2017

OPERATION & SAFETY REPORT OF MOCHOVCE AND BOHUNICE V2 NUCLEAR POWER PLANTS

SLOVENSKÉ ELEKTRÁRNE

The company is certified according to three management systems:

Certificate STN EN ISO 9001:2008 – Quality management system

Certificate STN OHSAS 18001:2009 – Occupational health and safety management certificate

Certificate STN EN ISO 14001:2005 – Environmental management system

Issued by Bureau Veritas

Technical data

Reactor type:	**VVER 440/V-213 – PWR**
Reactor thermal power:	1 471 MWt
Reactor rated power:	470 MWe (EMO) / 505 MWe (EBO V2)
In-house consumption:	~7.2 % (EMO) / ~6.8 % (EBO V2)
Fuel:	UO_2 (42 t)
Fuel enrichment:	4.87 % U-235
Nuclear steam supply system	
Number of cooling loops:	6
Coolant flowrate:	42 600 m^3/h
Total volume:	242 m^3
Working pressure and temperature:	12.26 MPa / 267.9°C – 297.3°C
Reactor pressure vessel	
Inner diameter:	3 542 mm
Wall thickness:	140 + 9 mm
Height:	11 805 mm
Steam generator	**6 per unit**
Type:	PGV - 213
Volume of steam generated:	450 tonnes per hour
Steam pressure and temperature at outlet:	4.61 MPa / 255°C
Turbine generator	**2 per unit**
Type:	ŠKODA 220 MWe (EMO)/ ŠKODA 250 MWe (EBO)
Rated speed:	3 000 rpm
Generator rated power:	259 MVA (EMO) / 273 MVA (EBO)
Terminal voltage:	15.75 kV
Rated current:	3 x 9 500 A (EMO) / 3 x 10 007 A (EBO)
Condenser	**2 per units**
Cooling water volume:	35 000 m^3/h
Max. temperature of cooling water:	33°C
Cooling towers	
Number:	4 (per 2 units)
Height:	125 m (EMO) / 120 m (EBO V2)

Start of operation

	1st criticality*	Start of permanent operation
EBO 3	07.08.1984	14.02.1985
EBO 4	02.08.1985	18.12.1985
EMO 1	09.06.1998	29.01.1999
EMO 2	01.12.1999	11.07.2000

EBO V2 – Bohunice V2 Nuclear Power Plant (Units 3&4)

EMO – Mochovce Nuclear Power Plant (Units 1&2|

* 1st criticality – first achieving of minimal controlled power

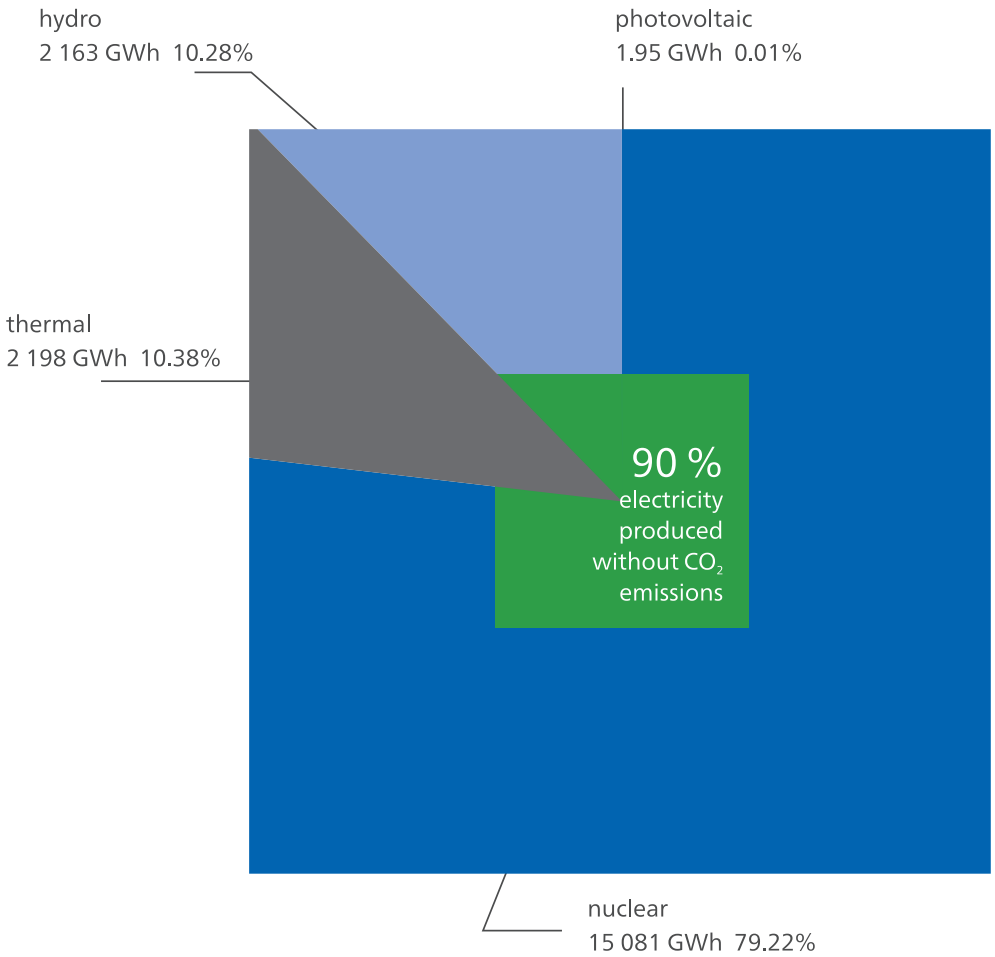
Probability of reactor core damage

	at full power	at the shutdown reactor
EBO 3	3.688E-06	6.15E-06
EBO 4	3.706E-06	6.15E-06
EMO 1	7.39E-06	7.92E-06
EMO 2	7.39E-06	7.92E-06

according to PSA - probabilistic safety assessment

Note: x E-06= x events per 1 milion year

Share resources in electricity generation



Electricity & heat supply

Indicator		Unit	2013	2014	2015	2016	2017	Since start of operation
Net generation	MWh	EBO	7 515 656	7 519 631	7 107 218	6 744 342	7 264 057	193 822 964
		EMO	7 101 545	6 937 680	7 012 670	7 029 172	6 767 004	116 418 451
Heat Supply	GJ	EBO	1 855 671	1 563 493	1 728 557	1 729 058	1 826 708	46 170 983
		EMO	291 103	231 202	239 015	247 061	269 115	4 900 872
General overhaul period	Dni	EBO3	19.18	21.1	46.36	43.59	22.09	1567.4
		EBO4	18.62	18.6	19.8	58.89	20.51	1486.13
		EMO1	23.55	20.6	27.2	24.2	50.1	723.4
		EMO2	20.00	38.3	19.3	20.5	20.0	610.6

Assessment of operational safety of SE nuclear installations

Foreword

This chapter fulfils requirements defined in the atomic Act No. 541/2004, section 10 /1) (i).

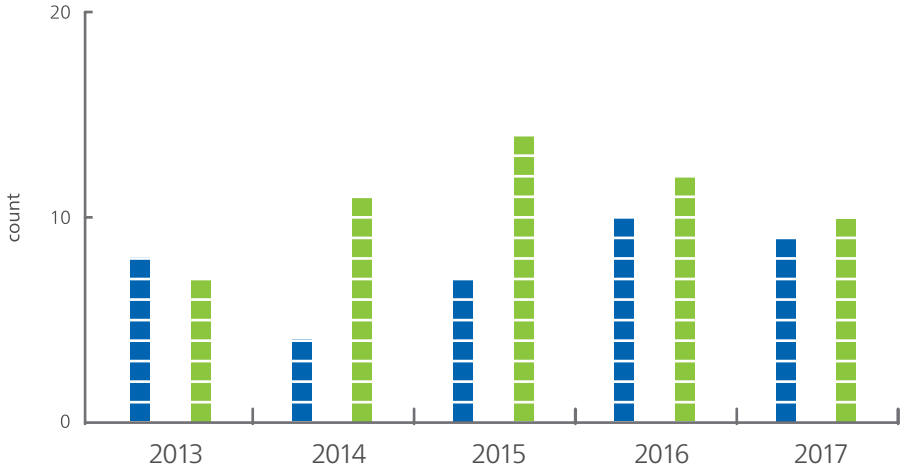
Pursuant to the Act, nuclear safety shall mean technical conditions and capability of the nuclear installation of transport equipment, as well as capability of their operating staff to prevent uncontrolled release of radioactive substances or ionizing radiation to the working or natural environment and the ability to prevent events and to mitigate consequences of events in nuclear installations or during transport of radioactive materials.

Slovenské elektrárne and holder of the operation license for nuclear installations issued by the Nuclear Regulatory Authority of the Slovak Republic pursuant to the Act No. 541/2004 defines in its strategic vision safety, Primarily nuclear safety and radiation protection, as a priority permanently taking precedence over production requirements and commercial profit.

Operational events

Nuclear installation failures described in the above mentioned act generally include any unplanned deviations from standard conditions. Thus, they are the power plant safety and reliability indicators. There are various types of events with causes of a different nature and a differing level of impact on safety.

Operating events reported by SE to the NRA SR:



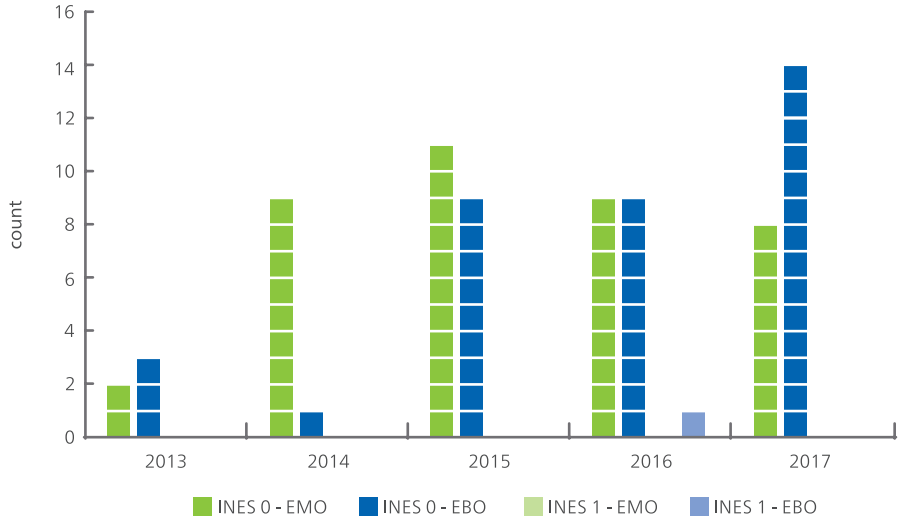
	2013	2014	2015	2016	2017
EBO	8	4	7	10	9
EMO	7	11	14	12	10

In EBO a total of 9 and in EMO 10 lowest-category events (fault) were recorded, reportable to the NRA SR. There were no incident or accident events recorded.

Assessment of operational events using the INES scale

In the IAEA instructions for assessing operational events at nuclear installations for the assessment of operational events at nuclear installations (NI) according to the INES scale, there are created seven degrees of seriousness with an impact on nuclear safety and the environment.

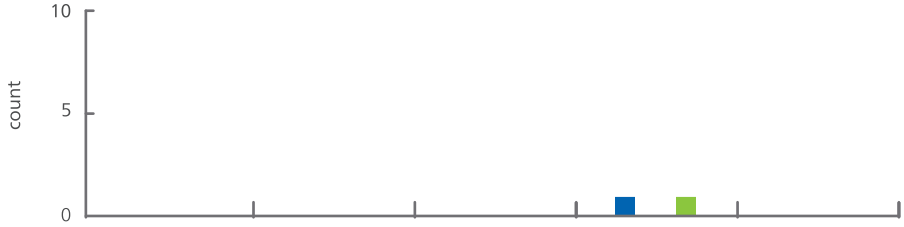
Number of events evaluated according to the INES scale
INES 0: below scale – deviation of no safety significance
INES 1: anomaly



In 2017, there was no event classified INES1 and more in EBO and EMO.

Breach of limits and conditions for operating a nuclear installation

The basic document for the operation of nuclear installations is the "limits and conditions of NPP operation" (I&C) approved by the NRA SR . A duty of the operator is to monitor and evaluate compliance with the conditions set out in the document. The indicator monitors the level of the management level, the organization of nuclear installation (nuclear power plant) operation, the correctness and conformity of operating regulations and instructions with the aim of ensuring the fulfilment of I&C requirements.



	2013	2014	2015	2016	2017
EBO 3	0	0	0	1	0
EBO 4	0	0	0	0	0
EMO 1	0	0	0	1	0
EMO 2	0	0	0	0	0

In 2017, no breach of the Technical Specification occurred in EBO and EMO.

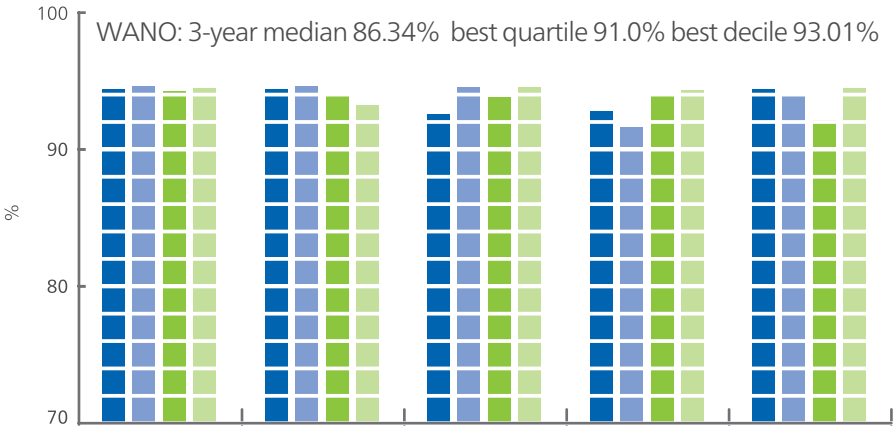
Operation

Slovenské elektrárne, as a nuclear installation operator, performs comprehensive assessments of the safety and reliability of the nuclear installation, using specific indicators monitoring selected areas, including those defined by the world association of nuclear operators (WAN O), of which it is a member

Results of individual WANO indicators:

Unit Capability Factor -UCF

The unit capability factor is the ratio between the electricity the power plant is capable to generate over monitored period, and reference energy production expressed as percentage considering external limiting factors (e.g., dispatcher ordered power regulation, etc.).



	2013	2014	2015	2016	2017
EBO 3	93.71	93.90	86.81	87.53	93.73
EBO 4	94.54	94.56	94.40	83.23	92.33
EMO 1	93.33	92.55	91.59	92.67	84.97
EMO 2	94.23	89.18	94.41	93.67	94.16

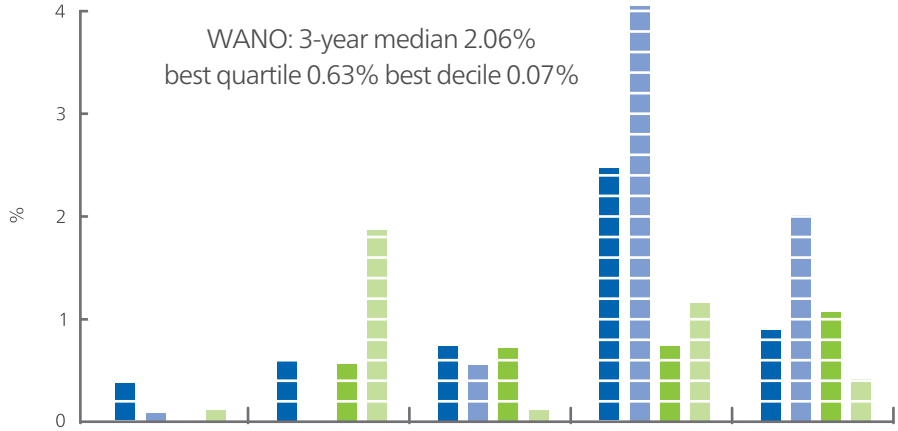
Median – average 50% of all monitored cases

Quartile – 25% of the best in monitored group

Decile – 10% of the best in monitored group

Unplanned Capability Loss Factor – UCLF

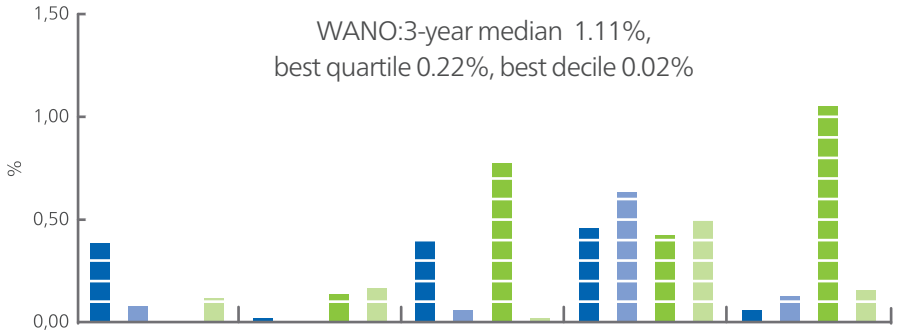
This coefficient monitors progress in minimization of outages and unit power reductions resulting from equipment failures and other unplanned events. the indicator is defined as the ratio between the mean value of unplanned power reductions and reference production.



	2013	2014	2015	2016	2017
EBO 3	0.36	0.58	0.73	2.46	0.89
EBO 4	0.07	0.00	0.54	4.05	2.03
EMO 1	0.00	0.55	0.71	0.73	1.07
EMO 2	0.10	1.86	0.10	1.15	0.41

Forced Loss Rate – FLR

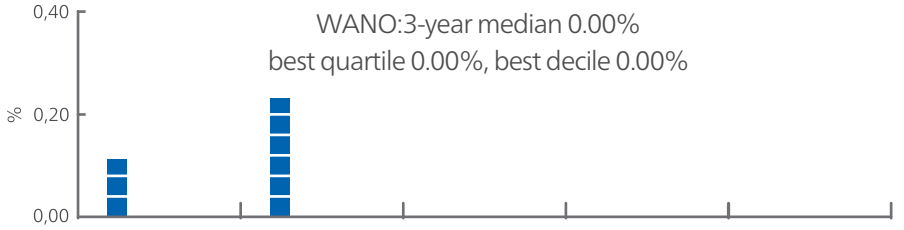
This coefficient is defined as the ratio of the unplanned energy losses during a given period of time, considering only the operating period, to the reference energy generation minus energy losses corresponding to planned outages and their possible unplanned extensions, during the same period.



	2013	2014	2015	2016	2017
EBO 3	0.38	0.01	0.40	0.45	0.05
EBO 4	0.07	0.00	0.05	0.63	0.12
EMO 1	0.00	0.13	0.77	0.42	1.05
EMO 2	0.11	0.16	0.01	0.49	0.15

Grid-Related Loss Factor – GRLF

The indicator is defined as the ratio of production loss due to grid instability of trip without the possibility of power plant impact during the monitored period, to the reference production value in the given quarter, expressed in %.

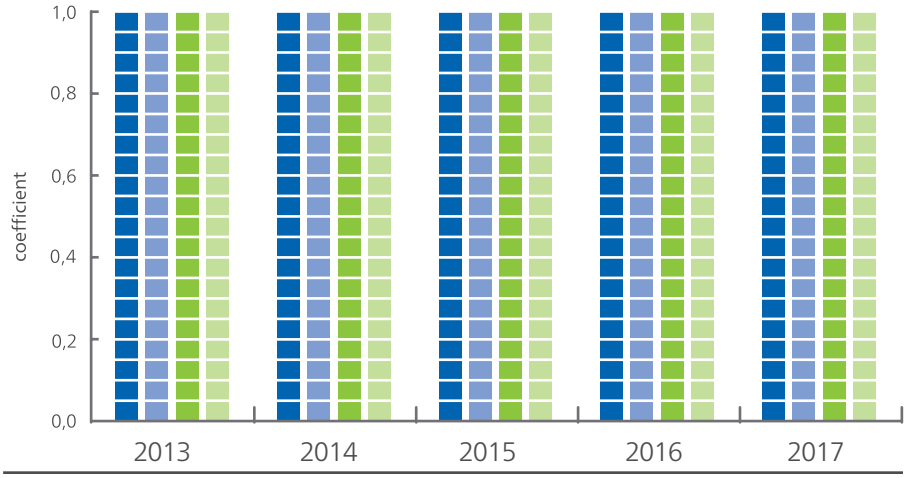


	2013	2014	2015	2016	2017
EBO 3	0.11	0.23	0.00	0.00	0.00
EBO 4	0.00	0.00	0.00	0.00	0.00
EMO 1	0.00	0.00	0.00	0.00	0.00
EMO 2	0.00	0.00	0.00	0.00	0.00

Chemistry Index

This indicator assesses the efficiency of the chemical mode in the steam generators. The best attainable value of the chemistry index is 1.0. The indicator compares the concentration of selected impurities against limit values. Each value is divided by the limit value and the sum of their proportions is normalized to 1.

WANO:3-year median 1.00, best quartile 1.0

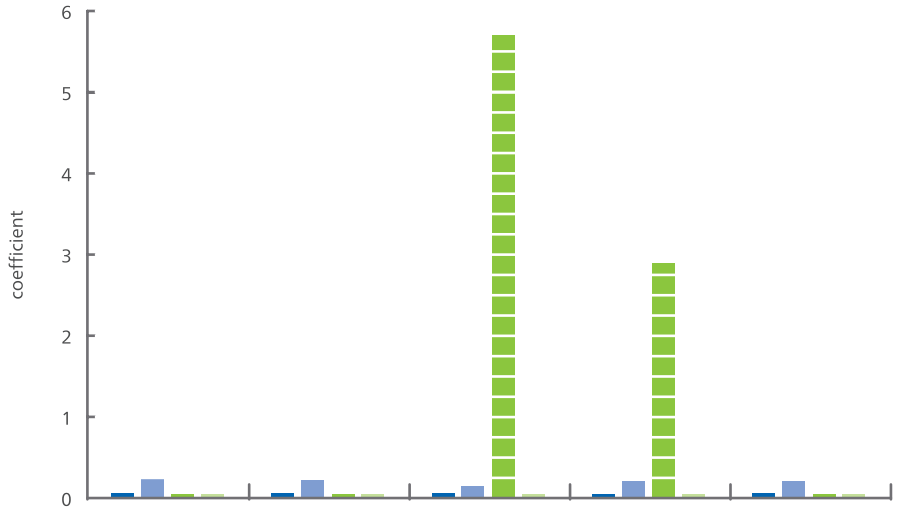


	2013	2014	2015	2016	2017
EBO 3	1	1	1	1	1
EBO 4	1	1	1	1	1
EMO 1	1	1	1	1	1
EMO 2	1	1	1	1	1

Fuel Reliability

This indicator monitors the improvement and maintenance of the high tightness of fuel. It is a general measure of fuel leakage. The indicator is defined as the balanced activity of the primary circuit given by iodine 131 activity in kBq/l and corrected by the uranium contribution and normalized by the coolant purification rate.

3WANO:3-year median 0.136, best quartile 0.037

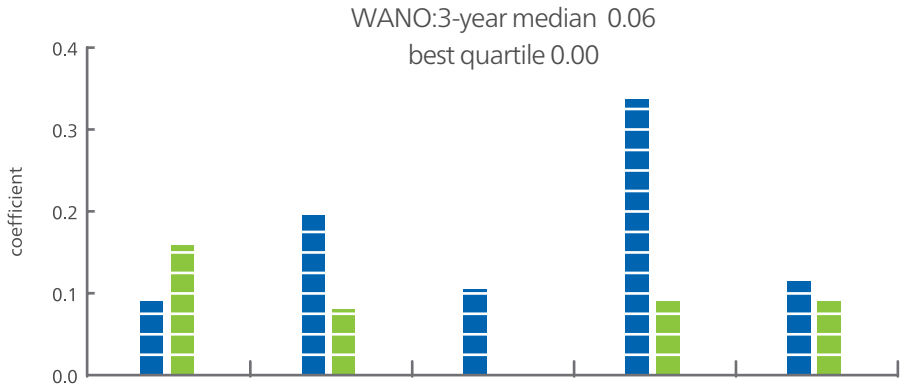


	2013	2014	2015	2016	2017
EBO 3	0.040	0.040	0.043	0.037	0.049
EBO 4	0.250	0.210	0.134	0.191	0.194
EMO 1	0.037	0.037	5.801	2.936	0.037
EMO 2	0.037	0.037	0.037	0.037	0.037

The indicator shows that fuel in all SE Units is leak-tight.

Industrial Safety Accident Rate – ISA

This indicator is defined as the number of accidents per 200 000 man-hours worked by NPP personnel. Contractors' employees are not included in this indicator

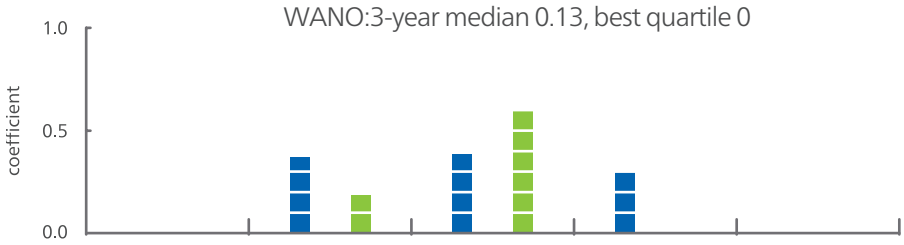


	2013	2014	2015	2016	2017
EBO	0.09	0.197	0.105	0.342	0115
EMO	0.16	0.08	0	0.09	0.09

In 2017, there was one occupational accident at EMO and one at EBO.

Contractor Industrial Safety Accident Rate – CISA

This indicator is defined as the number of accidents of all employees of contractor organizations, including all suppliers working at the NPP , resulting in lost worktime of one or more days (excluding the day of the accident) or fatalities per 200 000 man hours worked.

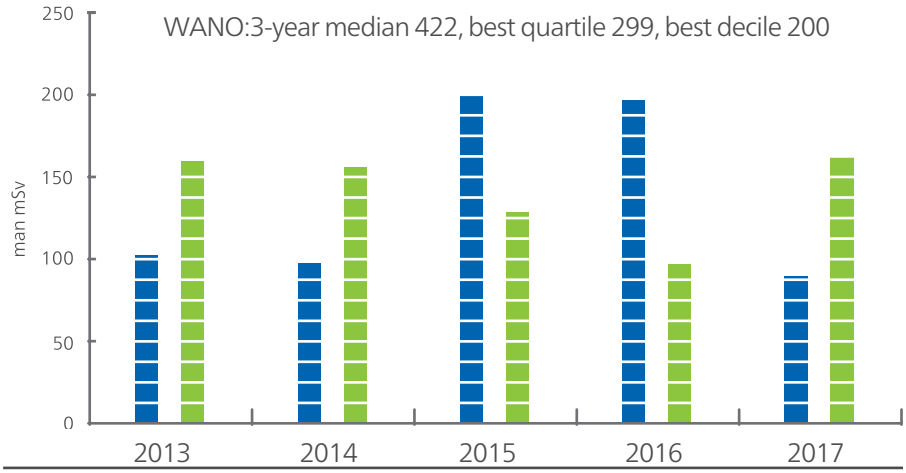


	2013	2014	2015	2016	2017
EBO	0	0.456	0.377	0.293	0
EMO	0	0.22	0.6	0	0

In 2017, no registered occupational accident of a contractor occurred at EMO a EBO.

Collective Radiation Exposure – CRE

This indicator monitors the decreasing trend of the overall radiation exposure of both NPP personnel and contractors. The indicator is a benchmark of radiation protection efficiency and application of the ALARA system (as low as reasonably achievable) aimed at exposure minimization.

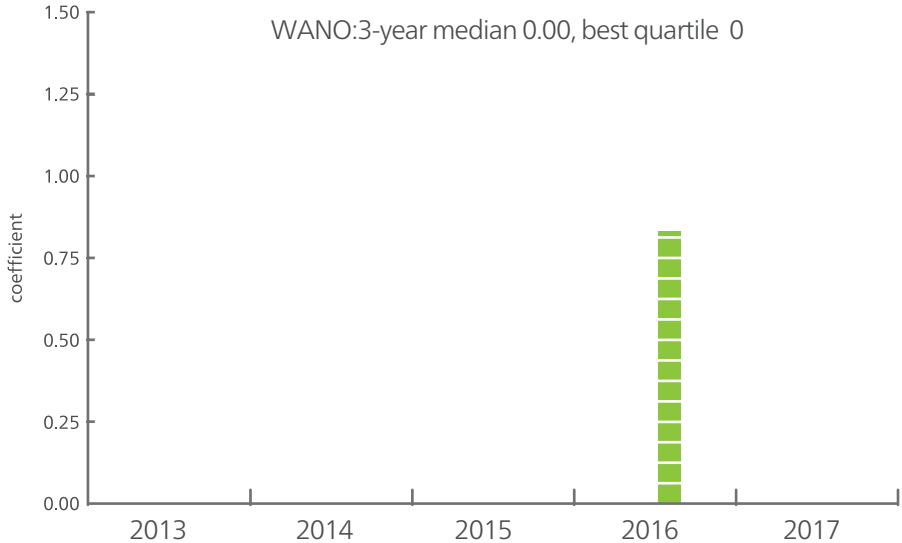


	2013	2014	2015	2016	2017
EBO	101.5	97	199.15	196	89.25
EMO	159	155.5	127.8	96	163

KED values for EBO and EMO refer to one single unit.

Unplanned automatic scrams per 7.000 critical hours

This indicator shows number of unplanned automatic unit scrams caused by AO-1 activation per 7.000 critical reactor hours.



	2013	2014	2015	2016	2017
EBO 3	0	0	0	0	0
EBO 4	0	0	0	0	0
EMO 1	0	0	0	0.83	0
EMO 2	0	0	0	0	0

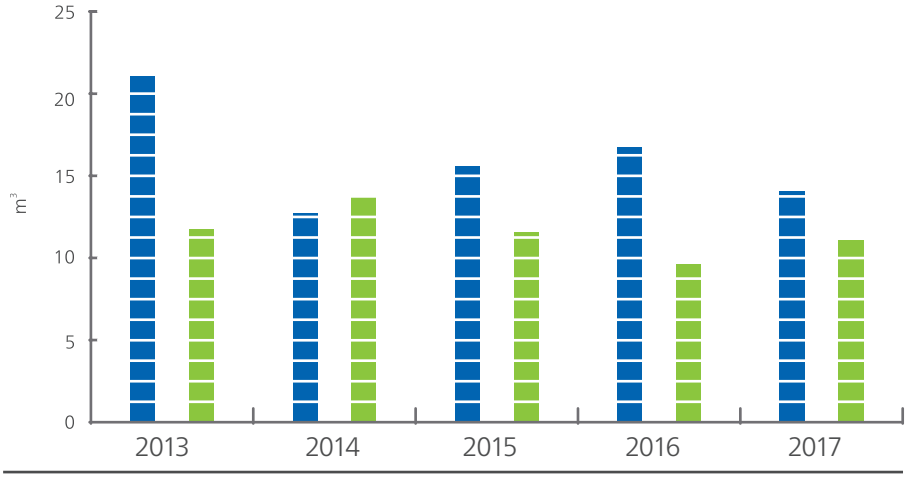
There were no automatic reactor scrams in 2017.

Waste production and releases to the atmosphere and hydrosphere

A small quantity of radioactive waste is produced in operating the nuclear installation. Liquid and solid wastes are processed and stored in the radioactive waste repository at Mochovce. In addition to this, radioactive substances are released into the environment in the form of liquid and gas discharges. Our objective is to minimize these environmental discharges. The values of discharges, types of substances and their limit values are set by state supervision authorities.

Production of liquid RAW

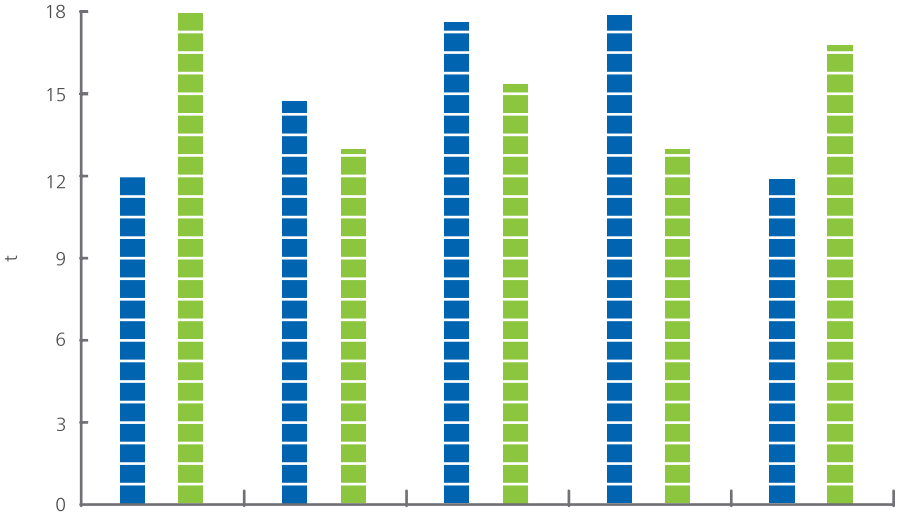
This indicator is defined as volume of liquid raw in cubic metres generated by the nuclear installation operation converted to the boric acid content of 120g/kg.



	2013	2014	2015	2016	2017
EBO	21.052	12.687	15.538	16.694	14.08
EMO	11.714	13.672	11.514	9.543	11.078

Production solid RAW

This indicator is defined as the volume of solid RAW in tonnes generated by the nuclear installation operation.



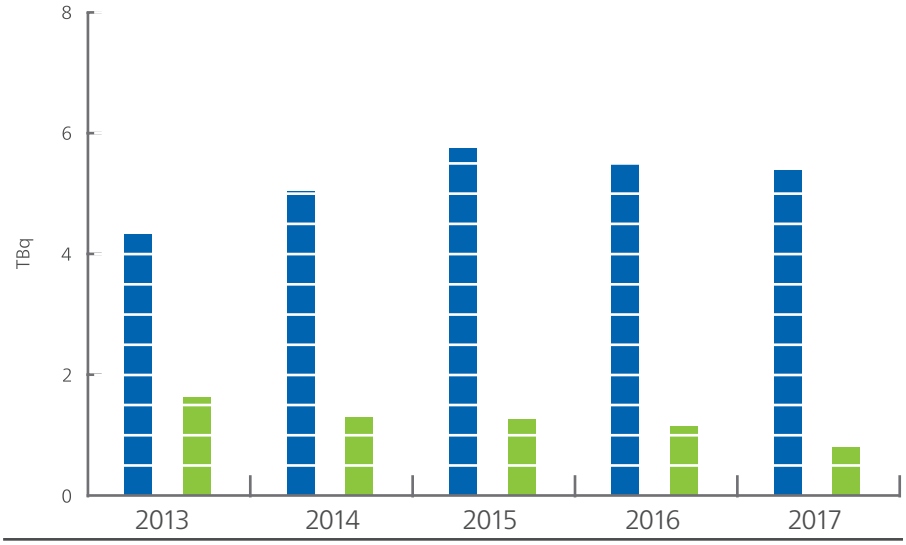
	2013	2014	2015	2016	2017
EBO	11.97	14.72	17.6	17.847	11.89
EMO	17.93	12.95	15.34	12.935	16.807

Emissions to atmosphere

Installation	Type of release	Activity	Unit	Share in target value for 2017 (%)*
EBO	Noble gases	5.455	TBq	0.33
	Aerosols	7.536	MBq	0.0135
	Iodine 131	0.416	MBq	0.0006
EMO	Noble gases	0.802	TBq	0.00196
	Aerosols	6.693	MBq	0.00394
	Iodine 131	22.54	MBq	0.0336

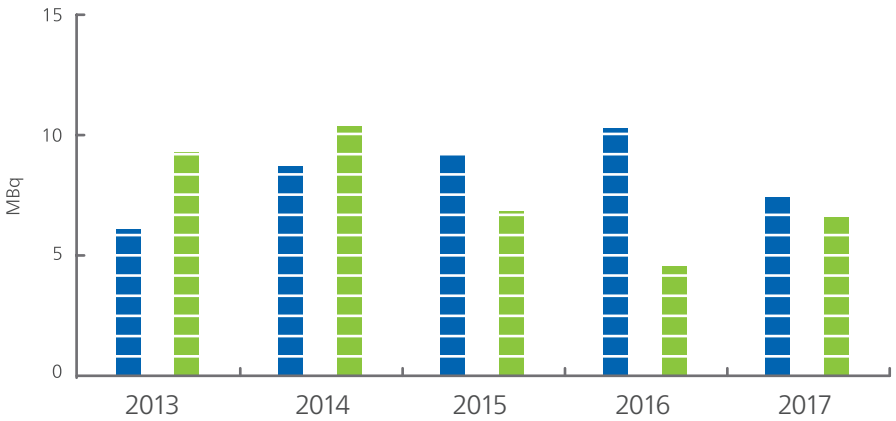
*TV – target value determined by the Public Health Authority

Emissions to atmosphere – noble gases



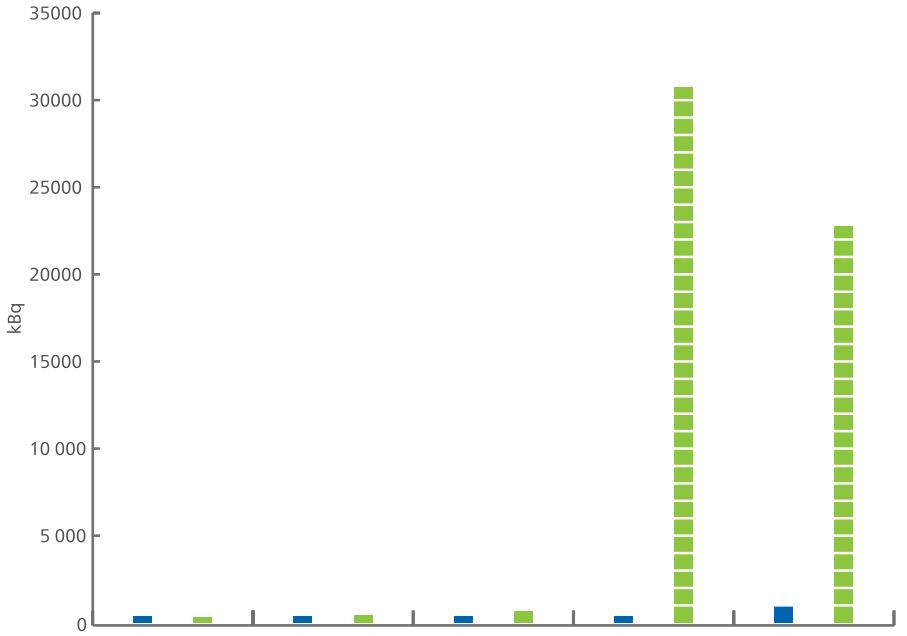
	2013	2014	2015	2016	2017
EBO	4.327	5.039	5.765	5.481	5.455
EMO	1.622	1.277	1.255	1.129	0.802

Emissions to atmosphere – aerosols



	2013	2014	2015	2016	2017
EBO	6.194	8.829	9.34	10.449	7.536
EMO	9.447	10.53	6.951	4.616	6.693

Emissions to atmosphere – iodine



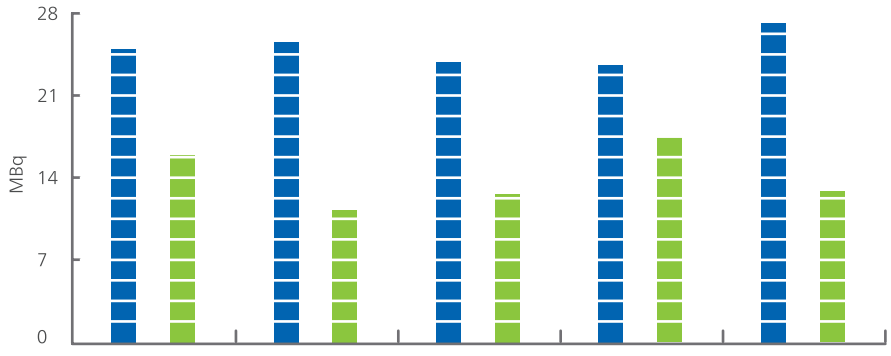
	2013	2014	2015	2016	2017
EBO	402	379	392	358	416
EMO	325	455	663.8	30460	22540

Releases to hydrosphere

installation	Type of release	Activity	Unit	Share on target value for 2017 (%)*
EBO	Activation and fission products	27.13	MBq	0.205
	Tritium	10.13	TBq	55
EMO	Activation and fission products	12.86	MBq	1.17
	Tritium	11.05	TBq	92.07

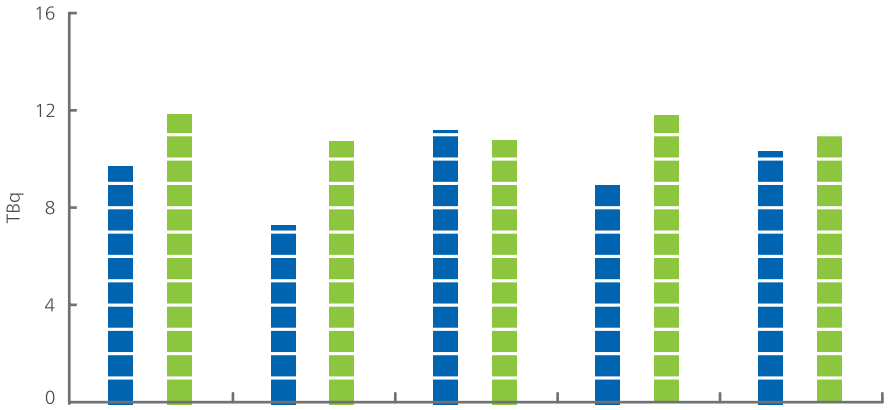
*TV – target value determined by the Public Health Authority

Releases to hydrosphere – activation and fission products



	2013	2014	2015	2016	2017
EBO	24.970	25.576	23.810	23.562	27.127
EMO	15.960	11.330	9.600	17.410	12.860

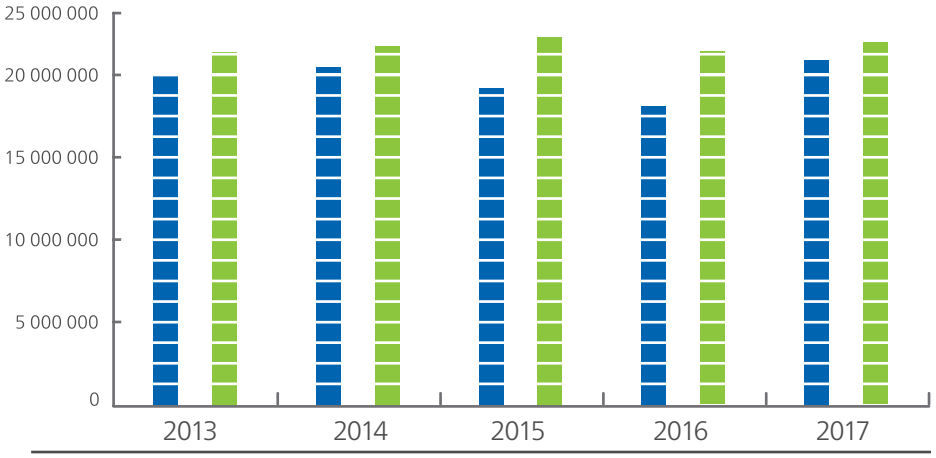
Releases to hydrosphere – tritium



	2013	2014	2015	2016	2017
EBO	9.762	7.337	11.203	8.983	10.13
EMO	11.87	10.75	10.806	11.79	11.05

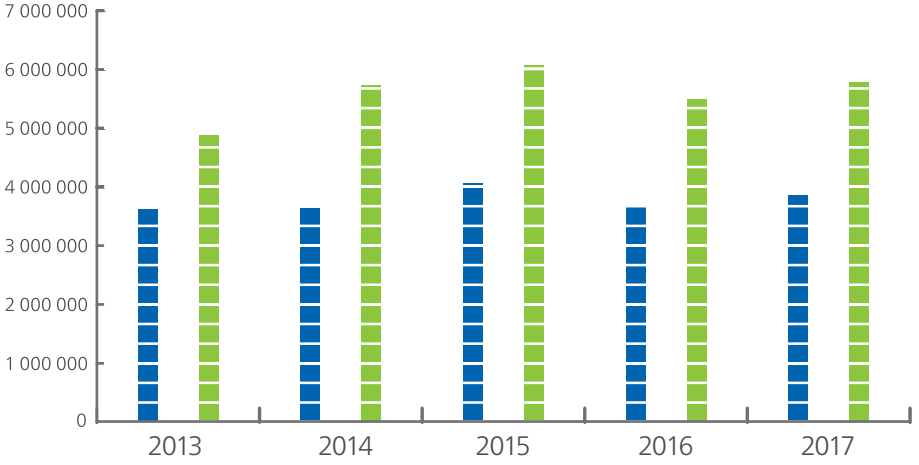
The impact of NPP operation to the surroundings was minimal. It is verified by calculation of the annual dose for citizens in the power plant surroundings according to the approved conservative methodology. The calculated maximum values are approximately 100 times lower than the permitted limit of 50 microsievert (50μSv) determined by the Public Health Authority of the Slovak Republic.

Surface water intake (m^3)



	2013	2014	2015	2016	2017
EBO	21 096 662	21 567 885	20 204 682	19 087 378	20 765 059
EMO	22 491 000	22 921 000	23 443 251	22 531 740	21 986 000

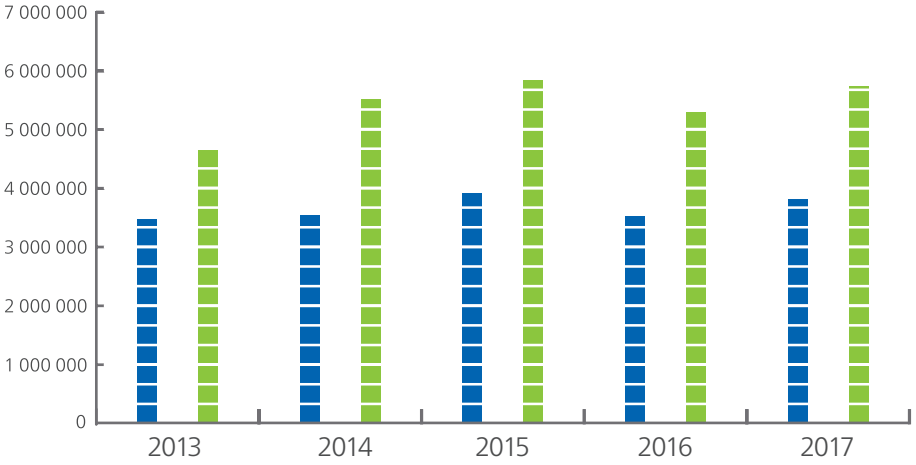
Wastewater discharge - Total volume (m³)



	2013	2014	2015	2016	2017
EBO	3 615 684	3 623 622	4 051 887	3 638 429	3 952 691
EMO	4 874 075	5 733 029	6 068 588	5 497 405	5 942 185

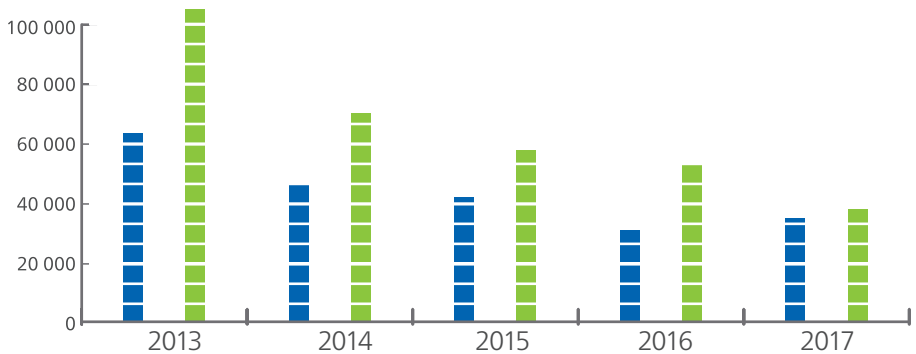
Allowed annual limits of discharged waters for 2 units	
EBO	4 200 000
EMO	6 000 000

Wastewater discharge - Industrial waste waters (m³)



	2013	2014	2015	2016	2017
EBO	3 552 310	3 623 622	4 010 005	3 607 734	3 917 886
EMO	4 769 165	5 662 984	6 010 806	5 444 252	5 904 441

Wastewater discharge - Treated sewage waters (m³)

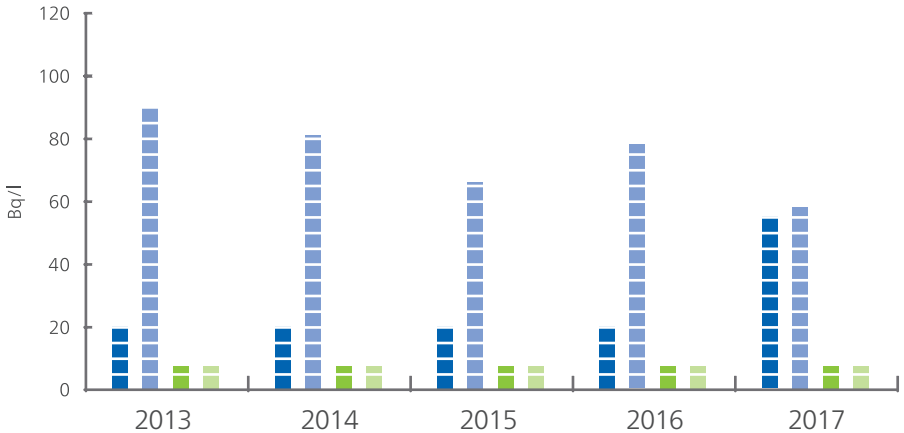


	2013	2014	2015	2016	2017
EBO	63 374	45 933	41 882	30 695	34 805
EMO	104 910	70 045	57 782	53 153	37 744

Permitted annual limits

Steam generator blowdown water activity

This indicator is defined as the maximum value of total β-activity of blowdown water dry residue from individual steam generators.

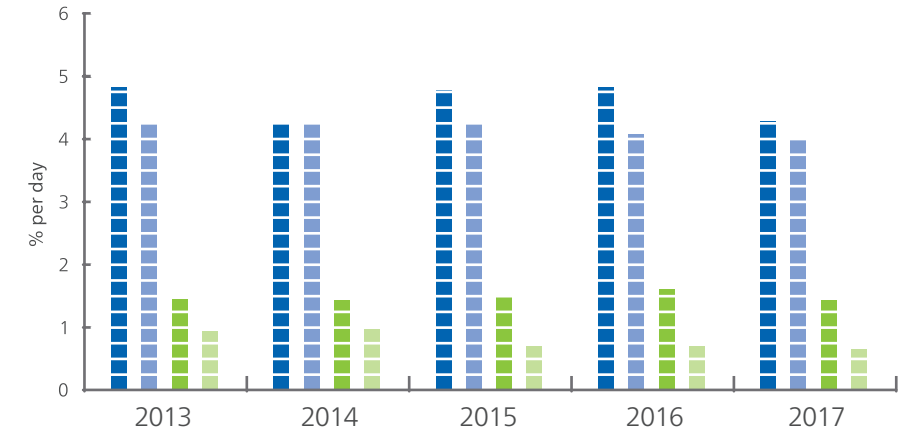


	2013	2014	2015	2016	2017
EBO 3	20	20	20	20	55
EBO 4	90	81	66	78	58
EMO 1	7	7	7	7	7
EMO 2	7	7	7	7	7

Small leaks of SG tubes were recorded, controlled, and then also eliminated in both EBO Units. Activity in the secondary circuit increased only a little and it was maintained below values allowed by the Technical Specification for operation of NI, i.e. 370 Bq/l. Activity of blow-down water in both EMO Units has been maintained at the lowest detectable level, i.e. 7 Bq/l, in long term.

Containment tightness

This indicator monitors the containment tightness as the third physical barrier against release of the fission products.
The indicator is defined as resulting air lost value from the containment for 24 hours given as percentage of the containment volume at over-pressure of 150 kPa .



	2013	2014	2015	2016	2017
EBO 3	4.81	4.25	4.78	4.817	4.39
EBO 4	4.44	4.25	4.25	4.07	4.106
EMO 1	1.424	1.491	1.488	1.583	1.459
EMO 2	0.915	0.946	0.679	0.686	0.6426

The containment tightness is prescribed by the limits and conditions.
For both Bohunice NPP units containment leakage, not exceed 13% per 24 hours.
For Mochovce NPP this value at 5% per 24 hours.

Emergency planning and preparedness

Main objectives in the emergency preparedness, such as assurance of technical, personnel and documentation readiness of employees and the complementary personnel for successful control of extraordinary events, are fulfilled with an emphasis put on reduction of the risk of accident, or mitigation of its consequences, prevention of damage to health, and reduction of the risk of extraordinary event effects on a human health.

Activities performed in 2017 create preconditions for further development and enhancement of quality of the emergency planning process in Slovenské elektrárne:

1. In 2017, the project "Enhancement of the Emergency Preparedness Project" was finished in both NPPs; the aim of the Project was to modify the emergency preparedness process in SE according to WANO requirements regarding implementation of the severe accident management in all operated Units. In the emergency preparedness area, measures resulting from the Project were implemented, and tasks for the next period were prioritised.
2. Functionality of the entire emergency response organisation and the emergency preparedness was reviewed during plant-wide emergency drills at both nuclear power plants. Personnel response to severe accident was trained during the drills in NPPs as well.
3. In 2017, the WANO peer review according to WANO PO&C 2013-1 requirements was organised in the Bohunice NPP.

The long-term strategic goal of Slovenske elektrarne in the emergency preparedness is permanent improvement of the processes, using own experience and experience of other power plant operators worldwide.

Increasing Safety

Investment projects and modifications implemented in EBO in 2017:

- modification of the technological systems
- modification of cooling unit YORK
- modification of the essential service water system
- modification of pumps
- replacement of 6 kV cables of primary and secondary circuit appliances
- replacement of inverters and rectifiers of the emergency power supplyreplacement of emergency flash protections in 6 kV switchboards
- replacement of accumulator batteries of the emergency power supply
- modification of safety valve control cabinets
- assurance of stand-by power supply of V2 NPP
- improvement of the home consumption power supply diagram – modification of emergency lighting
- supplementing of the back-up emergency control centre equipment
- modification of chemistry monitoring systems
- seismic requalification of temperature and level measurement in spent fuel pools
- mobile measuring unit
- upgrade of the monitoring system of non-specified loads of selected primary circuit components
- removal of rainwater from oil management roof
- change of use of rooms and optimisation of areas
- modification of electric valves of the primary circuit by replacement
- new interconnecting pipeline for filling of spent fuel pool and fuel transport pool
- modification of diesel generator start-up air tanks by their replacement

Investment projects and modifications implemented in EMO in 2017:

- reconstruction of section switchboards
- replacement of essential service water check valves
- modernization of safety systems of reactor protection and control system
- addition of 400kV circuit breakers in Unit 1
- replacement of hardware of in-core measurement system upper level complex
- replacement of boric acid concentration analysers
- reconstruction of check probes, geodetic points at earth dam – sludge bed Čifáre
- reconstruction of HP, LP turbine generator rotors
- replacement and reconstruction of obsolete and worn radiation monitoring equipment
- measurement of volume of condensate in HVAC
- modification of emergency lighting and connection to new DC switchboard
- supplementing of accumulator battery monitoring – system 4
- mobile measuring unit
- replacement of H3BO3 concentration analysers
- civil modifications (4 projects)
- I&C (4 projects)
- adding of air-conditioning unit to the radiation monitoring control room
- MO34 – extension of FDPS system superstructure – fire protection switch off
- periodical safety assessment – large-screen displays in MCR and simulator

Overall assessment of nuclear safety of nuclear installations

Based on the assessment of a set of operation safety indicators, the operation of nuclear installations of Slovenské elektrárne in 2017 can be considered safe and complying with legislation concerning the use of atomic energy, while fulfilling the conditions defined in valid permits issued by regulatory authorities. Corrective actions were adopted for events and indicators with negative trend. Operation of Slovenské elektrárne nuclear installations had minimal impact on the environment and minimal radiation exposure of personnel and public.

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SLOVENSKÉ ELEKTRÁRNE