plants in the post-operational phase and the eight nuclear power plants Biblis A, Biblis B, Isar 1, Neckarwestheim 1, Philippsburg 1, Mülheim-Kärlich, Obrigheim, Stade were considered.



HUNGARY

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	4	341 (with electronic dosimeters) 325 (with TLDs)

2) Principal events of the year 2017

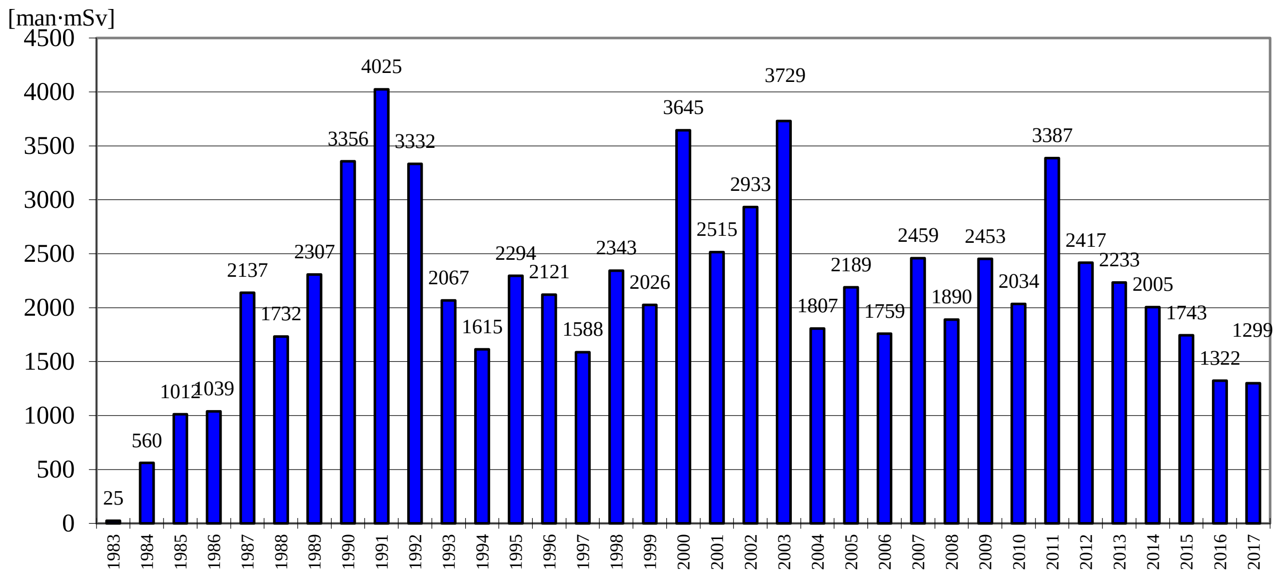
Summary of national dosimetric trends

Using the results of operational dosimetry the collective radiation exposure was 1365 man·mSv for 2017 at Paks NPP (934 man·mSv with dosimetry work permit and 372 man·mSv without dosimetry work permit). The highest individual radiation exposure was 9,7 mSv, which was well below the dose limit of 20 mSv/year, and our dose constraint of 12 mSv/year.

The collective dose was similar in comparison to the previous year.

The electronic dosimetry data correspond well with TLD data in 2017.

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



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

- *Events influencing dosimetric trends*

  There was one general overhaul (long maintenance outage) in 2017. The collective dose of the outage was 542 man·mSv on Unit 1.

- *Number and duration of outages*

  The durations of outages were 56 days on Unit 1, 29 days on Unit 3 and 26 days on Unit 4. The Unit-2 was not shut down for outage.

ITALY

1) Dose information for the year 2017

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	12.02 (1 unit - Trino NPP)
BWR	2	17.44 (1 unit Caorso NPP [1.22] + 1 unit Garigliano NPP [33.66])
GCR	1	1.24 (1 unit – Latina NPP)

JAPAN

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	20	144
BWR	22	115
All types	42	129
REACTORS OUT OF OPERATION OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	4	271
BWR	10	3,814
GCR	1	0
LWCHWR	1	131

2) Principal events of the year 2017

- *Outline of national dosimetry trend*

The average annual collective dose for operating reactors decreased from 148 man·mSv /unit in the previous year (2016) to 129 man·mSv /unit in 2017. The average annual collective dose for reactors out of operation or in decommissioning excluding Fukushima Daiichi NPP was 190 man·mSv /unit, and that of Fukushima Daiichi NPP was 6,252 man·mSv /unit.

The average annual collective dose of operating reactors was almost at the same level as for 2016. This is because almost all of the nuclear reactors have been shut down for a long time after the accident at Fukushima Daiichi NPP.

- *Operating status of nuclear power plants*

In FY 2017, at most five PWRs operated.

From April 1 to May 21, 2017:	2 units (Sendai 1, 2)
From May 22 to June 8, 2017:	3 units (Sendai 1, 2, Takahama 4)
From June 9, 2017 to January 28, 2018:	4 units (Sendai 1, 2, Takahama 3, 4)
From January 29 to March 24, 2018:	3 units (Sendai 2, Takahama 3, 4)
From March 25 to March 30, 2018:	4 units (Genkai 3, Sendai 2, Takahama 3, 4)
On March 31, 2018:	3 units (Sendai 2, Takahama 3, 4)

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

  Exposure dose distributions at Fukushima Daiichi NPP for dose during FY 2017 are shown below.

Cumulative dose Classification (mSv)	Fiscal year 2017 (April 2017 – March 2018)		
	TEPCO	Contractor	Total
＞50	0	0	0
20 ～ 50	0	74	74
10 ～ 20	18	1133	1151
5 ～ 10	85	1038	1123
1 ～ 5	306	3571	3877
≦1	1121	6597	7718
Total	1530	12413	13943
Max. (mSv)	15.94	32.74	32.74
Ave. (mSv)	1.15	2.88	2.69

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

- *Regulatory requirements*

  The examination of the new safety standards began in July 2013. Two PWRs and two BWRs obtained approval in FY 2017.

3) Report from Authority

- *The Nuclear Regulation Authority (NRA) ordinance amendment on the reporting format*

  The reporting format of the nuclear facilities was amended in order to collect more necessary data from the licensees in FY 2017. The main purpose of the amendments was to divide the dose category of 5 mSv and less into the categories of 0.1mSv and less, 0.1-1 mSv, 1-2 mSv and 2-5 mSv in the distribution of annual effective external dose in order to grasp the situation about the low dose range, and enable comparison with the international standard, and to obtain data on the amounts of radioactive waste generated in decommissioning, in consideration of increasing the number of reactors in decommissioning hereafter in Japan.

- *The equivalent dose limits to the lens of the eye*

  The NRA decided to implement the new equivalent dose limit of 50 mSv in a year and 100 mSv in 5 years (currently 150 mSv in a year) for the lens of the eye based on ICRP Statement on Tissue Reactions and IAEA GSR Part 3, following the recommendation of the Radiation Council, a body connected to the NRA, in March 2018.

  The Radiation Council established "The subcommittee on Radiation Protection of the Lens of the Eye" in July 2017, and discussed the feasibility of smoother implementation of the recommendation and other related issues, based on interviews of the concerned parties. The final report has been approved in February 2018.

  The NRA will implement the revisions of regulations on the new dose limit for the lens of the eye by April 1st 2021.

KOREA

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	21 (Note 1)	280
PHWR	4	413
All types	25	301

Notes (1) Kori Unit 1(PWR) has been permanently shut down since June 18, 2017.

2) Principal events of the year 2017

- *Outline of national dosimetric trend*

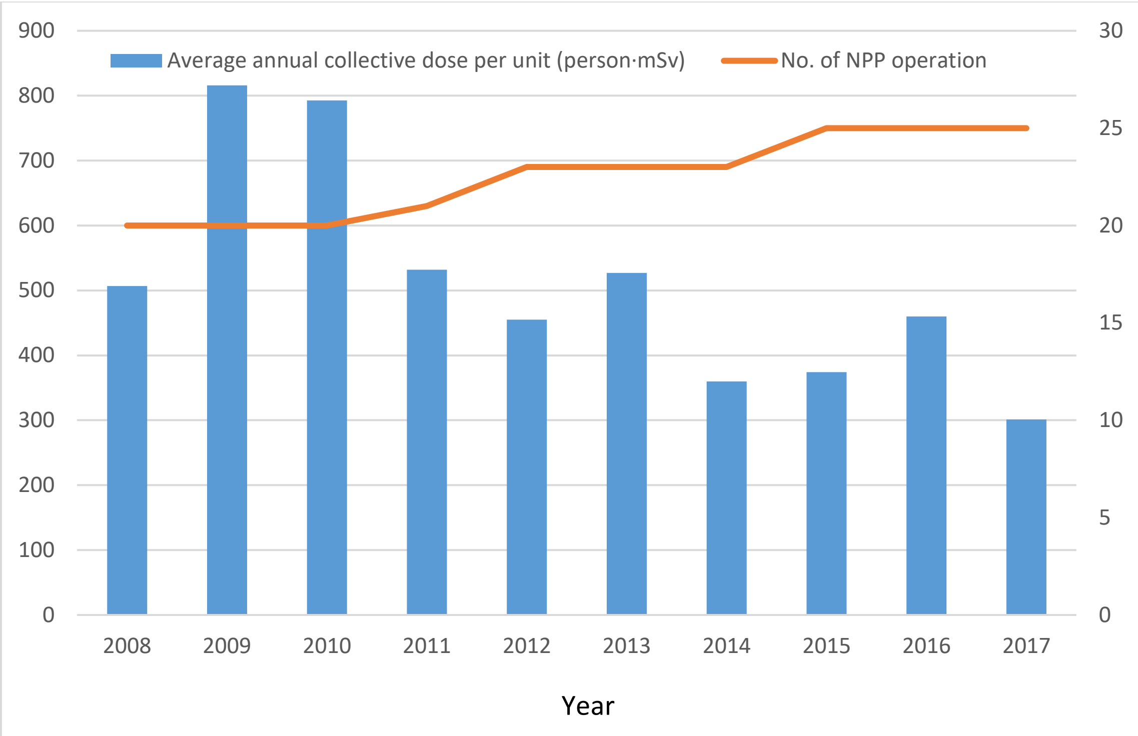
In 2017, total 25 NPPs were in operation; 21 PWRs and 4 PHWRs. The permanent shutdown of Unit 1 of the Kori NPP has been approved by the Nuclear Safety and Security Commission, the nuclear regulatory body. Kori Unit 1 is a 587 MWe PWR that started commercial operation in 1978.

In terms of NPP operation, total number of 14,501 workers had access to the radiation controlled area and received total amount of 7,528.40 person·mSv. The total number of workers increased by 105, but the total amount of collective dose decreased by 3,479.82 (approximately 31.6% reduction) compared to 11,008.22 person·mSv in the previous year 2016. Main contribution of dose reduction was the delay of main maintenance jobs in most NPPs to the next year despite the total duration of outages increased approximately 74.5% compared to that in 2016. The dominant contributors of the collective dose in 2017 were the works carried out during the outages, resulting in 86.7% of the total collective dose.

The average collective dose per unit in 2017 was 301 person·mSv based on the operation of 25 NPPs. The average individual dose in 2017 was 0.52 mSv. There was no individual whose dose exceeded 50 mSv. The maximum individual dose in 2017 was 17.64 mSv. The fractions of the number of individuals whose doses were less than 1 mSv to the total number of individuals were 86.8%. The radiation dose caused mainly by external exposure approximately 97.0%, and internal exposure contributed to only 3% of total amount of exposure. In PHWRs, the contribution of internal exposure was relatively higher (approximately 13.5%) than that (almost zero %) in PWRs due to tritium exposure.

Occupational dose distributions in NPPs (Year 2017)

Year	Total number of individuals	Number of individuals in the dose ranges (mSv)								
		< 0.1	[0.1-1)	[1-2)	[2-3)	[3-5)	[5-10)	[10-15)	[15-20)	[20-)
2017	14,501	10,008	2,584	751	397	382	305	66	8	0



Average collective dose per NPP unit from 2008 to 2017

LITHUANIA

1) Dose information for the year 2017

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	428

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

In 2017, the occupational doses at the Ignalina NPP (INPP) were uphold as low as possible, taking into account all economic, social and technological conditions: 587 man·mSv in 2012, 655 man·mSv in 2013, 638 man·mSv in 2014, 684 man·mSv in 2015 and 634 man·mSv in 2016, 897 man·mSv (79% of planned dose). The collective dose for INPP personnel was 856 man·mSv (80% of planned dose) and for contractor personnel was 41 man·mSv (59% of planned dose). External dosimetry system used – Thermoluminescence dosimeters (TLD).

18 mSv individual dose wasn't excess. The highest individual effective dose for INPP staff was 17.67 mSv, and for contractor personnel – 3,10 mSv. The average effective individual dose for INPP staff was 0.51 mSv, and for contractor personnel – 0.05 mSv.

The main works that contributed to the collective dose during technical service and decommissioning of Units 1 and 2 at the INPP were decommissioning of equipment, CONSTOR®RBMK-1500/M2 containers treatment, fuel handling; repairing of the hot cell; modernization and maintenance works at the spent fuel storage pool hall, reactor hall and reactor auxiliary buildings; waste and liquid waste handling; radiological monitoring of workplaces and radiological investigations; isolation of the main circulation circuit.

In 2017 no component or system replacements were performed. In 2017 there were no unexpected events.

- *New/experimental dose-reduction programmes*

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

- *Organisational evolutions*

In 2017 the most important decommissioning projects were realized. The exploitation of the Interim Spent Nuclear Fuel Storage Facility was started (project B1, ISFSF) and the fuel removal from units to the Storage Facility has started after a long period. Team work of the INPP personnel and interested parties allowed INPP to start a new stage of the New Solid Waste Treatment and Storage Facilities (B234 project), the "hot trial" using radioactive materials. The license for building and exploitation of the Near Surface

Repository for Low and Intermediate Level Short-Lived Radioactive Waste (B25 project) was obtained. In 2017 was made and agreement for building of The Disposal Module of the LANDFILL Facility for Short-Lived Very Low Level Waste (B19-2 project) and building works have been started.

Every year the scope of dismantling works increases, the ambitious plans are being established in 2016 were implemented in 2017. 6,7 thousand tons of the equipment and related constructions were dismantled in 2017. 44 thousand tons of the equipment were dismantled during the whole period of decommissioning.

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

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

3) Report from Authority (if a separate contribution is available)

In 2017 VATESI carried out radiation protection inspections at Ignalina NPP in accordance with an approved inspection plan. Inspections were made regarding how radiation protection requirements were fulfilled in the following areas and activities: clearance of radioactive materials, monitoring of occupational exposure, installation of appropriate technical means for workplace monitoring and monitoring of releases in Interim Spent Nuclear Fuel Storage Facility, transport of radioactive materials on site, dismantling of equipment and hot trials of the New Solid Waste Treatment and Storage Facilities. Inspections results showed that Ignalina NPP activities were carried out in accordance with the established radiation protection requirements.

In 2018 VATESI will continue supervision of radiation protection during decommissioning of INPP and management of radioactive waste.

MEXICO

1) Dose information for 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	2	5909

2) Principal events in ISOE participating countries

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.

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.
b) Chemical decontamination has been performed on three systems: RRC, RWCU and RHR.

Major evolutions

Chemical decontamination considerations.

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
- Portable demineralizer use during the outages
- 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.

NETHERLANDS

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	614
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 2017

- The collective dose during the outage 2017 is 560 man·mSv and during normal operation 54 man·mSv.
- During the outage, the reactor protection system was renewed (13 man·mSv dose was received) and concrete work in the reactor building was performed (30 man·mSv was received). Chemical and mechanical cleaning of the 2 Steam generators was performed (153 man·mSv was received).

PAKISTAN

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	4	123.998
PHWR	1	1208.95
All types	5	340.988

2) Principal events of the year 2017

- *Events influencing dosimetric trends (Outage information (number and duration)*

TYPE	UNIT	OUTAGES (No.)	DURATION (Days)
PWR	C-1	04	57.0
	C-2	04	9.92
	C-3	06	24.0
	C-4	03	57.0
PHWR	K-1	12	131.0

ROMANIA

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
PHWR	**2**	**0.254**

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

Normal operation of the plant (U1 & U2)

At the end of 2017:

- there are 151 employees with annual individual doses exceeding 1 mSv; 4 with individual doses exceeding 5 mSv; none with individual dose over 10 mSv (unplanned exposure) and none with individual dose over 15 mSv;
- the maximum individual dose for 2017 is 5.72 mSv;
- the contribution of internal dose due to tritium intake is 17.6%.

Planned Outage

- A 25-day planned outage was done at Unit#2 between May 6th and May 30th 2017. Activities with major contribution to the collective dose were as follows:
- ECT inspection of Steam Generators;
- Fuelling machine bridge components preventive maintenance;
- Feeder – yoke clearance measurements and correction;
- Inspection for tubing and supports damages in the feeder cabinets;
- Planned outages systematic inspections;
- Feeder thickness measurements, feeder clearance measurements, feeder - yoke measurements, elbow UT examination;
- Snubbers inspection; piping supports inspection;
- Implementation of engineering changes
- Reactor Building Leak Rate Test.

Total collective dose at the end of the planned outage was 296.59 man·mSv (227.28 man·mSv external dose and 69.31 man·mSv internal dose due to tritium intakes).
Finally this planned outage had a 58% contribution to the collective dose of 2017.

Unplanned outages

Unit 1 – May 02 - 05: Unit was orderly shutdown to remediate a heavy water leak. (31.35 man·mSv external dose).
Unit 2 – December 07 - 09: Unit was orderly shutdown to eliminate vibrations at a local area cooler. (5.97 man·mSv external dose).

- *New/experimental dose-reduction programmes*

In order to decrease individual and collective doses during normal operation of the plant an Actions Plan was issued for the optimization of the preventive maintenance program.

- *Regulatory requirements*

- Law 111/1996 on the safe deployment, regulation, licensing and control on nuclear activities, with subsequent modifications and completions
- Order of Ministry of Health, Ministry of Education and National Commission for Nuclear Activities Control no. 752/3978/136/2018 jointly approving the Basic Safety Standards on Radiological Safety

RUSSIAN FEDERATION

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	18	495.3
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	3	280.2

- *Summary of national dosimetric trends*

In 2017, the total effective annual collective dose of utilities' employees and contractors at the eighteen operating VVER type reactors was 8 915.4 man·mSv. This value presents 351.4 man·mSv (3.8 %) decrease from the year 2016 total collective dose of 9 266.8 man·mSv.

Comparative analysis has showed a considerable difference between average annual collective doses for the groups of VVER-440 MWe, VVER-1000 MWe and VVER-1200 MWe operating reactors. In 2017, the results were as follows:

- 611.3 man·mSv/unit with respect to the group of five operating VVER-440 reactors (Kola 1-4, Novovoronezh 4);
- 467.9 man·mSv/unit with respect to the group of twelve operating VVER-1000 reactors (Balakovo 1-4, Kalinin 1-4, Novovoronezh 5, Rostov 1-3).
- 243.8 man·mSv/unit with respect to the one operating VVER-1200 reactor (Novovoronezh 6).

These results demonstrate that average annual collective dose of VVER-440 reactors was higher at 30 % in comparison with VVER-1000 reactors.

Average annual collective dose for three reactors at the stage of decommissioning (Novovoronezh 1-3) was 280.2 man·mSv.

The total planned outages collective dose of utilities' employees and contractors represents 78.4 % of the total collective dose.

The total forced outages collective dose of utilities' employees and contractors represents 0.03 % of the total collective dose.

- *Individual doses*

In 2017, individual effective doses of utilities' employees and contractors did not exceed the control dose level of 18.0 mSv per year at any VVER-440, VVER-1000 or VVER-1200 reactor.

Planned outages duration and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Balakovo 1	31	632.8
Balakovo 2	75	958.4
Balakovo 3	No outage	—
Balakovo 4	58	792.9
Kalinin 1	38	573.02
Kalinin 2	50	382.33
Kalinin 3	No outage	—
Kalinin 4	20	159.3
Kola 1	67	918.1
Kola 2	61	450.4
Kola 3	48	369.1
Kola 4	33	280.7
Novovoronezh 4	21	225.2
Novovoronezh 5	40	744.5
Novovoronezh 6*	60	166.1
Rostov 1	41	261.2
Rostov 2	No outage	—
Rostov 3	73	73.17
* Unit 1 of the Novovoronezh II nuclear power plant (also known as Novovoronezh 6)		

Forced outages duration and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Rostov 2	45	1.85
Rostov 3	10	1.04

The maximum recorded individual dose was 15.0 mSv. This dose was gradually received over the full year by a worker of Novovoronezh NPP maintenance department. The maximum annual effective individual doses at other nuclear plants with VVER type reactors in 2017 varied from 6 mSv (Rostov NPP) to 14 mSv (Kola NPP).

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

Novovoronezh 3 was definitively shut down for decommissioning preparations in December 2016. Unit 1 with VVER-1200 reactor of the Novovoronezh II nuclear power plant (also known as Novovoronezh 6) was put into commercial operation in February 2017.

In 2017, despite the listed events and significant changes in collective doses (both increasing and decreasing) in some cases, the total effective annual collective dose of utilities' employees and contractors at the eighteen operating VVER type reactors, operated by Rosenergoatom Concern, have remained quite similar in comparison with the previous year.

The main reasons of these significant changes in collective doses at some reactors in comparison with previous year are:

1) lack of refueling outage in current year or previous year due to switching from a 12-month to an 18-month fuel cycle strategy for VVER-1000 reactors (Balakovo 1-3, Kalinin 3 and Rostov 1-2);

2) significant increasing in the scope of outage works or outage duration (for example, from 31 to 58 days at the Balakovo 4);

3) small amount of work completed during the Novovoronezh unit 4's scheduled refueling outage in 2017. The outage has been started only in December 2017, it will last till August 2018. Therefore almost all high-dose work will be performed in 2018.

It should be noted that, in 2017, the average annual collective dose for the three reactors at the stage of decommissioning have significantly increased as a result of the Novovoronezh 3 joining the given reactor group. A number of large tasks were done at the Novovoronezh 3 in 2017, including refit of its systems to provide additional safety of the neighboring Novovoronezh 4. These works have been performed as part of justification of the possibility of Novovoronezh 4 service life extension.

- *Optimization of radiation protection of workers at nuclear power plants*

Since 2015, Rosenergoatom Concern has been implementing the multi-year programme for optimisation of radiation protection of workers at nuclear power plants. Goals for the year 2020 were set in the Programme, including targets for individual, collective doses and other dosimetric indicators. The goals should be achieved by completing several tasks:

− improvement of work management;

− dose rate reduction;

− minimizing the amount of time spent in a radiation field.

- *Organizational evolutions*

In 2016, requirements for organization and technical support of occupational exposure monitoring at nuclear power plants in Russian Federation have been changed. Action plans were developed to meet these requirements. Concern Rosenergoatom NPPs have been implementing actions in order to improve the radiation monitoring methods, equipment and instrumentation.

SLOVAK REPUBLIC

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	4	126.152

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

- Bohunice NPP (2 units): The total annual effective dose in Bohunice NPP in 2017, calculated from legal film dosimeters, was 178.485 man·mSv (employees 65.99 man·mSv, outside workers 112.495 man·mSv). The maximum individual dose was 2.571 mSv (contractor). Without internal contamination. Without anomalies in radiation conditions
- Mochovce NPP (2 units):
  The total annual effective dose in Mochovce NPP in 2017, evaluated from legal film dosimeters and $E_{50,}$ was 326.123 man·mSv (employees 130.517 man·mSv, outside workers 195.606 man·mSv). The maximum individual dose was 4.336 mSv (employee).

- *Outage information*

Bohunice NPP:

- Unit 3 – 22.69 days standard maintenance outage. The collective exposure was 111.093 man·mSv from electronic operational dosimetry
- Unit 4 – 20.5 days standard maintenance outage. The collective exposure was 90.992 man·mSv from electronic operational dosimetry

Mochovce NPP:

- Unit 1 – 50.1 days extended maintenance outage. The collective exposure was 205.32 man·mSv from electronic operational dosimetry.
- Unit 2 – 20.0 days standard maintenance outage. The collective exposure was 9.626 man·mSv from electronic operational dosimetry

- *New reactors on line*

Mochovce NPP, Unit 3&4 still under construction.

3) Report from Authority

In 2017 The Slovak Radiation Regulatory Authority made inspections at both two nuclear power plant facilities in operation concerning optimization of radiation protection. The conclusions from the inspections are that the authority calls for more short and long term concrete and proactive goals for the optimization of radiation protection. The Slovak Radiation Regulatory Authority continued preparations for change the regulations for radiation protection according to Council Directive 2013/59/EURATOM. The major change in this revision includes: (1) to lower the individual effective dose limit from the current value of 50 mSv/year to 20mSv/year in alignment with the individual dose limits as published in Council Directive 2013/59/EURATOM; (2) to lower the current lens dose equivalent limit to 20mSv/year in alignment with the lens dose limit as published in Council Directive 2013/59/EURATOM. During 2017 The Slovak Radiation Regulatory Authority staff has been continuing to engage all licensee categories, industry groups, radiation protection professional organizations and public interest groups for input related to the potential changes to the radiation protection regulations.

SLOVENIA

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	63

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

  - The main tasks were:
    Preparatory work on the construction of a new Waste Manipulation Building and corrective actions for a new In-core Neutron Flux Detection system were carried out. No refuelling outage took place in this year due to the 18-month fuel cycle.
  - Three years rolling collective radiation exposure was 0.46 man·Sv in 2017, which is lower than before due to positive effects of the accomplished long-term Dose Reduction Programme (as already presented in 2016 report).
  - Preparations for the new building required radwaste handling or drums transportation. These actions resulted in a maximum individual dose of 7.56 mSv.

3) Report from Authority

The main activity of the regulatory authorities in 2017 was the transposition of a new European BSS directive. The Ionising Radiation Protection and Nuclear Safety Act was adopted at the end of 2017. The transposition process was presented at the 26th International Conference entitled *Nuclear Energy for New Europe NENE 2017*. The abstract is available at:
http://www.nss.si/nene2017/downloads/NENE2017_BoA.pdf, page 158.

SOUTH AFRICA

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	2	287.506

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

The 22nd refuelling outage commenced on the Koeberg Unit 2 on 18 April 2017 and was concluded within 37 days. The collective dose assessment predicted an estimated dose for all outage related activities to be 423 mSv. The actual collective dose for the outage was 440.141 man·mSv. A total of 29751 entries were made into radiological controlled areas for work which equates to 14.8 µSv per entry.

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

No major components or system replacements were performed. No reportable unexpected events or radiological incidents occurred and no new reactors were brought on line.

- *New/experimental dose-reduction programmes*

Historically, a dose estimate was performed for the valve work scope for the Mechanical Maintenance Group. This estimate was then separated into the different plant systems and Radiation Protection Certificates were derived for the valve work scope accordingly. A new process was introduced to derive dose targets and radiation protection certificates according to work sections in order to identify and appoint accountable leaders (dose champions) responsible for dose management relating to these work sections. This method proved to be successful and improvements in dose reduction, work performance and communication were experienced.
Additional shielding was installed in high occupancy areas of the plant to reduce ambient dose rates and subsequently reducing collective radiation exposure to personnel. Also, early identification of potential high radiation areas and early shielding interventions have contributed to dose reduction.

SPAIN

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	6	249.8
BWR	1	2331.84
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	236.6
BWR	1	135.51

2) Principal events of the year 2017

PWR

ALMARAZ NPP

a) *Number and duration of outages*

- 25th outage of ALMARAZ Unit 1:
  Duration: 33 days.
  Beginning: June 26th, 2017.
  Ending: July 28th, 2017.
  Collective dose: 385.727 man·mSv.
  Maximum individual dose: 2.844 mSv.

b) *Component or system replacement:*

- Implantation of the filtered containment venting system
- Design modification to collect and confine oil leaks from reactor coolant pump.

c) *New/experimental dose-reduction programmes*

- Limitation of maximum exposed workers for contractor enterprises during refuelling 25th of Unit 1.
- Shredding for minimizing radioactive waste volume.
- Centralized system for collect and treat waste liquid in order to reduce individual doses derived from cleaning and decontamination equipment, reduction of reaction times to respond to cleaning and decontamination needs and minimize the spread of contamination in the reactor building.
- Continuous improvement of the optimization dose program and of the radiation protection procedures and measures.
- Airborne contamination reduction while flooding reactor cavity.

d) Organisational evolution

- The Department has been recently reorganized into two major areas Operation Radiation Protection and Radioactive Waste management area.

ASCÓ NPP

a) Number and duration of outages

- 25th refuelling outage of Ascó 1
  Duration: 43 days
  Operational collective dose: 522.286 man·mSv.
  Maximum operational individual dose: 4.010 mSv.
  Relevant activities from RP point of view performed during refuelling outage:
  - Steam Generators drainage valves substitution
  - Fire detection system substitution in reactor containment and mechanical penetrations buildings.
  - Walk-down for inspection in reactor coolant nozzle-safe end region.
- 24th refuelling outage of Ascó 2
  Duration: 35 days
  Operational Collective dose: 397.490 man·mSv.
  Maximum operational individual dose: 3.183 mSv.
  Relevant activities from RP point of view performed during refuelling outage:
  - Steam Generators drainage valves substitution.
  - Unit 1 shutdown to repair a leakage in a steam generator drainage valve:
    - Duration: from 26/04/2017 to 27/04/2017
    - Collective dose: 0.927 man·mSv.
  - Unit 1 intervention in an isolation valve of the H2 dilution line in the reactor containment (at 100% power):
    - Duration: from 04/09/2017 to 15/09/2017
    - Collective dose: 3.059 man·mSv.

TRILLO NPP

a) Number and duration of outages

- 29th refuelling outage of CN Trillo
  Duration: 29 days.
  Operational collective dose: 192.242 man·mSv.
  Maximum operational individual dose: 2.09 mSv.
  Relevant activities from RP point of view performed during refuelling outage:
  - Modernization / change of the level sensors of the reactor vessel.
  - Implantation of the filtering system of the containment.
  - Ultrasonic inspection of the casings of the three main primary coolant pumps

  Capping of tubes in a high-pressure heat exchanger of the volume control system:
  - Duration: from 30/01/2017 to 17/03/2017
  - Collective dose: 5.697 man·mSv.

VANDELLÓS 2 NPP

a) Number and duration of outages

- Collective dose: 45.32 man·mSv (official dose).
- No refuelling outage in 2017.

COFRENTES NPP

- *Events influencing dosimetric trends*

In the 20th outage (2015) there was realized a chemical decontamination of the systems of recirculation (B33) and of water cleanup of the reactor (G33).

In relation with the evolution of the term source in the dry well in the 21th outage (2017) is observed that the values of rate of dose in the recirculation pipelines follow a behavior of recontamination similar to the observed one in the measures realized in the 16th outage (year 2007), after the chemical decontamination realized in the above mentioned systems in the 15th outage (year 2005). In relation with the reactor water cleanup system the behavior is a bit less accused to the observed one in the measures realized in the 18th outage (year 2011), after the chemical decontamination realized in it the 17th outage (year 2009).

a) Number and duration of outages

- 21th outage.
  Duration 36 days.
  There was 1 forced outage for recovery of FME in the feedwater sparger (37 days).

b) Component or system replacements

During the outage there has been carried out the substitution of control rods in order to reduce the inventory of tritium in the reactor.

c) New/experimental dose-reduction programmes

There has been strengthened the team of coordinators of the dry well in the outage with two members of the service of radiological protection.

Along the cycle 21 the planning of the outage jobs has been carried out by means of his group for systems. This process allows to involve the whole organization in the process of planning of the outage with major anticipation, allowing to realize the analysis of the activities with major depth.

The sequence of cavity disassembly and assembly has been modified due to the acquisition of the new plugs for the main steam pipelines. The placement of these plugs does not need the drain of the cavity below the lines of the main steam pipelines, for what it improves the nuclear safety and reduce the time with the cavity drained.

Bars have been designed for monitoring measure of the rate of dose in the nozzles by help of teledosimetry. With this system the associate dose is reduced and there is obtained the information of the rate of dose in the minor possible time and in a remote way, in order to optimize the process of cleanliness.

The environmental conditions have got improved in the refueling floor and steam tunnel by means of the installation of electrical outlets, water intakes or implementation of a better refrigeration of the zones.

Use of ventilated hoods for specific works with high risk of personal contamination to improve the workers conditions in reactor cavity.

Auxiliary filtering systems in reactor building spent fuel pools.
Use of equipment of remote inspection of nozzles and pipelines improved.
Use of suction robot in reactor building spent fuel pools.
The remote dose control system has been used in multitude of works in dry well, like CRDs change, LPRMs change, SRMs and IRMs revision, inspection of nozzles and pipelines and others.
IP type TV cameras installation in different points of the dry well and auxiliary building steam tunnel allowing the radiological control and supervision of the works from low radiation areas, and Additionally time-lapse TV cameras were installed in the refueling and turbine floor.
Screens installation at the dry well and refuelling floor entrances to be able to check the component locations and to control jobs from low radiation area. Besides, this tool has been in use during the job planning stage.
Temporary and permanent shieldings.
Trainings in scale models in jobs with high radiological load: LPRM's extraction and cut, CRD's change and cleaning of the PRM's conduit, inspection of nozzles and pipelines and others.

d) *Organisational evolutions*
Have been integrated in the Radiological Protection Service three workers who previously were dedicated to topics related to radiological protection inside the group of Iberdrola Engineering and Construction. With this organizational change, the SPR assumes the functions of Engineering of radiological protection, including the application of the criterion ALARA in the modifications of design.

BWR

SANTA MARIA DE GAROÑA NPP

a) *Number and duration of outages*

Date	Event	Collective Dose (man·mSv)*
January 2nd to December 30th	Reconditioning of drums containing waste built-in MICROCEL	123.416
January 3rd to October 17th	Conditioning of metallic materials	14.306

(*) Note that this is operational dose

3) Report from Authority

The CSN has been collaborating in activities for the transposition of the Euratom Directive 2013/59. A final draft version of the Regulation on the Protection of health against ionising radiations is available and the draft is under public consultation. Simultaneously an internal CSN group is reviewing certain aspects of the Regulation on Nuclear and Radioactive Installations that are affected by the provisions of this Directive

As a result of the application of the Integrated Plant Supervision System (SISC), nor significant findings nor indicators have been found in occupational radiation protection in 2017.

The spent nuclear fuel generated in Spain (with the exception of that generated at the operation of the Vandellós I nuclear power plant and that generated at the Santa María de Garoña nuclear power plant until 1982) is currently stored in the fuel pools associated with the nuclear reactors and in the dry storage casks located at the temporary Independent Spent Fuel Storage Installation (ATI for its Spanish acronym) at the Trillo, José Cabrera and Ascó nuclear power plant sites. During 2017, CSN carried out the assessments associated with the approval of the new casks design ENUN 32P dual-purpose container valid for the storage and transport of PWR spent fuel from Trillo, Almaraz and Vandellós II nuclear power plants. CSN also carried out the assessments associated with the licensing of the ATI's foreseen at the Santa María de Garoña and Almaraz plant sites in 2018.

Regarding the actions deriving from the Fukushima nuclear power plant accident, the CSN favorably appreciated in 2017 the requests for the commissioning of the filtering system of the containment (SVCF) for Trillo and Cofrentes NPP

Considering that all the Spanish NPP finish their 40-year design lifetime during the ten-year period following the next renewal of their Operation Permit (between 2020 and 2027), the CSN has review the CSN safety guide GS- 1.10 "*Periodic Safety Review for Nuclear Power Plants*" based on IAEA safety guide SSG-25.

SWEDEN

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	3	233
BWR	5	417
All types	8	356
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	3	21

2) Principal events of the year 2017

Barsebäck NPP

2 BWR UNITS shut down permanently in 1999 and 2005, in service operation preparing for decommissioning.

Major work performed during 2017 is project HINT - Removal of RPV internals in unit 2. The project started in September 2016 and the Barsebäck annual collective dose (2017) was 23.4 mmanSv TLD.

Oskarshamn NPP

Final shutdown of 2 of the 3 reactors at the OKG site have resulted in a restructuring program, with staff reductions that have been carried out in 2017 and has included both consultants and permanent staff.

The decision to permanently shut down the O1 reactor in mid of the year, and the less extensive efforts undertaken during the year, resulted in a lower collective dose than planned.

System operations and component replacement have in 2017 substantially followed the plans for revisions and short stops at the O1 and O3 reactors.

Data collection and analysis have continued regarding planned investments at the O3 reactor, such as an independent core cooling system.

Work has been done during 2017 to further increase the quality of the dose budget work for the facilities by "rolling out" individual dose budgets to departments and units. The purpose of the work is to gain a greater understanding of the need for high quality in the plans made in the line organizations and in the documentation delivered to the radiation protection organization, in advance of the preparation of the dose budgets. The aim is also to raise awareness of the lines radiation protection responsibilities when planning, for budgeting and for dose monitoring and for the purpose of getting understanding of their own responsibility, to minimize the doses to staff, both for their own staff and for contractors and hired staff.

Forsmark NPP

Forsmark 1, yearly outage: 25th June – 27th July (32 days): 453 mmanSv
Removal of valve V17 and associated T-piece in the reactor water clean-up system (331) due to problem with thermal cracking of the metal. Dose prognosis 80 mmanSv – outcome 44 mmanSv

- Reasons for a lower dose outcome: good communication and cooperation between RP personnel and work force conducting the work and successful use of tele dosimetry.
- No internal contamination incidents.
- Extended recurring testing done on certain reactor systems resulted in overrun dose prognosis for this specific work task.

Forsmark 2, yearly outage: 3rd September – 16th October (43 days): 355 mmanSv
Removal of valve V17 and associated T-piece in the reactor water clean-up system (331) due to problem with thermal cracking of the metal.

- Experiences and feedback from Forsmark 1 were taken into consideration.
- Dose prognosis 50 mmanSv – outcome 52 mmanSv.
- Good communication and cooperation between RP personnel and work force conducting the work and successful use of tele dosimetry.
- No internal contamination incidents.
- Some attitude issues with external personnel conducting relining of the condenser hatches led to that some of the personnel were locked out from FKA.

Forsmark 3, no outage planned 2017, but, due to fuel failures the unit had 3 unplanned stops.

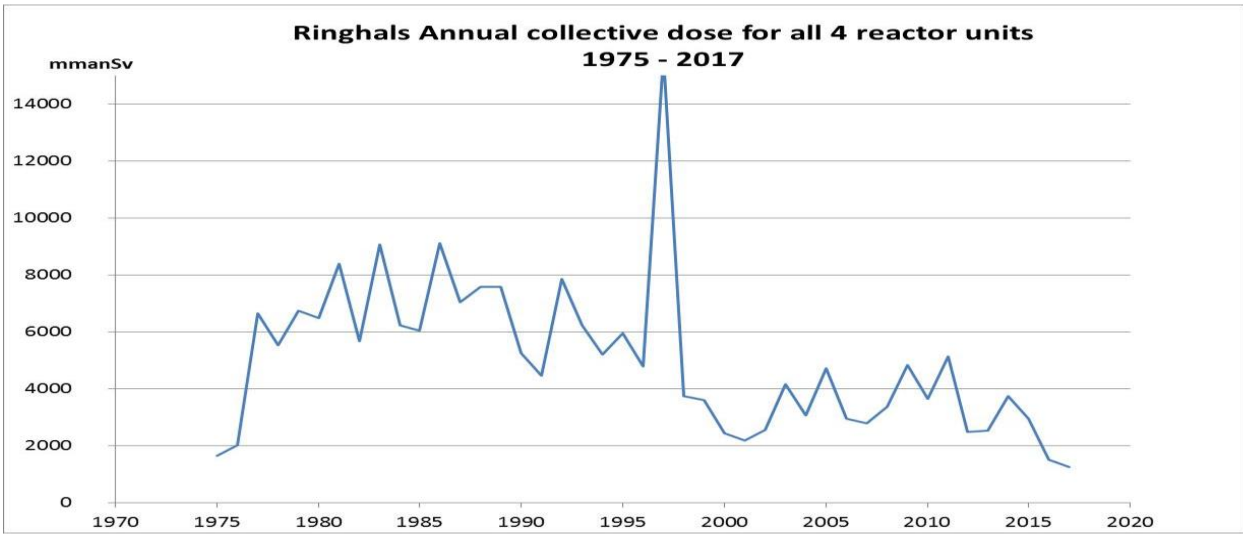
Forsmark, New/experimental dose-reduction programmes;

- Enhanced use of tele dosimetry.
- A time slot to perform RP ALARA-measures secured in outage planning, both for reactor and turbine, to enable shielding and other measures to be taken with little or no sharp time pressure.
- Specific eye lens dosimeters, $H_p(3)$, have been extendedly used in order to gather more data prior designing a monitoring programme for when the lower dose limit will apply after that the EU BSS will be adopted in the national regulations.
- A formalised procedure for preparation of dose prognosis was developed and launched.

Ringhals NPP

Ringhals 4 reactors were all performing well during 2017 from a Radiation Protection point of view which resulted in an all-time low collective dose (1261 mmanSv excluded waste handling, workshop and decontamination facility). The forecast for 2018 is < 1100 mmanSv.

The continuous work on source term control is one main factor in dose reducing measures along with, what we believe has effect, education and training SIP (Radiation Protection in practise). Furthermore, the fact that decision has been taken to finally shut down R2 in 2019 and R1 in 2020, has resulted in minimizing the outage work needed which decreased the total dose exposure.



3) Report from Authority

The Swedish Radiation Safety Authority (SSM) is working on a draft of a new radiation protection law, and a complete set of radiation protection legislation framework, supporting the law. The regulations include nuclear safety, radiation protection, security and safeguard. The radiation protection law and basic regulation is planned for implementation the 1st of June 2018.

SSM is actively following the planning of the decommissioning of the four reactors that close down 2016-2020 and normal surveys of the operating nuclear reactors.

The requested self-evaluation of education and competence regarding RP-training from each of the licensees was reviewed in 2017 with some findings; among other; some of the licensees could improve their verification that all personal that is required to have in-depth RP training also completes the training.

SSM have planned inspections for 2018 at the 3 operational nuclear power plant concerning "work at site" with focus on RP.

SWITZERLAND

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	3	177
BWR	2	1395

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

  Beznau NPP (KKB)

  - Unit 1 was shut down the entire year, due to extended investigations of RPV materials, as required by the regulator.
  - Unit 2 outage duration was 39 days. Major tasks involved replacement of inner block of main coolant pump, eddy current testing of steam generator tubes and RPV seams, testing of a residual heat radiator.

  Gösgen NPP (KKG)

  - Outage duration was 26 days. Since the beginning of zinc injection in 2005 the average dose rate of the primary circuit components has been reduced by 69%. In consequence the annual dose as well as the average individual dose was lowered significantly.

  Leibstadt NPP (KKL)

  - The plant was shut down January 1st – February 20th and September 18th – December 18th, due to outage work and problems with fuel elements. Because of these fuel problems the plant was operated at 86 % of rated power during the cycle. Two moisture separator reheaters of the turbine were replaced by new ones.

  Mühleberg NPP (KKM)

  - Outage duration was 26 days. KKM had a regular outage with in service inspection of RPV nozzles. A first sampling campaign for the radiological characterization of the plant with regard to the planned decommission starting 2019 was performed.

- *Organisational evolutions*

  KKM is starting to adapt its organization to the upcoming decommissioning phase.
- *Regulatory requirements*

  Several Radiation protection ordinances were updated with regard to ICRP publication 103 and Euratom Basic Safety Standards 2013. The Swiss government published the revised ordinances on April 26th 2017. They are effective as of January 1st 2018. Swiss ISOE members created a task group in order to gain a common understanding and implementation of the new regulations.

UKRAINE

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	15	608 man·mSv/unit

In 2017 the dose rate per unit was about the same level as in 2015-2016.

The common reason an increased level of this indicator could be defined as increased duration and scope of radiation works when performing overhauls and planned outages of the NPP’s units.

Degradation of last years is related to a significant scope of rehabilitation work performed with the intent of extending the life of NPP’s units beyond their original design lifetime and involving a significant number of contracted personnel to perform these activities.

UNITED KINGDOM

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR		294.6
GCR	14(1)	19.7
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
GCR	20(2)	31.706

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

2) Principal events of the year 2017

Sizewell B recorded a 2017 calendar year Collective Radiation Exposure of approx. 295 man·mSv which was 25% below the station goal. Britain's only commercial PWR started its fifteenth refuelling outage, in early November. Early in the outage, during bare metal inspections a boric acid leak was discovered on one of the Steam Generator channel head drain lines. Subsequent investigation highlighted stress corrosion defects in all four Steam Generator drain line welds. The discovery required extensive emergent work to machine out the defective material and to plug the drain lines. As a consequence of the new Steam Generator work the outage duration extended to 90 days, eventually completing at the end of January 2018. The collective radiation exposure for the emergent Steam Generator repair work was approx. 50 man·mSv (including support doses such as Radiological Protection).

Sizewell B carried out its first dry fuel storage campaign between February and June. Seven Holtec casks were loaded, each with 24 irradiated fuel assemblies, with an average cask heat load of 19 kW. Doses per cask fell from 6.5 man·mSv, for cask one, to 2.34 man·mSv for the seventh cask. Dose reduction was influenced by improved equipment reliability, modified radiation shielding and rapid incorporation of operating experience. The collective radiation exposure for the entire campaign was 26 man·mSv, compared to the initial estimate of 42 man·mSv.

Elsewhere in the EDF Energy operational fleet the annual collective radiation exposures recorded by the Advanced Gas Cooled reactors were low, ranging from 18 man·mSv to 83 man·mSv. The low radiation doses reflect the absence of any significant or novel work during the year.

The majority of the decommissioning Magnox sites are in Care and Maintenance preparations, Care and Maintenance being a passively safe and secure state where radiation levels are left to decay naturally. The first site is anticipated to enter this state in 2019. Wylfa NPP is the only Magnox site still in the defueling phase of decommissioning and is expected to have removed all irradiated fuel from its site by the end of 2019. Decommissioning site doses varied from 11.7 man·mSv to 208.3 man·mSv, with doses being very dependent upon the scope of work being carried out.

3) New Nuclear Build

Construction work is progressing well at Hinkley Point C, to build two EPR reactors with commissioning expected to complete in 2025. EDF Energy also intends to construct two further EPRs at Sizewell C, alongside the existing Sizewell B plant. Horizon Nuclear Power plans to build twin GE-Hitachi Advanced Boiling Water Reactors at Wylfa and has proposed the same at Oldbury. Regulatory approval, in the form of a Generic Design Assessment, was received for the ABWR design in December 2017.

Three Westinghouse AP1000 units are also proposed at Moorside by the Nu-Generation consortium. These proposals have also reached the Generic Design Assessment approval stage. EDF and Chinese General Nuclear have also agreed to advance plans for two Chinese *Hualong* HPR-1000 PWRs at Bradwell. Generic Design Assessment has commenced for this reactor design.

UNITED STATES

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	65	370.6
BWR	34	1178.6
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	12	14.97
BWR	2	100.27
FBR	1	0.00*

* Fermi 1

2) Principal events of the year 2017

Summary of USA Occupational Dose Trends

The USA PWR and BWR occupational dose averages for 2017 reflected a continued emphasis on dose reduction initiatives at the 99 operating commercial reactors: Also, four units transitioned to the decommissioning phase.

Reactor Type	Number of Units	Total Collective Dose, person·mSv	Avg Dose per Reactor, person·Sv/unit
PWR	65	24,092.06	0.371
BWR	34	40,073.42	1.18

The total collective dose for the 99 reactors in 2017 was 64,165.48 person·mSv, an increase of 16 percent from the 2016 total. The resulting average collective dose per reactor for USA LWR was 648.136 person·mSv/unit. No individual received between 20-30 mSv in 2017 (within the current 50 mSv annual dose limit in the USA).

US PWRs

The total collective dose for US PWRs in 2017 was 24,092.06 person·mSv for 65 operating PWR units, an increase of 16 percent from 2016. The 2017 average collective dose per reactor was 371 person·mSv/PWR unit. US PWR units are generally on 18- or 24-month refueling cycles. The US PWR sites that achieved annual site doses of under 100 person·mSv in 2017 were:

- Davis Besse 16 person·mSv Harris 2.17 person·mSv

US BWRs

The total collective dose for US BWRs in 2017 was 40,073.42 person·mSv for 34 operating BWR units an increase of 17% from 2016. The 2017 average collective dose per reactor was 1,179 person·mSv/BWR unit. Most US BWR units are on 24-month refueling cycles. This level of average collective dose is primarily due to power up-rates and water chemistry challenges at some US BWR units.

New plants on line/plants shut down

Southern Company is continuing the construction of two new PWRs at the Vogtle site in Georgia. South Carolina Electric & Gas halted constructing two new PWRs on the V.C. Summer site due to cost overruns and other issues.

Zion Units 1 and 2 located on Lake Michigan in Northern Illinois started decommissioning in 2010. Energy Solutions is responsible for the decommissioning of the site. Kewaunee, San Onofre 2,3 and Crystal River transitioned into the decommissioning phase. Oyster Creek will transition into decommissioning phase in 2018.

New/experimental dose-reduction programmes

Several RPMs are also implementing the H3D CZT detector system developed by the University of Michigan which achieves individual isotopic identification in plant RP surveys. Diablo Canyon has implemented a telemetry, real-time electronic dosimeter system to produce electronic RP dose surveys to save labor costs and improve accuracy.

Regulatory plans for major work in 2017

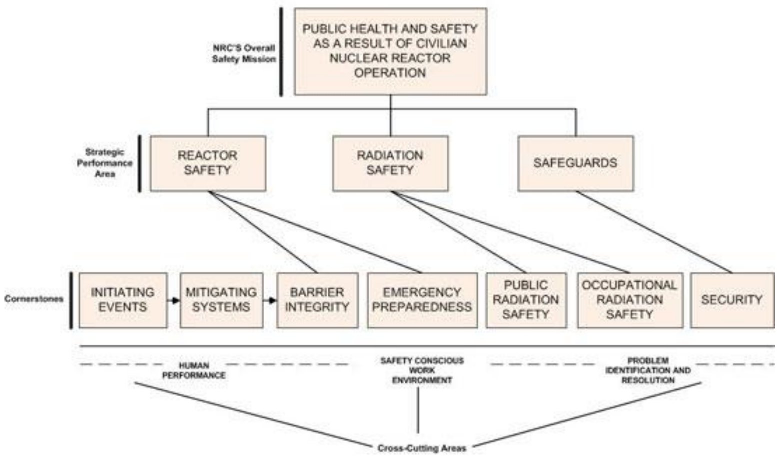
Some US PWRs are replacing up to 800 baffle bolts on their core barrel due to FME and embrittlement issues. About 200 baffle bolts are being replaced per refuelling outage at PWRs classified as highly susceptible by NRC. Some PWRs are having Westinghouse complete an Up Flow modification in the reactor vessel to preclude failed fuel episodes.

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 2017 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

The latest ROP Performance Indicator Findings can be found at http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/pi_summary.html.

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