2018

[ISOE Country Reports]

Rev. 7, 20/10/2022

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 2018 in 29[*] out of 31 ISOE countries and will be incorporated into the Twenty-Eighth Annual Report of the ISOE Programme.

[*] Dose info and principal events of 2018 are not presented for Belarus and United Arab Emirates which do not have NPPs in operation (or decommissioning).

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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 2018 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 1 October 2018, the ISOE programme included 78 Participating Utilities in 26 countries (348 operating units; 55 shutdown units; 10 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 2018 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 2018, 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 2018 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 2018 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 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	1	1064.641
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 2018

Outage information

The main contributions to the collective dose in 2018 were planned outage.

Collective doses during the 2018 outage

Outage number	Outage dates	Personal collective dose (man·mSv)		
		ANPP		Outside workers
		Planned	Received	Received
2018	01.06.2018 - 10.08.2018	1031,5	619,41	179,673

- *Organisational evolutions*

With the purpose of the ALARA principle further implementation at the Armenian NPP the "Program of the Armenian NPP Radiation protection for 2018" 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 1273 man·mSv;
- Non exceeding of personnel collective dose during outage above 1012 man·mSv;
- Non exceeding annual individual dose above 18 mSv.

3) Report from Authority

Zero draft of Atomic Law is developed with taking into account IAEA's recommendations, EU directives and IRRS mission recommendations. The Law will be finalized and submitted to the RA Government's approval in 2021.

New national BSS (Basic Safety Standards) in the process of development with taking into account IAEA's recommendations, EU directives and IRRS mission recommendations, which will replace existing following two documents: Decree № 1489-N as of 18.08.2006 on approval of radiation safety rules;

- 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.

BELGIUM

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	7	384.3 man·mSv/unit

2) Principal events of the year 2018

- *Events influencing dosimetric trends*

  There were several long outages, due to the discovery of problems with the integrity of the roof of the secondary bunker. Other outages were shortened and kept to a minimum to avoid electricity shortages in the winter.
  Outages:

- Doel 1&2: 05/2018-03/2019 (LTO outage + UPI Repair 1628 man·mSv)
- Doel 3: no outage in 2018
- Doel 4: 10/2018-12/2018 (249 Man·mSv)
- Tihange 1: 10/2018-11/2018 (161 Man·mSv)
- Tihange 2: 07/2018-06/2019 (255 Man·mSv)
- Tihange 3: 03/2018-12/2018 (429 man·mSv)

  a) At Doel 1 and 2, the unexpected inspections and replacement of the (Upper plenum Injection) UPI lines have led to an additional total collective dose of around 500 man·mSv. The pipes are in the reactor cavity, close to the reactor pressure vessel, where the ambient dose rate is 10 mSv/h. The work was well prepared. The ambient dose rate was cut in half by the placing of lead shielding. Important interventions in the cavity were rehearsed on a mock-up to reduce intervention times as much as possible. Other maintenance activities and the repair work on the Doel 1 reactor vessel head and the steam generators also contributed significantly to the total collective dose.
  b) At Doel 4, the total collective dose objective was exceeded due to additional non-destructive testing on welds carried out following the discovery of the UPI leak at Doel 1, and due to additional maintenance work on the pressurizer heaters.
  c) The total collective dose for the Tihange 3 outage exceeded the objective due to the outage being prolonged and additional work such as the extra inspection of the steam generator tubes.

- *New/experimental dose-reduction programmes*

  A zinc injection program was implemented at Doel 3 in 2011. This injection is still ongoing as of 2019 and the first results have become visible in the indicators. Over the

years, the 60Co surface activity in the primary circuit has decreased, and there has been a greater decrease in ex-core dose rates during the most recent cycles.
In 2018, analysis by ENGIE Laborelec revealed that a 110mAg silver contamination of the primary circuit at Tihange 1 and Tihange 2 was responsible for half of the dose rate contribution in some circuits linked to the primary circuits such as the reactor heat removal system. At Tihange, an inventory has been made of all components containing silver, mainly seals. Maintenance has launched an inspection plan to identify any components causing the contamination that can be replaced. Although no significant silver contamination is present at Doel, a similar analysis was launched proactively.

- *Regulatory requirements*

    a) Royal decree for the protection against ionising radiation has been updated.

BRAZIL

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	2	311 man·mSv/unit

2) Principal events of the year 2018

- *Events influencing dosimetric trends*

  Angra 1 had a refuelling outage, performed by 65148 person-hours and receiving 372 man·mSv of Collective Dose. The outage demanded 40 day to accomplish all the planned tasks.
  Angra 2 had a refuelling outage, performed by 73265 person-hours and receiving 249 man·mSv of Collective Dose. The outage demanded 31 day to accomplish all the planned tasks.
  The dose indexes from Angra 1 and Angra 2 (5.7 Sv/h and 3.4 Sv/h, respectively) demonstrates a very well optimized radiation protection process and good results. Consistent along the time.

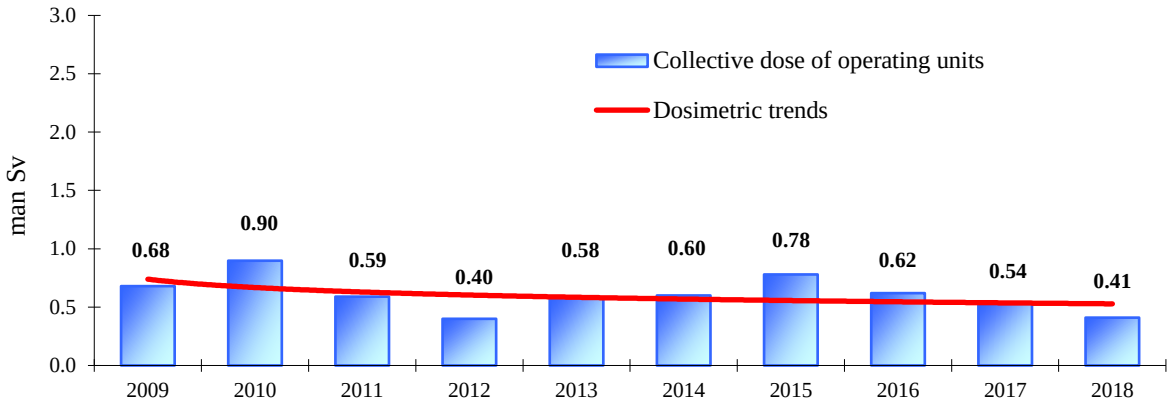
BULGARIA

1) Dose information for the year 2018

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	203
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	5.9

2) Principal events of the year 2018

Summary of dosimetric trends



Unit No.	Outage duration - days	Outage information
Unit 5	40 d	Refuelling and maintenance activities
Unit 6	38 d	Refuelling and maintenance activities

- *Events influencing dosimetric trends*

The average collective dose of reactors under decommissioning is calculated for four reactors VVER-440. The average collective dose of operating reactors is calculated for two reactors VVER-1000. The total collective effective dose and the average collective dose per unit at operating Bulgarian nuclear reactors decreased in 2018 approximately 20 percent from 2017. Almost the same level of decrease is mentioned for the reactors under decommissioning, but generally the doses associated with the decommissioning activities in the last several years are very low.

Operating reactors

The total amount of the collective dose of operating units is due to external exposure. In 2018, there are no doses imparted by internal exposure.

The main contributors to the collective dose in the year 2018 were the works carried out during the outages. The outage activities resulted in more than 90% of the total collective dose. In 2018 in the RCA were performed only low and medium risk planned maintenance activities. As examples could be given the following:

- systems and components investigation related to the life time extension project of Unit 6;
- visual control of the reactor and reactor shaft;
- replacement of the safety system pump aggregates;
- increased volume of radiography control;
- thermal insulation replacement.

Organizational evolutions

Improved work planning and work place monitoring aimed at optimization of exposure were applied in 2018.

Regulatory requirements

Bulgarian nuclear regulatory agency issued a new Radiation Protection Regulation. This regulation translates the requirements of Directive 2013/59/Euratom into the Bulgarian legislation. In particular, the new regulation addresses concepts such as implementation of dose constraints in planned exposure situations, reference levels in emergency exposure situations, European requirements for RPE and RPO, etc.

CANADA

1) Dose information for 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
CANDU	18*	1024*

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**	8**

*Darlington Unit 2 initiated a major refurbishment project in October 2016. In 2018 the Unit 2 refurbishment dose was 7.889 man·Sv. The Darlington Unit 2 dose is not included in the 2018 number of operating units or average annual collective dose.

** Canada has 3 permanently shut down units. The listed dose only includes the unit (Gentilly-2) that reports occupational dose separate from operating dose.

2) Principal events of the year 2018

Summary of national dosimetric trends

- 18.432 man·Sv for 18 operating units in 2018
- Average annual dose per unit: 1.024 man·Sv/unit in 2018

The total collective effective doses and the average collective dose per unit at operating Canadian nuclear plants increased in 2018 (approximately 38.2 percent) from 2017.

The average calculated dose for 2018 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 its inclusion in the dose for operating units has negligible impact on the calculated average. (The dose is included under the dose for the operational Pickering Units.) Gentilly-2 annual dose is reported separate from the operating units.

In 2018, approximately 87 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 10 percent of the dose received was from internal exposure, with tritium being the main contributor to the internal dose of exposed workers.

Bruce A

In 2018, all four units were operational at Bruce A Nuclear Generating Station. Bruce A, Units 1-4 completed planned and forced outages as listed below:

- Bruce A Unit 1 experienced forced outage F1811 due to issues with one phase of the Main Output Transformer for 21.2 days.
- Bruce A Unit 1 planned outage A1811 for 51 days in 2018.
- Bruce A Unit 2 experienced forced outage F1824 due to a drop lead and bracket in the switchyard for 3.0 days.
- Bruce A Unit 2 experienced forced outage F1823 for 17.0 days.
- Bruce A Unit 2 experienced forced outage F1822 due to PHT P1 seal replacement for 11.5 days.
- Bruce A Unit 2 experienced forced outage F1821 due to Main Turbine trip for 10.3 days.
- Bruce A Unit 3 planned outage A1831 for 150.5 days in 2018.
- Bruce A Unit 3 experienced forced outage F1831following a Safety System Test that revealed an impairment of the Emergency Coolant Injection System.
- Bruce A Unit 4 experienced Forced Outage F1841 to repair leaks in the Liquid Zone Control System for 6.0 days.
- Bruce A Unit 4 planned outage A1841 for 103.6 days in 2018.

Bruce A, Units 1-4 routine operations dose for 2017 was 0.345 man·Sv and the outage dose was 6.497 man·Sv. The total collective dose for Bruce A Units 1-4 was 6.842 man·Sv, which resulted in an average collective dose 1.711 man·Sv/unit.

Bruce B

Bruce B, Units 5-8 were operational in 2018 with planned outages in Unit 8. Outage activities accounted for approximately 81 percent of the total collective dose. Routine operations accounted for approximately 19 percent of the total station collective dose. The 2018 planned and forced outage results are listed below:

- Bruce B Unit 6 experienced forced outage F1861 due to fueling machine being locked for 2.2 days.
- Bruce B Unit 7 experienced forced outage F1871 due to a Mechanical Trip Solenoid Valve repair for 3.0 days.
- Bruce B Unit 8 started planned outage B1881 on 31 Aug 18.
- Bruce B Unit 8 experienced forced outage F1883 due to removal and return of sync breaker from service for maintenance for 2 days.
- Bruce B Unit 8 experienced forced outage F1882 due to PM4 tripping on differential protection for 2.6 days.
- Bruce B Unit 8 experienced forced outage F1881 due to RAB failure for 2.3 days.

Bruce B, Units 5-8 routine operations dose was 0.570 man·Sv. The outage dose was 2.473 man·Sv in 2018. The total dose was 3.043 man·Sv which resulted in an average collective dose 0.761 man·Sv/unit.

In 2018, approximately 4 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 0.449 man·Sv in 2018. Routine operations accounted for approximately 22 percent of the total collective dose. The total outage dose was 1.616 man·Sv. The internal dose for 2018 for Units 1, 3, 4 was 0.376 man·Sv. The external dose for 2018 for Units 1, 3, 4 was 1.690 man·Sv.

Outage scope included feeder inspections, pressure tube scrape, PHT spectacle flange modifications. Also, moderator heat exchanger inspection, valve repair and pump seal replacement. Finally, ACU Coil replacement, horizontal flux detector, ion chamber, and shutter maintenance. The average 2018 effective dose for the 3 units was 0.689 man·Sv per unit. The total collective dose for Units 1, 3, 4 was 2.065 man·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 2018. 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 2018 refurbishment internal dose for Darlington Unit 2 was 0.081 man·Sv. The 2018 refurbishment external dose for Darlington 2 was 7.808 man·Sv. The total Unit 2 refurbishment dose was 7.889 man·Sv.

Pickering Nuclear

In 2018, 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 84 percent of the collective dose at Pickering Nuclear Generating Station. Routine operations accounted for approximately 16 percent of the total collective dose. The routine collective dose for operational units was 0.795 man·Sv in 2018. The outage dose for the operational units was 4.109 man·Sv. The total dose was 4.904 man·Sv which resulted in an average of collective dose 0.817 man·Sv/unit. The Pickering outages are summarized below:

- Pickering Unit 4 completed planned outage P1841 in 112.3 days in 2018.
- Pickering Unit 6 completed planned outage P1861 in 124.0 days in 2018.
- Pickering Unit 8 completed planned outage P1881 in 109.9 days in 2018.

The total external dose for all 6 operating Pickering Units was 3.897 man·Sv in 2018 or 79 percent of the total annual dose. The total internal dose for all 6 operating Pickering Units was 1.007 man·Sv in 2018 or 21 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 Nuclear Generating Station (PLNGS) is a single unit station. During 2018, the station was operational. The station shut down in April 2018 for a 52 day outage. In 2018, workers at PLNGS received dose during completion of regular station running activities and maintenance as well as activities carried out during the planned outage listed above.
There were 2502 workers monitored during 2018; 890 of whom received radiation dose ≥ 0.01 mSv. The average worker who received dose had an effective dose of 1.3 mSv. The maximum individual effective dose received by a worker at PLNGS in 2018 was 13.3 mSv. This person was a member of the Fuel Handling work group, who received forty percent of the dose while completing work associated with the fueling machine bridge maintenance in close proximity to the reactor face during the planned maintenance outage.
Approval was given, as per SDP-01368-A051, Establishing Exposure Limits, to increase the dose allocation for 17 workers to permit them to receive >10 mSv effective dose for the 2018 calendar year. This approval was documented in PICA and was granted for workers who had been assigned to work with high external dose rates during the planned maintenance outage. Four of the 17 workers were assigned >10 mSv effective dose; the highest dose assigned was 13.3 mSv.
The total Collective dose for 2018 was 1,180 man·Sv.

Gentilly-2

Gentilly-2 is a single unit CANDU station. In 2018, 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 most radiological work activities with the transition from an operational unit to a safe storage state occurred in 2014. The 2018 station collective dose is only attributed to safe storage transition activities

Number of individuals monitored in 2018 at Gentilly-2 was 675. The total site collective dose in 2018 was 0.008 man·Sv.

Regulatory Update Highlights

Canadian Nuclear Power Plant (NPPs) operated safely during 2018. 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 2018.

Decommissioning Issues

Gentilly-2 continued to transition to safe storage in 2018.

New Plants under construction/plants shutdown:

No Units under construction in 2018.

Darlington Unit 2 continued refurbishment activities in 2018.

Conclusions

The 2018 average collective dose per operating unit for the Canadian fleet was 1.024 man·Sv/unit, not achieving the CANDU WANO dose target of 0.80 man·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 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	39	309.7
VVER	4	149.8
PHWR	2	427.5
All types	45	320.1

2) Principal events of the year 2018

- *Summary of national dosimetric trends*
  Eight new PWR units (HAIYANG1-2, SANMEN 1-2, TAISHAN 1, YANGJIANG 5 and TIANWAN 3-4) began commercial operation in 2018. For the 45 reactors, refueling outages were performed for 23 of 39 PWR units, 1 of 2 PHWR units, and 2 of 4 VVER units in 2018.
  The total collective dose for the Chinese nuclear fleet (39 PWR units, 4 VVER units and 2 PHWR units) in 2018 was 14.41 man·Sv. The resulting average collective dose was 320.1 man·mSv/unit. No individuals received a dose higher than 15 mSv in 2018.
  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 320.1 man·mSv/unit is slightly lower than the year 2017 (391.2 man·mSv/unit).
  In 2018, 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*
  The nuclear safety law of the People's Republic of China came into effect on January 1, 2018
  The National Information System on Occupational Radiation Exposure by NNSA was established in Nov 26, 2018.
  Nuclear and Radiation Safety Management System was preliminarily established in 2018, including general introduction, and a series of guidelines and technical review plans.

3) Report from Authority

The NNSA Annual Report in 2018 (Chinese) has been published.

CZECH REPUBLIC

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	6	154

2) Principal events of the year 2018

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

NPP, Unit	Outage information	CED [man·mSv]
Temelin, Unit 1	60 days, standard maintenance outage with refuelling	95
Temelin, Unit 2	63 days, standard maintenance outage with refuelling	107
Dukovany, Unit 1	53 days, standard maintenance outage with refuelling	139
Dukovany, Unit 2	54 days, standard maintenance outage with refuelling	123
Dukovany, Unit 3	24 days, standard maintenance outage with refuelling	106
Dukovany, Unit 4	62 days, standard maintenance outage with refuelling	185

CED remained stable in comparison with the previous year, even decreased a little bit. Even so CED was affected by non-destructive testing of heterogenous welds in steam generator and welding of steam generator feed water inlet.

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.

- *Regulatory requirements*

    a) Radiation protection status for the year of 2018 has been evaluated according to new Czech legislation.

FINLAND

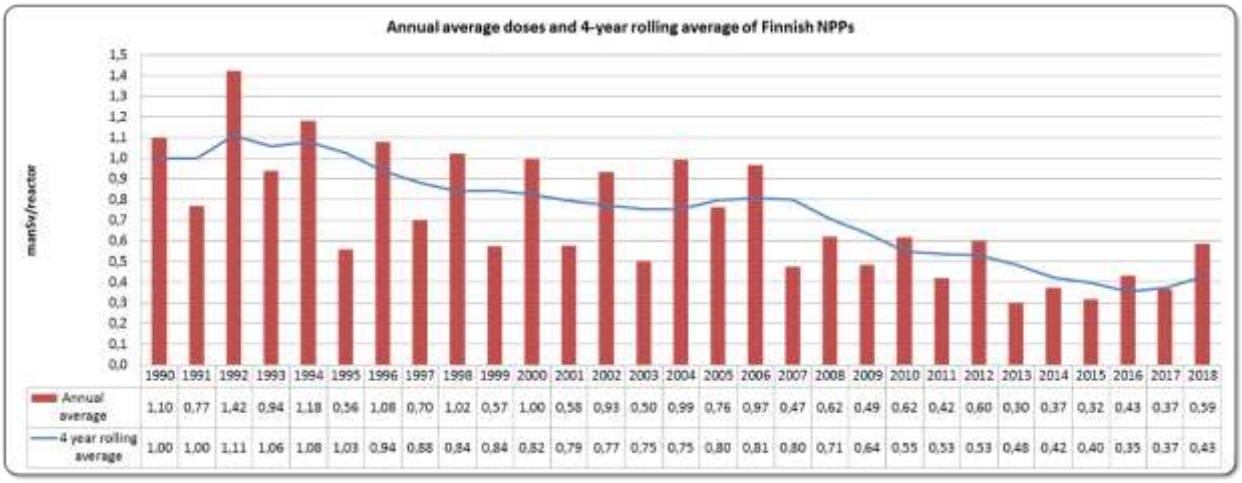
1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	2	620
BWR	2	551
All types	4	585

2) Principal events of the year 2018

- *Summary of national dosimetric trends*

The annual collective dose strongly depends on the length and type of annual outages. The 2018 collective dose (2.341 man·Sv) is a result of two long outages out of four. 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</u>

The annual maintenance outage at the unit Olkiluoto 1 (OL1) took place in the time period from mid-May to late June (ca. 41 days). In addition to normal refuelling and maintenance works, over 20 significant maintenance and repair works were implemented. The special works that caused the largest doses were the change of the reactor coolant purification systems´ heat exchanger and maintenance of one major valve of this system, and also the renewal of reactor internal pumps. The effect of the fuel leakage in 2017 was clearly visible and e.g. in the turbine plant, the dose rates were about 20 % higher in comparison to the outage in 2017. The total collective dose of the outage in OL1 was 0,742 man·Sv.

At the unit Olkiluoto 2 (OL2) the outage started at late April and ended in early May (13 days). No such works were carried out which caused large doses. However, there were fuel leakages detected in two

fuel rods which caused higher dose rates and an increased need to use PPE. The total collective dose of the outage in OL2 was 0,176 man·Sv.

During the outages, there were 5 different events where it was assumed that a worker was exposed to relatively high dose rates caused by NDT-inspections. However, the dose caused by these events was rather low (~0,010 mSv at maximum). The events were investigated and corrective actions were defined.

The results from year 2017 eye lens dose monitoring were verified with a smaller scale campaign. The conclusion was that a separate eye lens dosimeter is needed in special cases only.

Olkiluoto 3 (OL3) is still in the commissioning phase. The primary neutron sources arrived to the site and neutron doses were monitored during the handling of these sources. The dose exposure in OL3 is still negligible.

Loviisa

At unit 2, a long inspection outage was performed. The duration of the outage was ca. 47 days. The collective dose of the outage was 0.947 man·Sv, mainly caused by primary side inspections, internal inspections of steam generators, maintenance works and related auxiliary tasks (insulation, scaffolding, RP and cleaning).

At unit 1, the outage was a normal short maintenance outage with a collective dose accumulation of 0.236 man·Sv and duration of ca. 27 days.

Compared to similar outage types, the collective dose of LO1 outage was the lowest and the collective dose of LO2 among the lowest.

Source term reduction: The 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.

3) Report from Authority

In order to meet the updated IAEA regulations and the new European Directives, a process to update the Nuclear Energy Act, the Radiation Act and the YVL-guides in Finland continued during 2018. The New Radiation Act was issued 15.12.2018.

On 20 September 2018, the Finnish Government granted TVO an updated operating license under the Nuclear Energy Act for the nuclear power plant units Olkiluoto 1 and Olkiluoto 2. TVO has now a license to operate the units until the end of 2038. TVO was also granted a license to use the current interim storage facility for spent nuclear fuel and storages for other nuclear waste located at the Olkiluoto site until the end of 2038.

Olkiluoto 3 has entered the commissioning phase. The licensee submitted an operating license application in April 2016. STUK ‘s safety assessment on the application was under preparation during

2018. The licensee was granted an operating license in March 2019 after STUK finalised its safety assessment.

One new unit is in the construction license phase (Fennovoima's Hanhikivi unit 1, AES-2006) and STUK is currently reviewing the first part of the CLA documentation sent to STUK. During 2018, STUK carried out inspections on the activities of the license applicant.

The Finnish Government granted a construction license for Olkiluoto Spent Nuclear Fuel encapsulation plant and disposal facility on 12th November 2015. The actual construction work started in the end of 2016. The operating license application is expected in the early 2020's.

The only research reactor in Finland has entered the decommissioning phase. The license application for decommissioning was submitted in June 2017. STUK gave its safety assessment in March 2019.

FRANCE

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	58	670
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	45
PHWR	1	5
GCR	6	3
FNR	1	1

2) Principal events of the year 2018

Summary of national dosimetric trends

For 2018, the average collective dose of the French nuclear fleet (58 PWR) is 670 man·mSv/unit (as compared to the 2018 annual EDF objective of 690 man·mSv/unit). The average collective dose for the 3-loop reactors (900 MWe - 34 reactors) is 760 man·mSv/unit and the average collective dose for the 4-loop reactors (1300 MWe and 1450 MWe - 24 reactors) is 540 man·mSv/unit.

Type and number of outages

Type	**Number**
ASR – short outage	20
VP – standard outage	20
VD – ten-year outage	5
No outage	13
Forced outage	4 (*)

(*): dose > 18 man·mSv

Specific activities

Type	**Number**
SGR	0
RVHR	0

The outage collective dose represents 83 % of the total collective dose. The collective dose received when the reactor is in operation represents 17 % of the total collective dose. The collective dose due to neutron is 0.216 man·Sv; 68 % of which (0.147 man·Sv) is due to spent fuel transport.

Individual doses

In 2018, no worker received an individual dose higher than 16 mSv in 12 rolling months on the EDF fleet. 80 % of the exposed workers received a cumulative dose lower than 1 mSv and 99.7 % of the exposed workers received less than 10 mSv.

The main 2018 events with a dosimetric impact are the following:

- Paluel 2 Steam Generator Replacement (SGR)
  Fall of a used SG (March 2016), the outage duration has been 3 years (from 05/16/2015 to 07/23/2018), the total collective dose was 2766 man·mSv.
- Thermal sleeves replacement
  The thermal sleeves replacement follows the mechanical failure of the H8 control rod at Belleville 2 in 2017. The failure is due to wear of the thermal sleeves and the associated risk of a foreign materiel.

  In 2018, replacement of the thermal sleeves at Belleville 2 (1 sleeve; 15 man·mSv), St-Alban 2 (13 sleeves; 91 man·mSv), Nogent 1 (1 sleeve; 6 man·mSv), Paluel 3 (20 sleeves; 142 man·mSv).

3-loop reactors – 900 MWe

2018 was special year for Fessenheim NPP, with a standard outage scheduled on unit 1, turned into a short outage and finally the outage was cancelled. No outage for the NPP in 2018.

- A 75 day outage for fuel economy for Tricastin 2
- No outage for Bugey 3 and Gravelines 2
- 1 outage started in 2018 for Tricastin 3

The 3-loop reactors outage program was composed of 11 short outages, 16 standard outages, 2 ten-year outages (Cruas 2 started in 2017 and Gravelines 6).

The lowest collective doses for the various outage types were:

- Short outage: 0.173 man·Sv at Chinon B3
- Standard outage: 0.643 man·Sv at Dampierre 2
- Ten-year outage: 1.583 man·Sv at Gravelines 6

4-loop reactors – 1300 MWe and 1450 MWe

In 2016, 5 units had no outage. Nogent 1 had no outage scheduled in 2018 but had a forced outage.

The 4-loop reactors outage program was composed of 9 short outages, 4 standard outages and 3 ten-year outages.

One ten-year outage started in 2015 and ended in 2018 (Paluel 2) with SGR (fall of the SG in 2016).

One outage, started in 2017, ended in 2018 (Belleville 2, mechanical failure of control rod).

Three outages started in 2018 and were not finished : Belleville 1 and Penly 1 (short outages) and Flamanville 1 (3rd ten-year outage).

The lowest collective doses for the various outage types were:

- Short outage: 0.179 man·Sv at Cattenom 1
- Standard outage: 0.639 man·Sv at Nogent 2
- Ten-year outage: 1.013 man·Sv at Chooz 1

Main radiation protection significant events (ESR)

In 2018, 2 events have been classified level 1 at the INES scale (3 in 2017). They all concern skin doses.

- Cruas NPP

  1 event on unit 4 in May 2018: Contamination on the face (beard) by Co-60, during the control of several valves. The skin dose was estimated to be higher than one quarter of the annual limit.

- Tricastin NPP

  1 event in November 2018: Contamination during the replacement of self-locking devices in the reactor building. The skin dose was estimated to be higher than one quarter of the annual limit.

Announcement in 2019

Fessenheim NPP: Unit 1 should be finally shut down in September 2020 and Unit 2 in August 2022.

2019 goals

The collective dose objective for 2019 for the French nuclear fleet is set at 0.70 man·Sv/unit.

For the individual dose, the objectives are the same than in 2018. 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

In order to maintain the momentum on individual dosimetry of the most exposed workers, a monthly follow-up of companies with at least 5 workers > 10mSv over 12 rolling months is carried out.

Future activities in 2019

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, tests with the gamma camera)
- Chemical decontamination of the most polluted circuits
- Optimization of biological shielding (using CADOR software)
- Organizational preparation of the RMS.

44 outages are planned for 2019 (45 in 2018) with 15 short outages (20 in 2018), 22 standard outages (21 in 2018), 7 ten-year outages (4 in 2018) and 1 SGR (Gravelines 5). 4 outages that have begun in 2018 are planned to end in 2019: the short outages at Belleville 1 and Penly 1, the standard outage at Tricastin 3 and the ten-year outage at Flamanville 1.

For 2019, hydro tests on RHRS circuits (activities generating high dosimetry despite feed-back of previous years) are expected: Belleville 2, Blayais 2 and 4, Bugey 3, Cattenom 3 and 4, Chinon 3, Chooz 2, Cruas 1 and 2, Dampierre 1, Flamanville 2, Gravelines 1, 4 and 5, Paluel 2 and 4, St-Alban 2, Tricastin 1 and 2 and St-Laurent 1.

3) Report from Authority

French Nuclear Safety Authority (ASN) checks compliance with the regulations relative to the protection of workers liable to ionising radiation in NPPs. In this respect, ASN concerns itself with all workers active on the sites, whether EDF or contractor personnel.

ASN considers that in 2018 the way the NPPs deal with radiation protection varies, notably with regard to control of radiological cleanness within the facilities and the steps taken to prevent the risk of contamination. In the light of these findings, ASN carries out tightened checks on the implementation of the action plans required to correct these situations on the reactors concerned.

ASN considers that, on the whole, the radiation protection situation of the NPPs in 2018 should be improved on the following points:

- A lack of radiation protection culture on the part of certain outside contractors was fond by the ASN inspectors on several sites. Steps are required to reinforce monitoring and develop exchanges between the various EDF entities and outside contractors concerning the protective measures to be taken;
- Control of industrial radiography worksites remains fragile.

ASN in particular identifies several events concerning shortcomings in signage or involving the presence of workers in the exclusion zones. Progress is required in the preparation of the workers, more specifically multiple contractor activities, the optimisation of signage and the quality of the installation walk downs carried out when preparing these worksites;

- The dosimetry optimisation approach must be reinforced, more particularly the exhaustiveness of the risk assessments for the work and their reassessment following unforeseen events;
- Greater rigorousness is required in the administrative management of sources;
- Control of radiological zoning is progressing, although greater vigilance is required regarding the removal of signs by unauthorised staff.

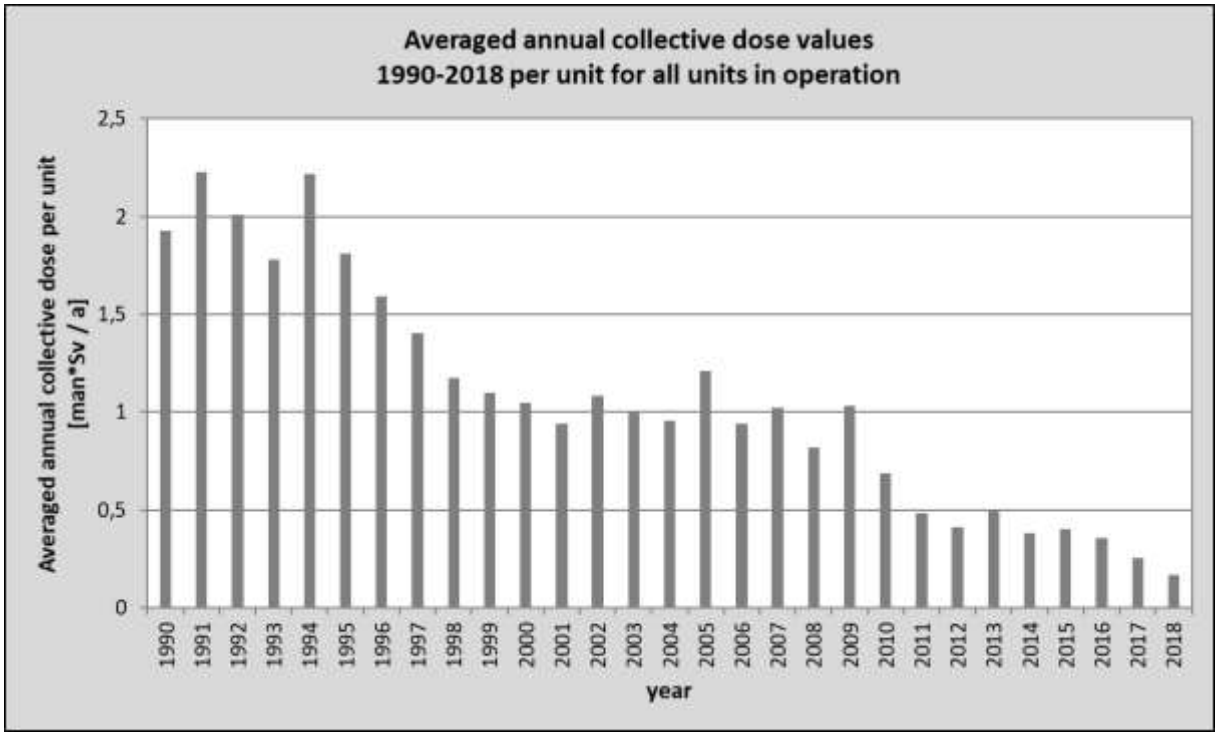
GERMANY

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	6	103.8
BWR	1	554.1
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	94.8
BWR	5	108.4

2) Principal events of the year 2018

Summary of national dosimetric trends

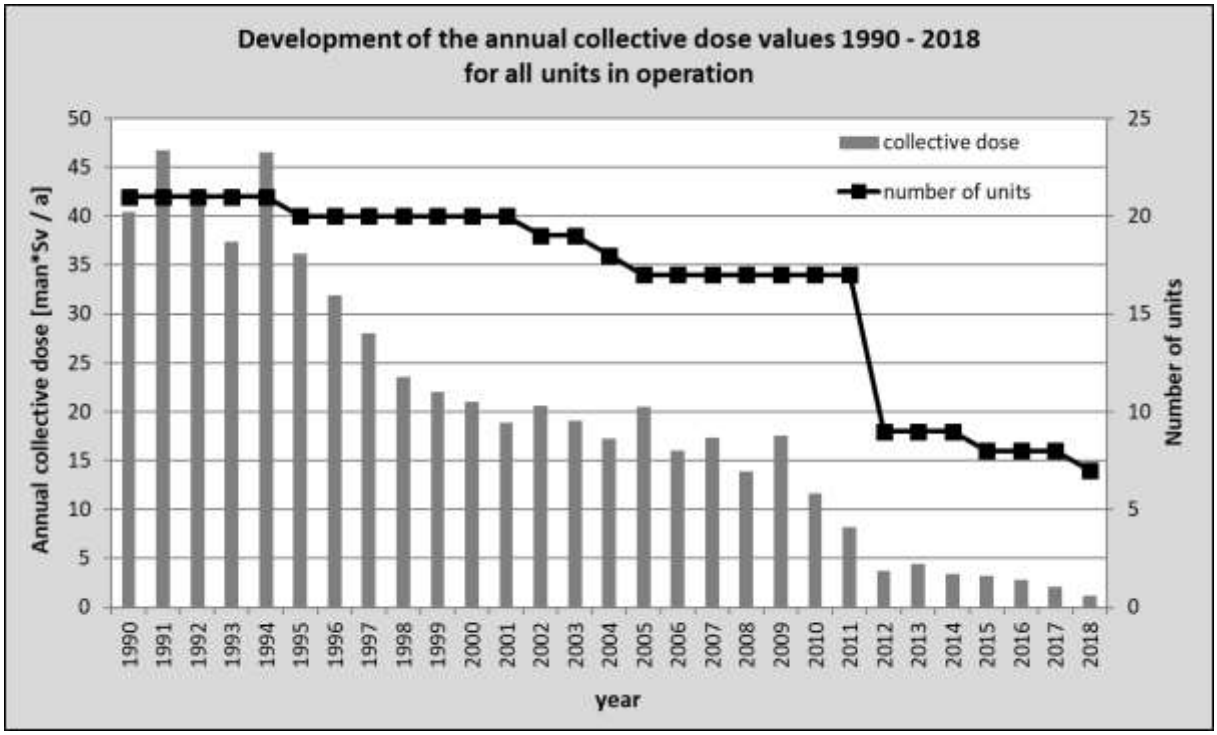


After the accident in Fukushima, Germany decided to terminate the use of nuclear power for the commercial generation of electricity. This was enforced by an amendment of the Atomic Energy Act on 6 August 2011, where further operation of eight nuclear power plants (Biblis A, Biblis B, Brunsbüttel, Isar 1, Krümmel, Neckarwestheim 1, Philippsburg 1 and Unterweser) was terminated. With this

amendment, the remaining nine nuclear power plants in operation were/will be permanently shut down step by step by the end of the year 2022, one plant at the latest by the end of 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 and Grundremmingen B on 31 December 2017. 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) and of two in 2018 (Unterweser and Grafenrheinfeld). The remaining three nuclear power plants, which were switched off, were in the post-operational phase; to Krümmel and Grundremmingen B a decommissioning licence was not issued until the end of the year 2018, while Brunsbüttel obtained the decommissioning license on 21 December 2018.

The trend in the average annual collective dose for all units in operation from 1990 to 2018 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 2018, the average annual collective dose per unit in operation (6 PWR, 1 BWR) was 0,17 man·Sv, whereas the PWR achieving 0,10 man·Sv and the value for the BWR was 0,55 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 0,10 man·Sv. Here the three plants in the post-operational phase and the ten nuclear power plants Unterweser, Grafenrheinfeld, Biblis A, Biblis B, Isar 1, Neckarwestheim 1, Philippsburg 1, Mülheim-Kärlich, Obrigheim and Stade were considered.



HUNGARY

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	**4**	**285 (with electronic dosimeters); 313 (with TLDs**

2) Principal events of the year 2018

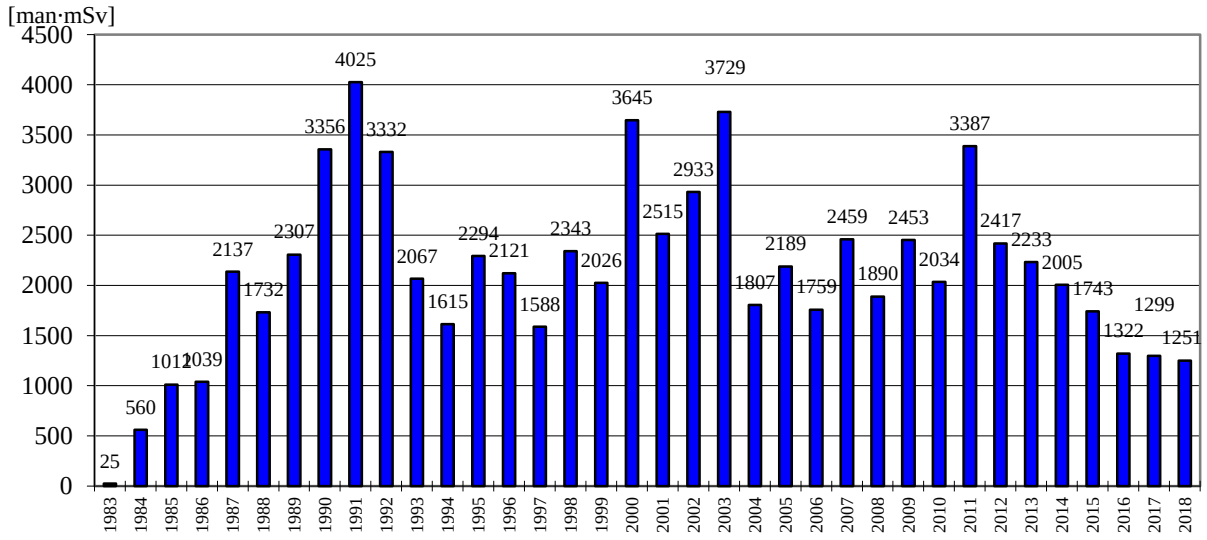
Summary of national dosimetric trends

Using the results of operational dosimetry the collective radiation exposure was 1140 man·mSv for 2018 at Paks NPP (780 man·mSv with dosimetry work permit and 360 man·mSv without dosimetry work permit). The highest individual radiation exposure was 7,7 mSv, which was well below the dose limit of 20 mSv/year, and our dose constraint of 12 mSv/year.

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

The electronic dosimetry data correspond acceptable with TLD data in 2018.

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 2018. The collective dose of the outage was 298 man·mSv on Unit 3.

Number and duration of outages

The durations of outages were 27 days on Unit 1, 26 days on Unit 2 and 52 days on Unit 3. The Unit 4 was not shut down for outage.

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

ITALY

1) Dose information for the year 2018

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	15.58 (1 unit - Trino NPP)
BWR	2	21.86 (1 unit Caorso NPP [2.67] + 1 unit Garigliano NPP [41.04])
GCR	1	7.10 (1 unit – Latina NPP)

JAPAN

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	18	228
BWR	22	98
All types	40	156
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	6	119
BWR	10	2,802
GCR	1	0
LWCHWR	1	68

2) Principal events of the year 2018

- *Outline of national dosimetric trend*

  The average annual collective dose for operating reactors decreased from 129 man·mSv /unit in the previous year (2017) to 156 man·mSv /unit in 2018. The average annual collective dose for reactors out of operation or in decommissioning excluding Fukushima Daiichi NPP was 101 man·mSv /unit, and that of Fukushima Daiichi NPP was 4,603 man·mSv /unit.
  The average annual collective dose of operating reactors was almost at the same level as for 2017. 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 2018, at most nine PWRs operated.
  From April 1 to April 17, 2018: 4 units (Takahama3, 4, Ohi3, Sendai2)
  From April 18 to April 23, 2018: 5 units (Takahama3, 4, Ohi3, Genkai3, Sendai2)
  From April24 to May 10, 2018: 4 units (Takahama3, 4, Ohi3 Genkai3)
  From May 11 to May 18, 2018: 5 units (Takahama3, 4, Ohi3, 4, Genkai3)
  From May 19, 2018 to June 2, 2018: 4 units (Takahama3, Ohi3, 4, Genkai3)
  From June 3 to June 18, 2018: 5 units (Takahama3, Ohi3, 4, Genkai3, Sendai1)
  From June 19 to August 3, 2018: 6 units (Takahama3, Ohi3, 4, Genkai3, 4, Sendai1)
  From August 4, 2018 to August 30, 2018: 5 units (Ohi3, 4, Genkai3, 4, Sendai1)
  From August 31 to September 2, 2018: 6 units (Ohi3, 4, Genkai3, 4, Sendai1, 2)
  From September 3 to October 29, 2018: 7 units (Takahama4, Ohi3, 4, Genkai3, 4, Sendai1, 2)
  From October 30 to December 6, 2018: 8 units (Takahama4, Ohi3, 4, Genkai3, 4, Sendai1, 2, Ikata3)

On December 7, 2018: 9 units (Takahama3, 4, Ohi3, 4, Ikata3, Genkai3, 4, Sendai1, 2)

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

Exposure dose distributions at Fukushima Daiichi NPP for dose during FY 2018 are shown below.

Cumulative dose Classification (mSv)	Fiscal year 2018 (April 2018 – March 2019)		
	TEPCO	Contractor	Total
>50	0	0	0
20 ~ 50	0	0	0
10 ~ 20	21	853	874
5 ~ 10	70	870	940
1 ~ 5	247	2856	3103
≤1	1105	5284	6389
Total	1443	9863	11306
Max. (mSv)	15.55	19.90	19.90
Ave. (mSv)	1.04	2.65	2.44

* 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. One PWR obtained approval in FY 2018.

3) Report from Authority

- *Inspection System Reform*

Inspection of nuclear facility has been done in several types separately each of which is prescribed in the Reactor Regulation Act, focusing on, for example, checking pass or fail according to the checklist. In April 2017, the Act was amended for further enhancement of safety, making the system flexible and covering the licensees' whole activities relevant to safety with a focus on safety issues and concerns. Concretely, the system in which the NRA can check the overall licensees' activities relevant to safety any time (the system in which the NRA can keep a close check "at any time" and "to anything") has been developed, putting an obligation on licensees to inspect compliance to the regulatory requirements by themselves. In addition, the system was designed to implement effective and performance-based regulation by rating the level of operational safety activities comprehensively for each nuclear power station and reflecting the safety performance to the next inspection properly. With this system, the NRA encourages licensees to address the maintenance and improvement of the level of safety voluntarily. Such new inspection system integrating the former segmented inspections has been under trial operation from autumn in 2018, and is aimed at launching practical operation as a systemized inspection program in FY2020 after examination and improvement of the associated problems.

KOREA

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	20	368
PHWR	4	397
All types	24	373
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	70

2) Principal events of the year 2018

- *Outline of national dosimetric trend*

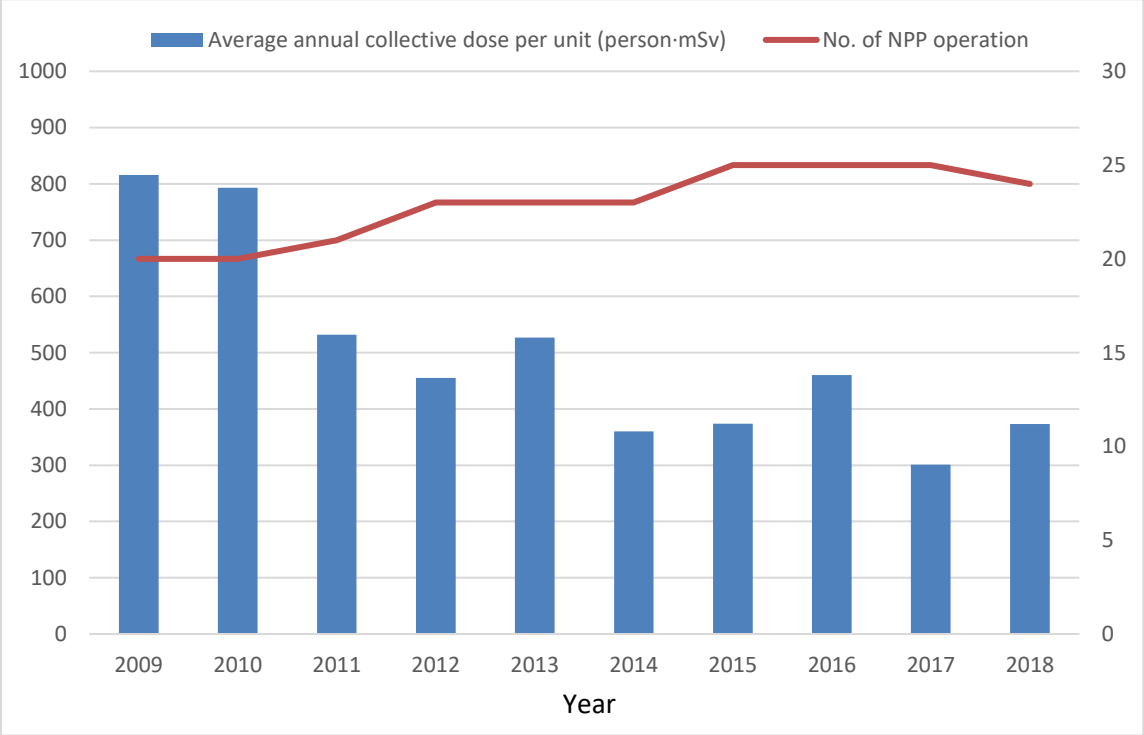
  In 2018, the total number of operating nuclear power reactors was 24; including 20 PWRs and 4 PHWRs. A PWR, Kori unit 1, has been permanently shut down since June 18, 2017.

  In terms of nuclear power plant (NPP) operation, the total number of 15,877 workers had access to the radiation controlled area and received a total amount of 9,025.55 man·mSv. The total number of workers increased by 1,376 in 2018, and the total amount of collective dose increased by 1,497.15 (approximately 19.9%) compared to 7,528.40 man·mSv in the previous year 2017. The main contribution of dose increase happened during the main maintenance jobs in most NPPs accompanying the increase in the total duration of outages approximately 18.9% compared to that in 2017. The dominant contributors to the collective dose in 2018 were the work carried out during the outages, resulting in 90.7% of the total collective dose.

  The average collective dose per unit in 2018 was 373 man·mSv based on the operation of 24 NPPs. The average individual dose in 2018 was 0.57 mSv. There was no individual whose dose exceeded 50 mSv. The maximum individual dose in 2018 was 13.71 mSv. The fractions of the number of individuals whose doses were less than 1 mSv to the total number of individuals were 85.37%. The radiation dose caused mainly by external exposure approximately 96.6%, and internal exposure contributed to only 3.4% of the total amount of exposure. In PHWRs, the contribution of internal exposure was relatively higher (approximately 19.3%) than that (almost zero %) in PWRs due to tritium exposure. In the case of the permanently shut-down reactor, Kori unit 1 reported 69.67 man·mSv due to the maintenance jobs during the outage.

Occupational dose distributions in NPPs (Year 2018)

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-)
2018	15,877	10,356	3,198	969	462	466	328	89	9	0



Average collective dose per NPP unit from 2009 to 2018

LITHUANIA

1) Dose information for the year 2018

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	418

2) Principal events of the year 2018

- *Events influencing dosimetric trends*

In 2018, the occupational doses at the Ignalina NPP (INPP) were uphold as low as possible, taking into account all economic, social and technological conditions: 634 man·mSv in 2016, 897 man·mSv in 2017, 836 man·mSv (72% of planned dose) in 2018. The collective dose for INPP personnel was 823 man·mSv (75% of planned dose) and for contractors personnel was 13 man·mSv (18% 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 15,47 mSv, and for contractors personnel – 1,4 mSv. The average effective individual dose for INPP staff was 0,5 mSv, and for contractors personnel – 0,02 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 2018 no component or system replacements were performed. In 2018 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 2018 the most important decommissioning projects were realized. The exploitation of the Interim Spent Nuclear Fuel Storage Facility was started in 2017 (project B1, ISFSF) and the fuel removal from units to the Storage Facility was continued in 2018. 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. 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 continued in 2018.

Every year the scope of dismantling works increases, the ambitious plans are being established in 2017 were implemented in 2018. 5 thousand tons of the equipment and related constructions had been dismantled in 2018. 156 thousand tons of the equipment had been 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 2018 VATESI carried out radiation protection inspections at Ignalina NPP in accordance with an approved inspection plan. Assessments were made regarding how radiation protection requirements were fulfilled in the following areas and activities: clearance of radioactive materials, dismantling of equipment, monitoring of occupational exposure, calibration and testing of individual and workplace monitoring equipment, contamination control of workers, work planning and work permit procedure for dose intensive works, using of radioactive sources. Inspections results showed that Ignalina NPP activities were carried out in accordance with the established radiation protection requirements. During the inspection of the arrangements for contamination control of workers, areas for improvement were identified, and recommendations regarding review of the corresponding Ignalina NPP procedures were provided. The corrective measures were implemented in due time.

Three radiation protection related nuclear safety legal documents were approved in 2018: BSR-1.9.5-2018 “Assessment of justification of activities with the sources of ionising radiation in the nuclear energy area”, BSR-1.9.6-2018 “Recognition of Radiation Protection Expert for Activities with Sources of Ionizing Radiation in Nuclear Energy Area and Duties of Undertakings carrying out Aforementioned Activities to Consult with Radiation Protection Expert” and BSR-1.9.7-2018 “Rules of Procedure for Recognition of Dosimetry Services”.

In 2019 VATESI will continue supervision and control of nuclear safety of decommissioning of INPP, management of radioactive waste, including the construction and operation of new nuclear facilities, as well as the radiation protection of these activities and facilities.

MEXICO

1) Dose information for 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	2	727.43

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. Unit 1 collective dose for 2018 was 758.16 man-mSv. Unit 2 collective dose for 2018 was 696.70 man-mSv.

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.
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 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	378
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 2018

- During the outage 2018, one internal contamination occurred, while performing maintenance on a safety valve of the primary pressuriser. The effective life-time dose was estimated as less than 0,01 mSv.

PAKISTAN

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	4	243.328
PHWR	1	3830.11
All types	5	960.684

2) Principal events of the year 2018

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

TYPE	UNIT	OUTAGES (No.)	DURATION (Days)
PWR	C-1	09	76.53
	C-2	06	44.97
	C-3	04	67.30
	C-4	06	12.83
PHWR	K-1	11	169.00

ROMANIA

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PHWR	**2**	**247**

2) Principal events of the year 2018

- *Events influencing dosimetric trends*

Normal operation of the plant (U1 & U2)

At the end of 2018:

- there are 140 employees with annual individual doses exceeding 1 mSv; 3 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 2018 is 5.84 mSv;
- the contribution of internal dose due to tritium intake is 17.3%.

Planned Outage

- A 34-day planned outage was done at Unit#1 between May 2nd and June 4th 2018. 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

Total collective dose at the end of the planned outage was 310 man·mSv (247.5 man·mSv external dose and 62.5 man·mSv internal dose due to tritium intakes).
Finally this planned outage had a 62% contribution to the collective dose of 2018.

Unplanned outages

Unit 2 – September 05 - 08: Unit was orderly shutdown to remediate a minor Fueling Machine Bridge malfunction. (10.6 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 and implemented for the optimization of the preventive maintenance program.
On December 2018 actions plan “Improving Personnel response at contamination monitors alarms at the exit of the RCA” was issued.
Personnel response at contamination monitors alarms is one of the topics in the RP staff observation & coaching program. All RP personnel are already involved in the observation / guidance program, in order to identify and correct deficiencies on work practice, RP fundamentals, RP equipment and systems.

A special designed application was used for the first time during 2018 planned outage for tracking accumulated collective external dose for each job, in order to compare it with estimated collective dose and the execution status. This allowed us quick identification of jobs needing dose re-evaluation.
The application is still used for monitoring dose progress of all radiation jobs.

RP supervisors attend all high radiological work risk activities pre-job briefing. RP technicians act as RP assistants high radiological work risk activities (including industrial radiographies).

RUSSIAN FEDERATION

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	19	748.2
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	274.8

- *Summary of national dosimetric trends*

In 2018, the total effective annual collective dose of own employees and contractors at nineteen operating VVER type reactors was 14216 man·mSv. This value represents 59 % increase in comparison to 2017. Observed change is a result of significant increase in outages duration in comparison with the previous year (1191 days in 2018 compared to 716 days in 2017), which, in turn, associated with modernization and life-extension activities performed at VVER-440 units.

Comparative analysis has showed a considerable difference between average annual collective doses for the groups of VVER-440, VVER-1000 and VVER-1200 reactors in operation. In 2018, the results were as follows:

- 1645.5 man·mSv/unit with respect to the group of five operating VVER-440 reactors (Kola 1-4, Novovoronezh 4);
- 435.9 man·mSv/unit with respect to the group of thirteen operating VVER-1000 reactors (Balakovo 1-4, Kalinin 1-4, Novovoronezh 5, Rostov 1-4);
- 321.3 man·mSv/unit with respect to the one operating VVER-1200 reactor (Novovoronezh 6, also known as Novovoronezh II nuclear power plant Unit 1).

These results show that average annual collective dose for the VVER-440 is 4-5 times higher than the average values for the VVER-1000 and VVER-1200.

Average annual collective dose for three reactors at the stage of decommissioning (Novovoronezh 1-3) in 2018 was 824.5 man·mSv.

The total planned outages collective dose of own employees and contractors represents 87.8 % of the total collective dose.

The total forced outages collective dose of own employees and contractors represents 0.01 % of the total collective dose.

- *Individual doses*

In 2018, individual effective doses of own employees and contractors did not exceed the control dose level of 18.0 mSv per year at any VVER-440, VVER-1000 and VVER-1200 reactor.

The maximum-recorded individual dose was 17.6 mSv. This dose was gradually received over the full year by a worker of Kola NPP maintenance department. The maximum annual effective individual doses at other nuclear plants with VVER type reactors in 2017 varied from 7.9 mSv (Rostov NPP) to 16.9 mSv (Novovoronezh NPP).

Planned outages duration and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Balakovo 1	85	1493.5
Balakovo 2	38	321.2
Balakovo 3	67	856.4
Balakovo 4	No outage	—
Kalinin 1	No outage	—
Kalinin 2	No outage	—
Kalinin 3	45	374.1
Kalinin 4	No outage	—
Kola 1	249	2833.1
Kola 2	53	304.6
Kola 3	46	437.5
Kola 4	52	442.3
Novovoronezh 4	362	3777.2
Novovoronezh 5	36	738.4
Novovoronezh 6	43	255.1
Rostov 1	42	220.6
Rostov 2	40	291.4
Rostov 3	33	141.5
Rostov 4	No outage	—

Forced outages duration and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Rostov 1	5	0.072
Rostov 2	32	0.699
Rostov 3	1	0.010

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

In 2018 the contribution of three units to Rosenergoatom Concern collective dose was approximately 58 %. This is completely due to radiation works during:

1) overhaul and modernization of Novovoronezh Nuclear Power Plant Unit 4 (362 days);

2) planned maintenance outage including life-extension activities at Kola Nuclear Power Plant Unit 1 (249 days);

3) extended outage with annealing of a reactor vessel at Balakovo Nuclear Power Plant Unit 1 (85 day).

Rostov Nuclear Power Plant Unit 4 (VVER-1000) was put into commercial operation on September 2018.

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

Further occupational doses reduction would be achieved by implementation of set of technical and organizational activities under the Programme for optimization of occupational radiation protection at Russian NPPs, revised every five years. In this Programme targets for collective and individual doses for each NPP are set. The targets will be achieved by Improving of current, annual and long-term dose planning, as well as the revision of local procedures, replacement of equipment and other activities under the Programme.

SLOVAK REPUBLIC

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	4	158.201

2) Principal events of the year 2018

- *Events influencing dosimetric trends*

- Bohunice NPP (2 units): The total annual effective dose in Bohunice NPP in 2018, calculated from legal film dosimeters and E_{50}, was 317.697 man·mSv (employees 77.719 man·mSv, outside workers 239.978 man·mSv). The maximum individual dose was 3.988 mSv (contractor). Without internal contamination. Without anomalies in radiation conditions
- Mochovce NPP (2 units):
  The total annual effective dose in Mochovce NPP in 2018, evaluated from legal film dosimeters and $E_{50,}$ was 315.108 man·mSv (employees 119.886 man·mSv, outside workers 195.222 man·mSv). The maximum individual dose was 4.780 mSv (contractor).

- *Outage information*

  Bohunice NPP:

- Unit 3 – 19.45 days standard maintenance outage. The collective exposure was 103.521 man·mSv from electronic operational dosimetry
- Unit 4 – 39.93 days standard maintenance outage. The collective exposure was 263.392 man·mSv from electronic operational dosimetry

  Mochovce NPP:

- Unit 1 – 18.5 days extended maintenance outage. The collective exposure was 111.474 man·mSv from electronic operational dosimetry. The maximum individual dose was 1.461 mSv.
- Unit 2 – 46.6 days standard maintenance outage. The collective exposure was 200.348 man·mSv from electronic operational dosimetry. The maximum individual dose was 3.619 mSv.

- *New reactors on line*
  Mochovce NPP, Units 3 & 4 are under construction. Cold hydro test was finished on Unit 3.

3) Report from Authority

In 2018, 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 finished preparations and applied 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 2018 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 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	783

2) Principal events of the year 2018

- *Events influencing dosimetric trends*
  - Outage duration 31 days (1.4.-1.5.2018), 678 man·mSv;
  - Component or system replacements: Installation of additional pressurizer valves and starting installation of some of alternate cooling features.
  - Safety upgrade programme is going on:
    Phase 1 – already implemented (2013): passive containment filtering and venting, and passive hydrogen recombiners;
    Phase 2 – to be completed by the end of 2019:
    - Emergency control room with a new technical support centre
    - Additional pressurizer by-pass valves
    - Alternative spent fuel pool cooling
    - Spent fuel pool spray system
    - New shelter building for operative support centre

    Phase 3 – to be completed in the next years:
    - Bunkered building with safety injection pump and borated water tank
    - Auxiliary feed water pump with condensate storage tank
    - Make-up possible from underground water source
    - Additional alternative RHR pump
    - Construction of spent fuel dry storage

3) Report from Authority

Main activity of the regulatory authorities in 2018 was still the transposition of the new European BSS directive. The Ionising Radiation and Nuclear Safety Act was adopted in the end of 2017 and came into force on 6th January 2018. Several governmental decrees and ministerial regulations were adopted in 2018:

- Decree on national radon program (OJ RS, No. 18/18)
- Decree on limit doses, reference levels and radioactive contamination (OJ RS, No. 18/18)
- Decree on activities involving radiation (OJ RS No. 19/18)
- Rules on the use of radiation sources and on activities involving radiation (OJ RS, No. 27/18)
- Rules on the monitoring of radioactivity (OJ RS No. 27/18)
- Rules on the criteria of using ionising radiation sources for medical purposes and practices involving non-medical imaging exposure (OJ RS, No. 33/18)
- Rules on approving of experts performing professional tasks in the field of ionising radiation (OJ RS, No. 39/18)

- Rules on the obligations of the person carrying out a radiation practice and person possessing an ionising radiation source (OJ RS, No. 43/18)
- Rules on special radiation protection requirements and method of dose assessment (OJ RS, No. (OJ RS, No. 47/18)
- Rules on radiation protection measures in controlled and supervised areas (OJ RS, No. 47/18)
- Rules on approving radiation protection experts (OJ RS, No. 47/18).

Together with the Rules on health surveillance of exposed workers (OJ RS, No. 2/04) which remained in force, and the Decree on the content and elaboration of protection and rescue plans (OJ RS, No. 24/12, 78/16 in 26/19) which was amended in the beginning of 2019, the BSS transposition in Slovenia is completed.

SOUTH AFRICA

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	2	606

2) Principal events of the year 2018

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

  Major maintenance outage on both units during the year. Replacement of refueling water storage tank on unit 2 during October 2018.

- *Regulatory requirements*

  Evaluation of eye lens dose limit of 20 mSv per year

SPAIN

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	6	400.65
BWR	1	249.84
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	102.19
BWR	1	143.76

2) Principal events of the year 2018

PWR

ALMARAZ NPP

a) Number and duration of outages

- 26th outage of ALMARAZ Unit 1:
  Duration: 34 days.
  Beginning: October 28th, 2018.
  Ending: December 2nd, 2018.
  Collective dose: 425.797 man·mSv.
  Maximum individual dose: 2.833 mSv.

- 24th outage of ALMARAZ Unit 2:
  Duration: 32 days.
  Beginning: April 8th, 2018.
  Ending: May 11th, 2018.
  Collective dose: 394.451 man·mSv.
  Maximum individual dose: 2.675 mSv.

b) Major evolutions

- Loading cask ENUN32P dry storage fuel:
  Beginning: October 1sh, 2018.
  Ending: December 12th, 2018.
  Collective dose: 2.275 man·mSv.
  Maximum individual dose: 0.406 mSv.

c) Component or system replacement:

- Design modification to collect and confine oil leaks from reactor coolant pump.

d) New/experimental dose-reduction programmes

- Promoting the use of remote devices for minimise auxiliary works, number of workers and doses.

ASCÓ NPP

a) Number and duration of outages

- 26th refuelling outage of Ascó 1
  Duration: 43 days
  Collective dose: 472.08 man·mSv.
  Maximum operational individual dose: 4.230 mSv.
  Relevant activities from RP point of view performed during refuelling outage:
  - Steam Generator channel head drainage valves replacement.
  - Fuel management system refurbishment.

b) Number and duration of outages

Realization of 6 spent fuel transfer campaigns to the Temporary Repository on Ascó site.

TRILLO NPP

a) Number and duration of outages

- 30th outage
  Duration: 30 days.
  Beginning: May 18th, 2018.
  Ending: June 25th, 2018.
  Collective dose: 302.236 man·mSv.
  Maximum individual dose: 3.04 mSv.

b) Major evolutions

- Loading 2 cask ENUN32P dry storage fuel:
  Beginning: December 3th, 2018.
  Ending: December 22nd, 2018.
  Collective dose: 2.037 man·mSv.
  Maximum individual dose: 0.240 mSv.
  Maximum individual dose second cask: 0.177 mSv.

VANDELLÓS 2 NPP

- *Events influencing dosimetric trends*

In 2018, 4 incidences have been recorded which have resulted in a significant radiological cost in the collective dose:

1) 02/03/2018 an unscheduled stop occurred due to a leak detection in a pressure barrier's valve. In a subsequent inspection, a leak was discovered in a steam generator drain welding. To repair the leaks, the reactor fuel unloading was required. Repairs were made in the pressure barrier's valve

and the drains of the 3 steam generators were modified. The plant's power rising process started on 12/04/2018.

2) During this mentioned process, a new leak was discovered in the sealing assembly of a thermocouple column that forced the plant to stop again until the start of the planned refueling outage (22nd cycle) on 12/05/2018.

3) In the 22nd refueling outage, the following activities were carried out:

- Inside inspection of one steam generator. Due to the obtained results in this steam generator, the scope of the inspection was increased to the cold legs of the other 2 steam generators.
- Engine substitution in a reactor coolant pump.
- Duplication of the signals in the remote stop panel (design modification).
- Sealing assemblies substitution of 3 thermocouple columns on the vessel's lid.

The plant's power rising process started on 20/07/2018.

4) 18/12/2018 an unscheduled stop occurred due to a leak detection in a pressure barrier's valve. To repair the leak, the reactor fuel unloading was not required. The plant's power rising process started already in 2019.

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 clean-up of the reactor (G33).

In relation with the evolution of the term source in the dry well in the 21st outage (2017) is observed that the values of rate of dose in the recirculation pipelines follow a behaviour 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 clean-up system the behaviour 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

21st outage.
Duration 36 days.
There was 1 forced outage for recovery of FME in the feed water sparser (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 ratio 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 tele dosimetry. 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 refuelling 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 29th	Reconditioning of drums containing waste built-in MICROCEL	93.763
April 10th to December 29th	Conditioning of sludge from decanter tanks TNK-2034A/B	22.144

(*) Note that this is operational dose

REPORT FROM AUTHORITY (IF A SEPARATE CONTRIBUTION IS AVAILABLE)

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 2018.

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 2018, CSN carried out the assessments associated with the approval of the modifications in the HI-STORM dual-purpose cask valid for the storage and transport of PWR spent fuel from Ascó, nuclear power plants. CSN also carried out the assessments associated with the licensing of the cask HI-STAR 150 for Cofrentes NPP spent fuel and ATI's foreseen at Cofrentes site.

From 15 – 26 October 2018 Spain took place the International Atomic Energy Agency's (IAEA) joint verification mission: the Integrated Regulatory Review Service (IRRS) and the Integrated Review Service for the Management, Dismantling and Restoration of Radioactive Wastes and Spent Fuels (ARTEMIS). It was the first time the IAEA has conducted two revisions of different scope combined into a single mission.

The IRRS component of the peer review provided an independent expert assessment of the Spanish regulatory framework, functions and activities, assessed the effectiveness of their application and exchanged information and experiences in the areas of nuclear safety and radiation protection covered by the IRRS. The IAEA safety standards served as the basis for the IRRS review. The ARTEMIS component of the peer review provided independent expert opinion and advice on radioactive waste and spent nuclear fuel management, based upon the IAEA safety standards and technical guidance, as well as international good practices. For more information: https://www.csn.es/documents/10182/2181879/INFORME%20FINAL%20IRRS%20ARTEMIS%202018%20(English).pdf

During 2018 the CSN has been involve in the assessment of documents submitted by Vandellós and Almaraz for the renewal of their operating permit according to 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 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	3	207
BWR	5	356
All types	8	300
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
BWR	4	46

2) Principal events of the year 2018

Ringhals NPP

Ringhals four reactors were all performing well during 2018 from a Radiation Protection point of view which resulted in an all-time low collective dose, 866 man·mSv (included waste handling, workshop and decontamination facility). The forecast for 2019 is < 1000 man·mSv .

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) along with an increasing interest and effort from the entire organisation to implement ALARA on daily bases, and in projects for long term ALARA-investments.

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 on these units.

No internal contaminations, giving an equivalent dose > 0,25 mSv, have been encountered during the year.

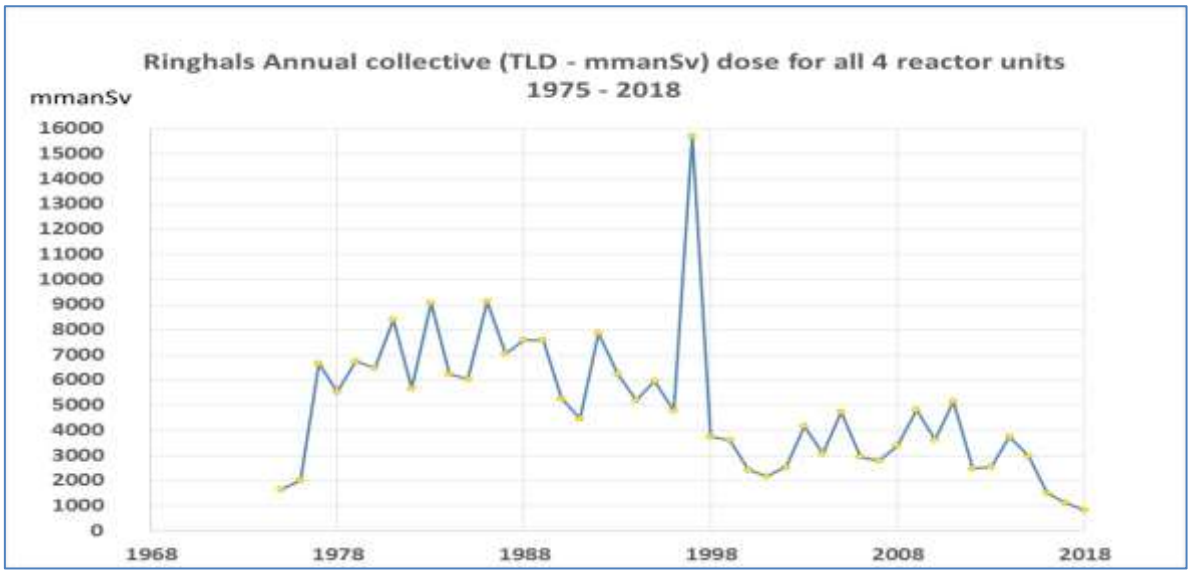
Source term management is always in focus and in long term there will be analysis made concerning origin of antimony sources to reduce outage doses on the PWR reactors (Ringhals 3 and 4).

A part of source term reduction is online trending of nuclide specific build up in reactor system oxide layers and implementation on unit 3 and 4 is in planning and the experience from Ringhals 1 OLA (OnLine nuclide specific Activity) and DOSOLA (DOS rate OnLine Activity) will be carefully considered.

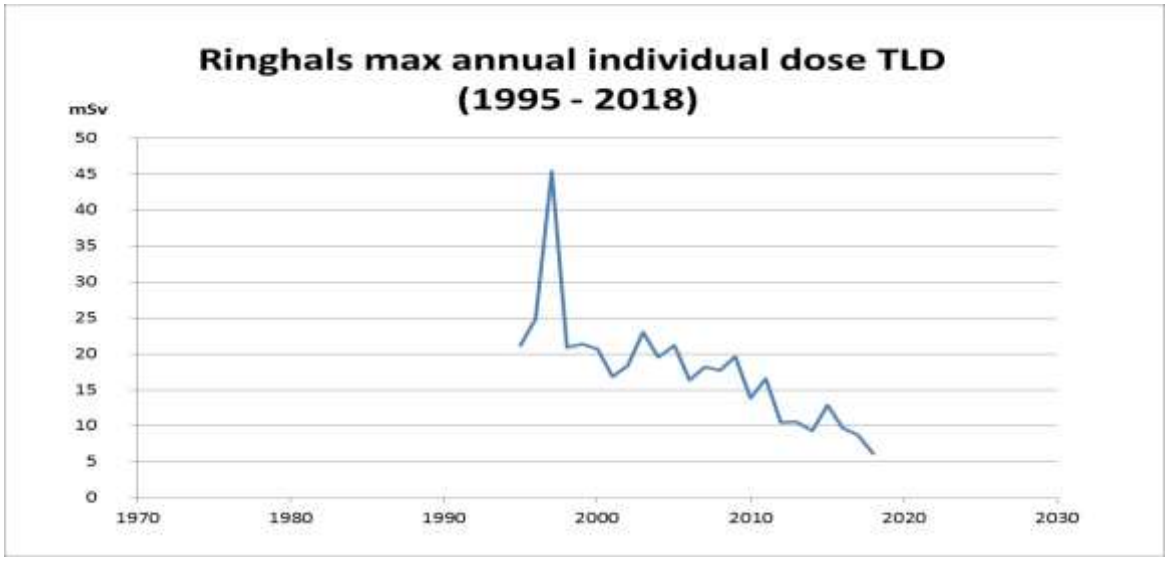
Three INES classifications were performed during 2018 which resulted in INES 1 reports (3). The radiation protection event deviations concerned radioactive source handling, entrance in high dose rate area and lack in radioactive equipment control.

Furthermore, dosimetry system and logistic concerning dose to the eye lens is proceeding and for example, CRDM maintenance crew will be given extra focus during outage 2019, because statistics

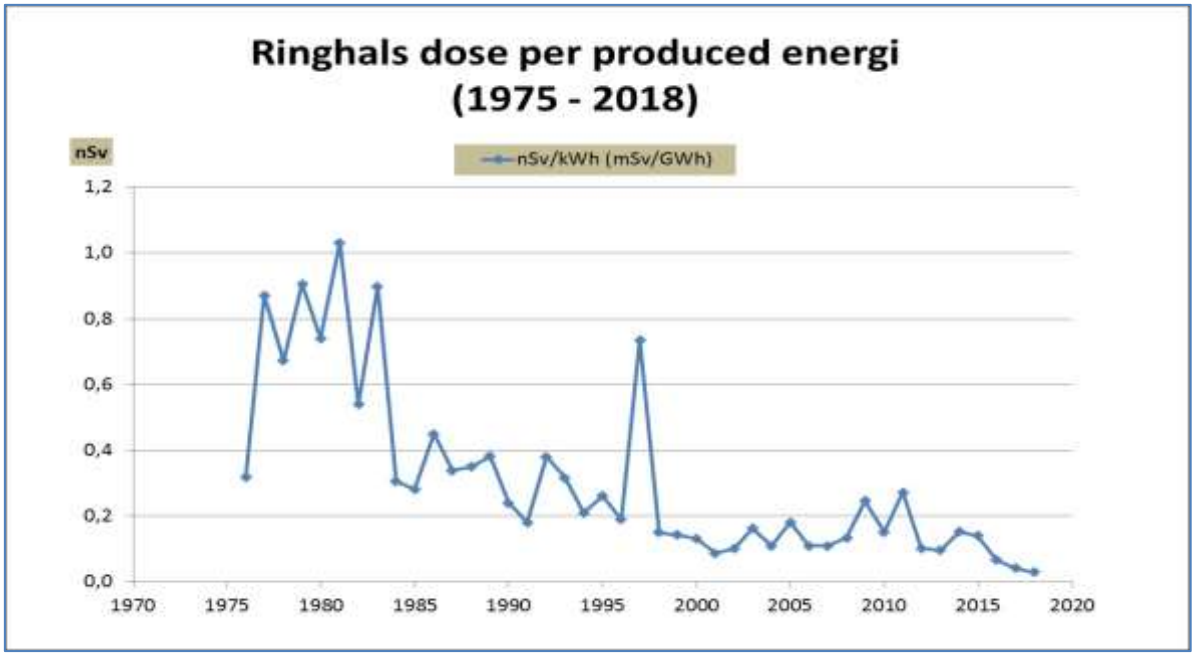
shows higher dose for Hp3 than Hp10 (typical 60 % higher), done in cooperation with Swedish nuclear power plants.



Above shows the annual collective dose since mid-70th when Ringhals 2 went into operation.

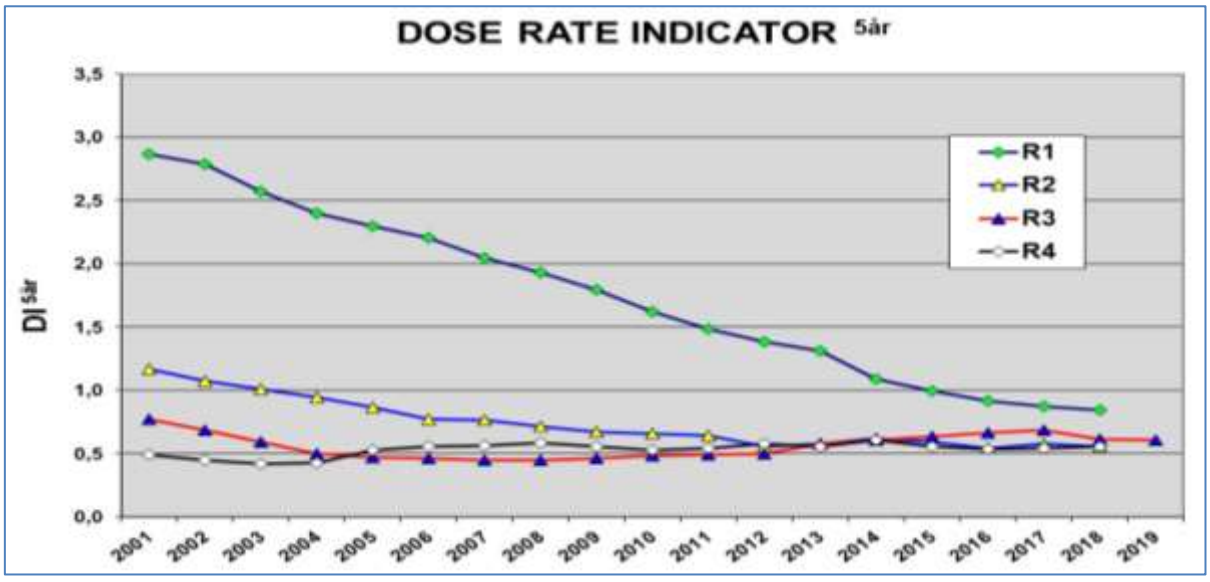


Since the mid-90th individual doses have decreased, and the company goal was met a couple of years ago and the long-term goal for maximum entitled annual individual dose will probably be 6 mSv.



Ringhals availability on grid has improved as well as decreasing CRE have resulted in a level of 30 µSv per produced GWh.

The construction works continuous on the new independent core cooling system (OBH) at two PWR reactor units (R3/R4).



Graph above illustrates dose rate index per Ringhals reactor for 5 rolling years.

Based on the 2018 ALARA analysis and evaluation, the radiation protection work at Ringhals is generally considered to function satisfactorily. During 2018, several measures were started to develop and strengthen the ALARA-business. The dose outcome is the lowest since Ringhals started, both from an individual and a collective dose perspective. No contamination spread has been detected in uncontrolled areas. In cases of contamination spread on the controlled side, the area has been limited and has not resulted in any recordable mortgage effective dose to the person.

Forsmark NPP

Forsmark 1

The planned outage was a short “refueling outage”, 13 days. No major work was performed besides the changing of fuel. The collective dose received was 136 man·mSv, in accordance with the dose projection.

The dose rates in the reactor and turbine systems remain fairly stable.

Forsmark 2

The planned outage was a “maintenance outage”, lasting for 33 days. The collective dose received was 338 man·mSv, somewhat lower than the dose projection, due to incorrect communication regarding a modification project.

Some radiological incidents occurred regarding for example personnel not wearing correct protection equipment, spread of contamination in the reactor hall and not closing door to high radiation area.

The highest collective dose was received in connection with inspection and maintenance of valves in the reactor coolant system and work with the Control Rod Drive Mechanism service (CRDMs). Regarding the latter work the elevator for the CRDM platform was renewed and 26 control rods were maintained, including control rod indications.

The dose rates in the reactor systems show a continued upward trend since previous years. This is probably due to the system decontamination performed some 4 years earlier, although the dose rates now even exceed those encountered before the system decontamination. The dose rates in the turbine systems on the other hand show a slightly decreasing trend.

Forsmark 3

The outage was mainly an “maintenance outage” but in addition a large plant modification was performed, namely changing containment penetrations (“KabRI”) due to aging and environmental qualification reasons. The overall collective dose received was 457 man·mSv, exactly as the dose projection. The KabRI accounted for 44 man·mSv. In the planning of this work training in mock-up was performed and specific RP information given. Most of the remaining doses were obtained during maintenance work on valves in the reactor systems. The need for a large maintenance program was partly due to the previous 18-month operational cycle, with no planned outage during 2017. The collective dose for work on the turbine systems was 94 man·mSv, compared with the dose projection 63 man·mSv. The higher outcome was mainly due to extended repair work on the high-pressure preheaters and leakage in some valves in the Main Steam system (MS).

The dose rates in the reactor systems shows no significant changes compared with previous years, but the dose rates in the turbine systems show a somewhat upward negative trend.

Beside the planned outage there were two short shutdowns (one week each) due to fuel leaks.

Forsmark

A new dose information system was taken into operation, allowing any person working at Forsmark to see his or her radiation dose received during recent day, week, month and year. It will also allow managers to see the individual radiation doses for his or hers working group.

A monitoring program for measuring dose to the lens of the eye has been put into operation. This means that for some type of work it will be mandatory to wear eye dosimeters (TLD) during work, along with the ordinary whole body TLD and EPD. The doses received by the lens of the eye will also be recorded in the national central dose database for nuclear facilities (CDIS).
The construction works continuous on the new independent core cooling system (OBH) on all three reactor units. This is a major post Fukushima upgrade. The OBH systems will be commissioned in the end of 2020.
No internal contaminations, equivalent dose > 0,25 mSv, have been encountered during the year.
In June a new radiation protection law and ordinance came into force, together with several new and revised regulations from the Swedish Radiation Safety Authority. Even if the need for actual changes in procedures and routines were limited it resulted in a massive workload changing the management system, instructions and training material. This work will continue during 2019.

Oskarshamn NPP

OKG

Final closure of two of the three reactors within OKG resulted in a two-round restructuring program from 2017 to 2019, with staff reductions and a reorganization of the company, with an adaptation of staff to manage a facility in continued operation and two plants under decommissioning

The total dose for OKG was 508 man·mSv based on measurements with TL dosimeters and 588 persons with a registered dose resulted in the maximum individual dose of 8.8 mSv.

Measurements for control of internal intake did not show that any of these persons had an internal intake that resulted in a mortgage effective dose exceeding 0.25 mSv.

In recent years, OKG has achieved increased accuracy and quality in its work with dose forecasting and has achieved increasingly clear cooperation across organizational boundaries, in planning measures and in implementation at the plant and with a clear understanding of their own personal responsibility for dose and for the importance of collaboration and clear communication.

The supervisory authority´s radiation safety evaluation of OKG 2018 was overwhelmingly positive and the Authority has expressed satisfaction with OKG, who received the best grade ever.

O3 reactor

The 2018 outage was conducted over twenty-eight days, with some delay due to additional work such as repairs, extra inspections that required several power outage and problems with indications and transducers that had to be replaced.

During the outage a special focus was on health, safety, physical protection and the environment, communication and high quality, which gave a good result.

The security was put ahead of schedule and experiences were reported in the deviation and experience system, which provided the basis for improvements and experiences to be include in the outage 2019, areas of concern are; contamination alarms, work environment, fire protection, housekeeping, human performance and human performance tools, foreign materials exclusion and good practice.

Work on planning for the introduction of an independent cooling system at the reactor has continued during 2018.

Decommissioning of O1 and O2 reactors

During 2018, the work has primarily focused on radiological mapping of the plants and on segmentation of internal parts at the O2 reactor.

Extensive efforts have also been made in terms of planning for upcoming sub-projects, including the preparation of work packages for implementations.

During the year, planning and preparation of documentation for the construction of intermediate repository and clearance facilities were also carried out.

Barsebäck NPP

Barsebäck two reactors have been finally shut down, unit 1 since 1999 and unit two 2005.

The annual collective dose received was 27 man·mSv (TLD).

The two largest dose contributors were project BREDA and project HINT.

BREDA was a cooperation between Uniper, Vattenfall, Fortum and TVO. The project involved taking core samples from reactor vessel and reactor vessel head, to analyze how the material has been affected from radiation and thermal impact for 40 years operation. Collective dose 13 man·mSv (EPD).

Project HINT, segmentation of internals received a collective dose of 13 man·mSv (EPD).

Highest individual dose 2018 was 3,0 mSv (TLD).

3) Report from Authority

A new Radiation Protection Act (2018:396) was decided by the Swedish Parliament on 26 April 2018 and entered into force on 1 June 2018. Also, a new regulation on basic rules for all licensed activities involving ionising radiation were decided (SSMFS 2018:1) on 24 May 2018. These regulations came into force on 1 June 2018.

The new lower dose limit to the equivalent dose to the lens of the eye is stated in the radiation protection ordinance. Requirements on the application on this are specified in SSMFS 2018:1. These include the situations when measurements need to be conducted. A joint project has been carried out together with all Swedish nuclear facilities in connection with this lower dose limit. Shared methods and guidelines have been developed.

SSM is actively following the planning/ work carrying out of the decommissioning of the four reactors that will be closed in 2016-2020 but also normal supervision of the operating nuclear reactors has been conducted.

SSM have planned inspections for 2019 at the three operational nuclear power plants concerning

"ALARA- activities."

SWITZERLAND

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	3	150
BWR	2	986

2) Principal events of the year 2018

- *Events influencing dosimetric trends*

  Beznau NPP (KKB)

  - Unit 1 was restarted after a multi-year shutdown. The regulator accepted the safety case concerning RPV materials. Unit 2 carried out a regular outage to replace fuel.

  Gösgen NPP (KKG)

  - Gösgen adapted its organisation to a possible plant life extension. The planned outage lasted 21,5 days.

  Leibstadt NPP (KKL)

  - Leibstadt outage lasted 46 days, 20 days longer than planned. The outage time extension was due to a vibration-induced crack in a safety system, which was generated during a test. The coloration on some fuel rods, which were observed in the previous cycle, were identified as crud deposits. Local dry-out could be ruled out. However, the reactor was operated with slightly limited thermal power around 90%.

  Mühleberg NPP (KKM)

  - Mühleberg performed its final outage before decommissioning. As a consequence, the workload was reduced compared to previous outages. In order to lower dose rates during the upcoming decommissioning, the injection of noble metals into the feedwater will be continued.

UKRAINE

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	15	677

In 2018 the dose rate per unit was some higher than previous years.

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 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	1	96.2
GCR	14(1)	50.3
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)	23.983

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

2) Principal events of the year 2018

Sizewell B recorded a 2018 calendar year Collective Radiation Exposure of approx. 96 man·mSv which was 25% below the station goal. Britain's only commercial PWR continued its fifteenth refuelling outage, into January. The outage had started late in 2017 and lasted for around 90 days due to the work needed to repair the Steam Generator drain lines. Eventually a relatively simple repair technique was used, machining out the affected weld material then welding a plug into the drain. Approximately 70% of the annual collective radiation exposure was recorded during the thirty days of refuelling outage, during January 2018. For the remainder of the calendar year the reactor operated without incident.

Elsewhere in the EDF Energy operational fleet the total annual collective radiation exposure recorded by the Advanced Gas Cooled reactors was higher than recent years due to in-vessel inspections at Heysham 2 and Torness NPPs. Heysham 2 recorded a collective radiation exposure of around 215 man·mSv and Torness a collective radiation exposure of approximately 290 man·mSv. These doses are atypical for an AGR, where the annual CRE is usually a few tens of man·mSv per year. The higher doses were due to these AGRs having to conduct in-vessel inspections, to support their continued safety case. Hunterston B was shut down for the majority of the calendar year due to the discovery of unexpected indications in the graphite moderator. Work is in progress to prepare a revised safety case to justify a start up early in 2019.

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, Bradwell NPP is anticipated to enter this state in March 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 approximately 20 man·mSv to 80 man·mSv, with doses reflecting the quantity of work being carried out. Unlike previous years the doses across decommissioning sites are relatively similar, with no site performing work that results in significant doses.

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 has postponed their plans to build twin GE-Hitachi Advanced Boiling Water Reactors at Wylfa and Oldbury. Similarly Toshiba has cancelled plans to construct three Westinghouse AP1000 units at Moorside in Cumbria.

EDF Energy and Chinese General Nuclear have begun seeking Generic Design Approval for the construction of two Chinese Hualong HPR-1000 PWRs at Bradwell.

UNITED STATES

1) Dose information for the year 2018

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	65	333.982
BWR	33	1108.966
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
PWR	13	26.307
BWR	6	93.878
FBR	1	0.00*

* Fermi 1

2) Principal events of the year 2018

Summary of USA Occupational Dose Trends

The occupational dose averages for 2018 continue to reflect an emphasis on exposure reduction. Exposure reduction initiatives at the 98 operating commercial reactors resulted in an overall 6.8% reduction in annual occupational exposure. Occupational exposure from the 33 operating BWR units shows a 5.9% reduction from 1178.6 man·mSv/unit (2017) to 1109.0 man·mSv/unit (2018). Whereas, the 65 operating PWR units show a 9.9% reduction from 370.6 man·mSv/unit (2017) to 334.0 man·mSv/unit (2018).

A significant increase is identified in shutdown/decommissioning reactor exposures per unit as a result of 5 units; 2 BWR units and 3 PWR Units. Oyster Creek shut down for decommissioning late in the year of 2018, resulting in a significant amount of operating dose being reported in the shutdown category, 378.87 man·mSv for this single unit. Secondly, Vermont Yankee took significant exposure due to decommissioning activities that resulted in 178.07 man·mSv for another single unit. San Onofre, a 3-unit PWR, also took significant exposure for decommissioning activities that resulted in a total of 245.74 person-mSv or 81.91 man·mSv/unit.

Distribution of exposure to workers

Cumulative dose Classification (mSv)	No Measurable Exposure	< 1	1 – 2.5	2.5 – 5	5 – 7.5	7.5 – 10	10 – 20	20 – 30	> 30
BWRs	30,454	20,674	6,258	3,021	831	250	134	1	0
PWRs	58,751	23,532	4,772	1,186	255	66	34	0	0
Totals	89,205	44,206	11,030	4,207	1,086	316	168	1	0

	Total number monitored	Total number with measurable dose	Average of measurable dose (mSv)
BWRs	61,623	31,169	1.17
PWRs	88,596	29,845	0.73
Totals	150,219	61,014	0.96

Plants shut down

Oyster Creek, a single unit BWR, is no longer in commercial operation.

3) Regulatory Affairs

There were no substantive changes in the regulatory scheme for commercial power reactors in 2018. Please see the description in the 2017 Annual report for the United States for detail on the regulatory system in place.