2017

[ISOE Country Reports]

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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NUCLEAR ENERGY AGENCY

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

The mission of the NEA is:

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

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

FOREWORD

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

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

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

This special edition of country reports presents dose information and principal events of 2017 in 13[*] out of 31 ISOE countries and will be incorporated into the Twenty-Seventh Annual Report of the ISOE Programme.

[*] Dose info and principal events of 2017 are not presented for Belgium, Canada, Finland, France, Hungary, Italy, Japan, Korea, Mexico, Netherlands, Romania, Slovak Republic, Spain, Sweden, United States.
Note: Belarus and United Arab Emirates 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 2016 from 13[†] out of 31 ISOE countries and will be incorporated into the Twenty-Seventh Annual Report of the ISOE Programme.

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

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

While ISOE is well known for its occupational exposure data and analyses, the programme's strength comes from its objective to share such information broadly amongst its participants. In 2017, the ISOE Network website (www.isoe-network.net) continued to provide the ISOE membership with a comprehensive web-based information and experience exchange portal on dose reduction and ISOE ALARA resources.

The annual ISOE ALARA Symposia on occupational exposure management at nuclear power plants continued to provide an important forum for ISOE participants and for vendors to exchange practical information and experience on occupational exposure issues. The technical centres continued to host international / regional symposia, which in 2017 included: the ISOE North-American ALARA Symposium organised by the North American Technical Centre in Fort Lauderdale (USA) on 9-11 January and the ISOE ATC Benchmarking Exchange for Radiation Protection organised by the Asian Technical Centre and Nuclear Research Association (NSRA) in Kyoto (Japan) on 25-27 October. Regional and international symposia provide a global forum to promote the exchange of ideas and management approaches for maintaining occupational radiation exposures as low as reasonably achievable.

[†] Dose info and principal events of 2017 are not presented for Belgium, Canada, Finland, France, Hungary, Italy, Japan, Korea, Mexico, Netherlands, Romania, Slovak Republic, Spain, Sweden, United States.
Note: Belarus and United Arab Emirates do not have NPPs in operation (or decommissioning).

PRINCIPAL EVENTS IN PARTICIPATING COUNTRIES

ARMENIA

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	1	1058,235
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	1	N/A

2) Principal events of the year 2017

Outage information

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

Collective doses during the 2017 outage

Outage number	Outage dates	Personal collective dose (man·mSv)		
		ANPP		Outside workers
		Planned	Received	Received
2017	10.05.17 - 07.07.17	899	824,635	114,116

Maximum personal doses during the 2017 outage

Outage number	Outage dates	Maximum personal dose (mSv)	
		ANPP	Outside workers
2017	10.05.17 - 07.07.17	17,337	5.005

- *Organisational evolutions*

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

The tasks were the following:

- Non exceeding of annual personnel collective dose above 1,31 man·Sv;
- Non exceeding of personnel collective dose during outage above 917 man·Sv;
- Non exceeding annual individual dose above 20 mSv.

3) Report from Authority

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

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

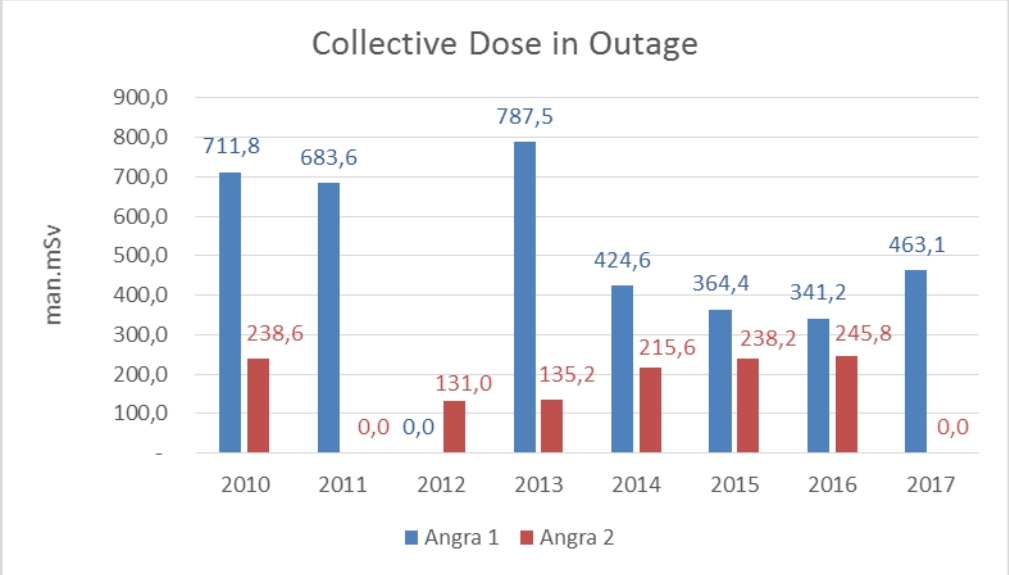
BRAZIL

1) Dose information for the year 2017

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

2) Principal events of the year 2017

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



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

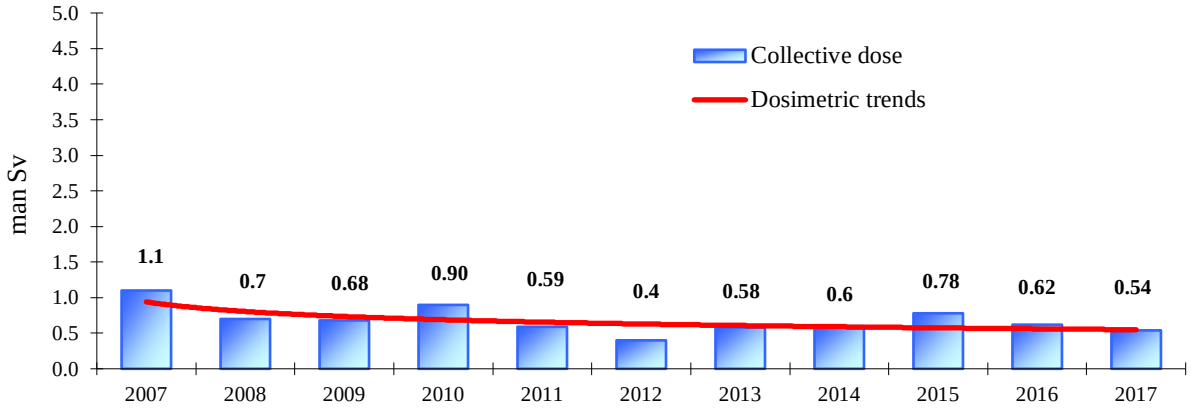
BULGARIA

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER-1000	2	251
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER-440	4	9.3

2) Principal events of the year 2017

Summary of dosimetric trends



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

- *Events influencing dosimetric trends*

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

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

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

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

CHINA

1) Dose information for the year 2017

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

2) Principal events of the year 2017

- *Summary of national dosimetric trends*
  Two new PWR units (FUQING-4 and YANGJIANG-4) began commercial operation in 2017. For the 37 reactors, refueling outages were performed for 23 of 33 PWR units, 1 of 2 PHWR units, and 1 of 2 VVER units in 2017.
  The total collective dose for the Chinese nuclear fleet (33 PWR units, 2 VVER units and 2 PHWR units) in 2017 was 14.473 man·Sv. The resulting average collective dose was 391.2 man·mSv/unit. No individuals received a dose higher than 10 mSv in 2017.
  In the operation of nuclear power plants, annual collective dose is mainly from outages. The ALARA programme is well implemented during the design and operation of all nuclear power plants. The average annual collective dose per unit of 391.2 man·mSv/unit varied slightly in comparison with the year 2016 (364.7 man·mSv/unit).
  In 2017, there were no radiological events threatening the safety of people and the environment at the operational nuclear power plants. The monitoring index over the year showed that the integrity of three safety barriers was in sound status.
- *Regulatory requirements*
  In Feb. 2017, the Thirteenth Five-year Plan and 2025 Perspective Plan on Nuclear Safety and Prevention & Control of Radioactive Pollution was approved by the State Council of the People's Republic of China.
  In Sep. 2017, the Nuclear Safety Act of the People's Republic of China was issued.
  The National Information System on Occupational Radiation Exposure by NNSA is under construction in 2017, and will be finished by the end of 2018.

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

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

CZECH REPUBLIC

1) Dose information for the year 2017

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

2) Principal events of the year 2017

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

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

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

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

LITHUANIA

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
REACTORS DEFINITIVELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
LWGR	2	428,00

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

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

18 mSv individual dose wasn't excess. The highest individual effective dose for INPP staff was 17,67 mSv, and for contractor personnel – 3,10 mSv. The average effective individual dose for INPP staff was 0,51 mSv, and for contractor personnel – 0,05 mSv.

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

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

- *New/experimental dose-reduction programmes*

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

- *Organisational evolutions*

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

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

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

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

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

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

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

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

PAKISTAN

1) Dose information for the year 2017

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

2) Principal events of the year 2017

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

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

RUSSIAN FEDERATION

1) Dose information for the year 2017

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv/unit]**
VVER	18	495.2
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	274.9

- *Summary of national dosimetric trends*

In 2017, the total effective annual collective dose of utilities' employees and contractors at the eighteen operating VVER type reactors was 8914.4 man·mSv. This value presents 355.4 man·mSv (3.8 %) decrease from the year 2016 total collective dose of 9269.8 man·mSv.

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

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

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

Average annual collective dose for three reactors at the stage of decommissioning (Novovoronezh 1-3) was 824.7 man·mSv.

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

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

- *Individual doses*

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

Planned outages duration and collective doses

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

Forced outages duration and collective doses

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

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

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

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

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

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

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

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

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

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

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

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

− improvement of work management;

− dose rate reduction;

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

- *Organizational evolutions*

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

SLOVENIA

1) Dose information for the year 2017

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

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

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

3) Report from Authority

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

SOUTH AFRICA

1) Dose information for the year 2017

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

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

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

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

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

- *New/experimental dose-reduction programmes*

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

SWITZERLAND

1) Dose information for the year 2017

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

2) Principal events of the year 2017

- *Events influencing dosimetric trends*

  Beznau NPP (KKB)

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

  Gösgen NPP (KKG)

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

  Leibstadt NPP (KKL)

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

  Mühleberg NPP (KKM)

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

- *Organisational evolutions*

  KKM is starting to adapt its organization to the upcoming decommissioning phase.

- *Regulatory requirements*

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

UKRAINE

1) Dose information for the year 2017

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

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

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

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

UNITED KINGDOM

1) Dose information for the year 2017

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

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

2) Principal events of the year 2017

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

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

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

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

3) New Nuclear Build

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

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