2016

OPERATION AND 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

General 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	
Cooling water volume:	35 000 m^3/h
Max. temperature of cooling water:	33°C
Chladiace veže	
Number:	4 (per 2 units)
Height:	125 m (EMO) / 120 m (EBO V2)

Start of operation

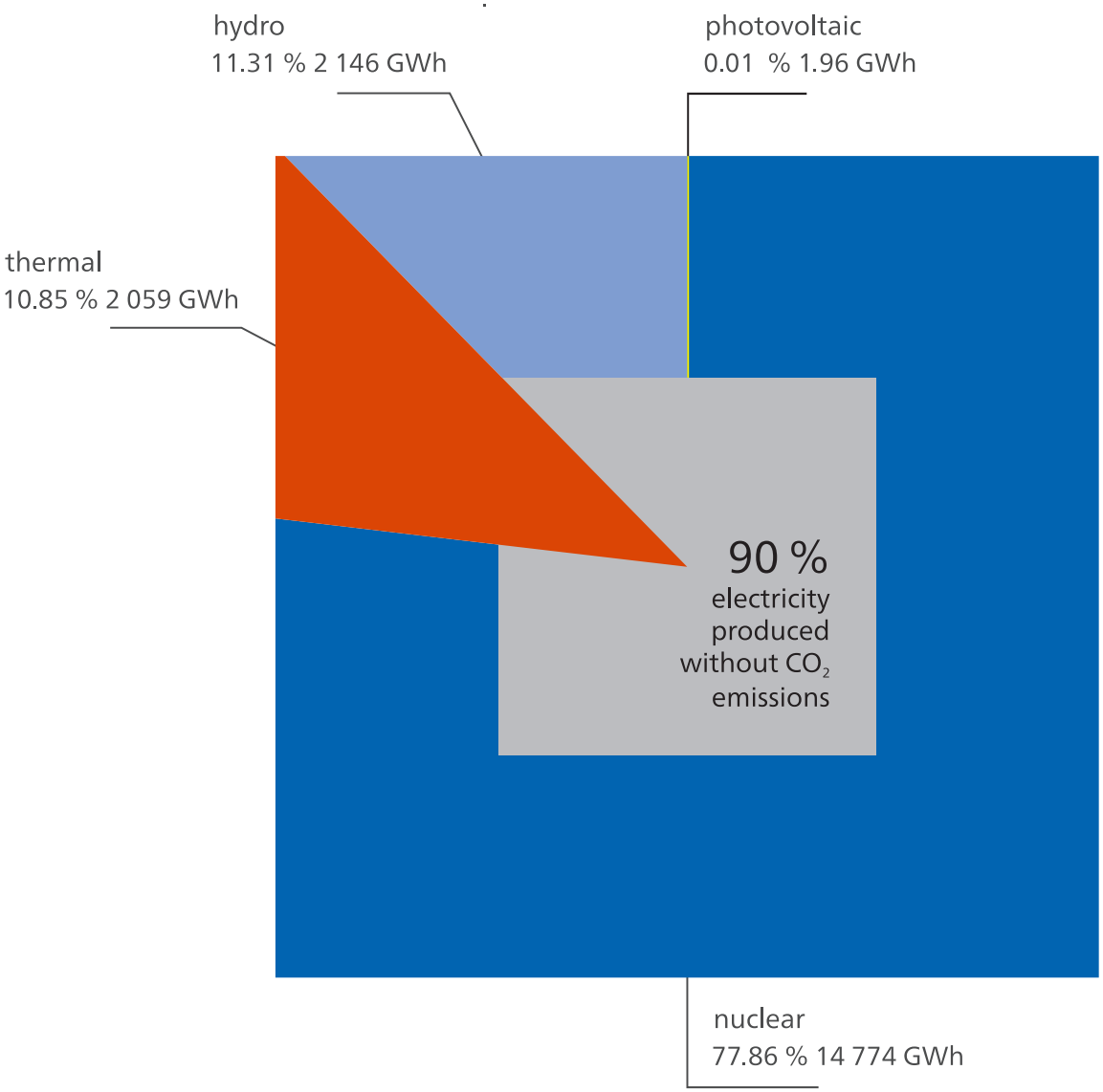
	1st criticality *	Start of permanent operation
EBO 3	07.08.1984	14.02.1985
EBO 4	02.08.1985	18.12.1985
EMO 1	09.06.1998	29.01.1999
EMO 2	01.12.1999	11.07.2000

EBO – Bohunice nuclear power plant v2 (units 3&4)

EMO – Mochovce nuclear power plant (units 1&2)

* 1st criticality – first attainment of minimal controlled power

Share in electricity generation



Electricity & heat generation

Indicator		Unit	2012	2013	2014	2015	2016	Since start of operation
Net	kWh	EBO	7 424 948	7 515 656	7 519 631	7 107 218	6 744 342	186 558 907
generation	kWh	EMO	7 024 165	7 101 545	6 937 680	7 012 670	7 029 172	109 651 447
Heat	GJ	EBO	1 922 150	1 855 671	1 563 493	1 728 557	1 729 058	44 344 275
Supply	GJ	EMO	263 699	291 103	231 202	239 015	247 061	4 631 757
General	days	EBO3	20.36	19.18	21.1	46.36	43.59	1545.31
overhaul	days	EBO4	33.98	18.62	18.6	19.8	58.89	1465.62
period	days	EMO1	23.2	23.55	20.6	27.2	24.2	673.3
	days	EMO2	24.9	20.00	38.3	19.3	20.5	590.6

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).

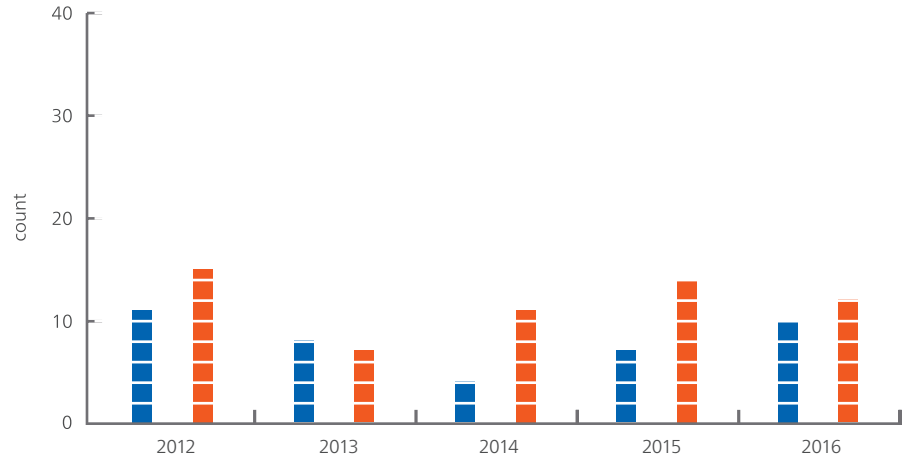
Pursuant to the Act, nuclear safety shall mean technical conditions and capability of the nuclear installation of transport equipment, as well as capability of their operating staff to prevent uncontrolled release of radioactive substances or ionizing radiation to the working or natural environment and 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:



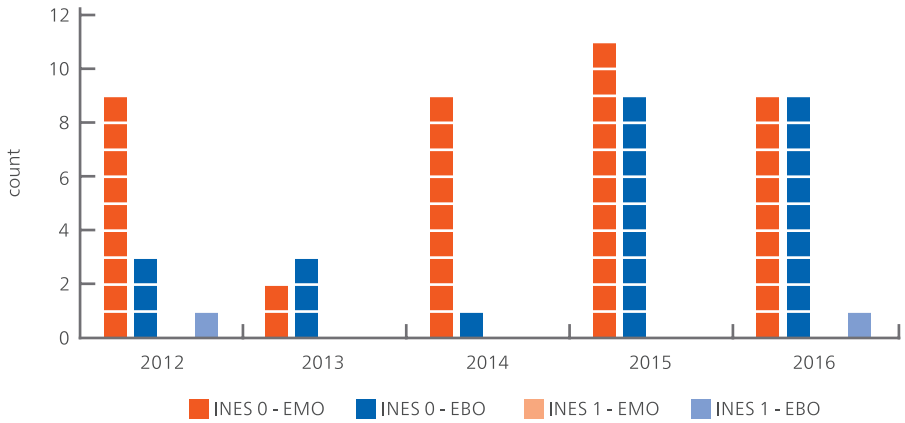
	2012	2013	2014	2015	2016
EBO	11	8	4	7	10
EMO	15	7	11	14	12

At EBO a total of 10 and in EMO 12 lowest-category events (faults) were recorded, reportable to the NRA SR. There was no recorded incident or accident event.

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 2016 one event was recorded at EBO at the INES grade 1. During the shutdown of Unit 3 for general overhaul, the pressuriser cooling trend did, for a short time, not conform to the technical specification and the allowable difference between the pressuriser and primary circuit coolant temperatures was exceeded. The incident had no negative impact on the state of the primary circuit equipment.

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.

In 2016 one I&C breach occurred at EBO Unit 3. The event was classified at level 1 on the INES scale. At EMO Unit 1 in 2016 there was one I&C breach. By staff error it was not identified that one of the three pumps for emergency feed water to the steam generators was on a non-projected course of operation. For this reason, repair was not performed at the set time of 72 hours. The incident had no direct impact on safety, since the operation of this pump at the time was not required and the other two pumps were ready to fulfil their function if needed.

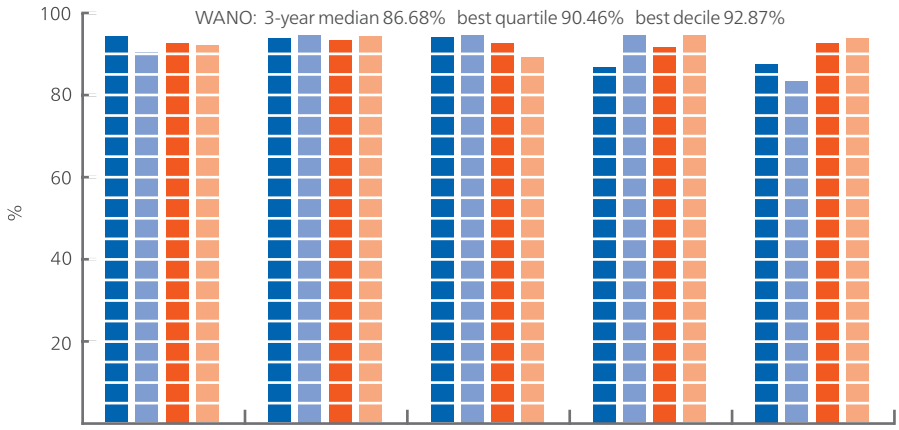
Operation of nuclear installations

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 (WANO), of which it is a member.

Results of individual WANO indicators in comparison with WANO PWR values from 4Q 2016:

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.).



	2012	2013	2014	2015	2016
EBO 3	94.17	93.71	93.9	86.81	87.53
EBO 4	90.3	94.54	94.56	94.4	83.23
EMO 1	92.63	93.33	92.55	91.59	92.67
EMO 2	91.96	94.23	89.18	94.41	93.67

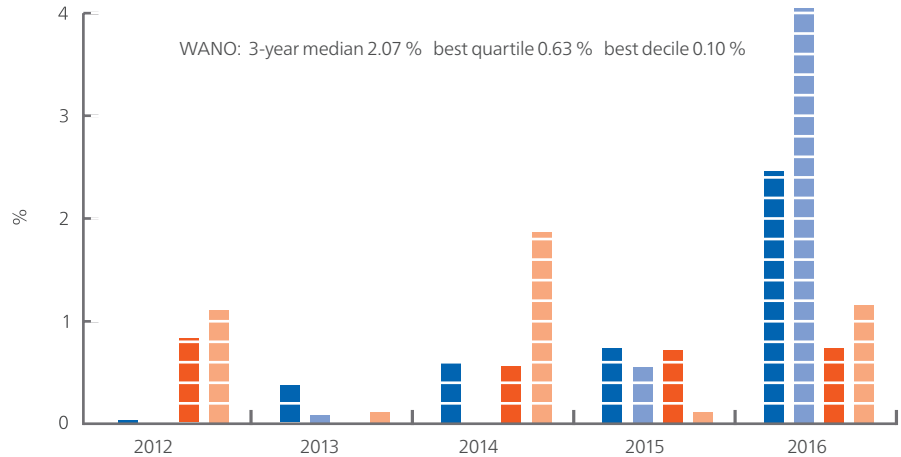
Median – average 50% of all monitored cases

Quartile – 25% of the best in monitored group

Decile – 10% of the best in monitored group

Unplanned Capability Loss Factor – UCLF

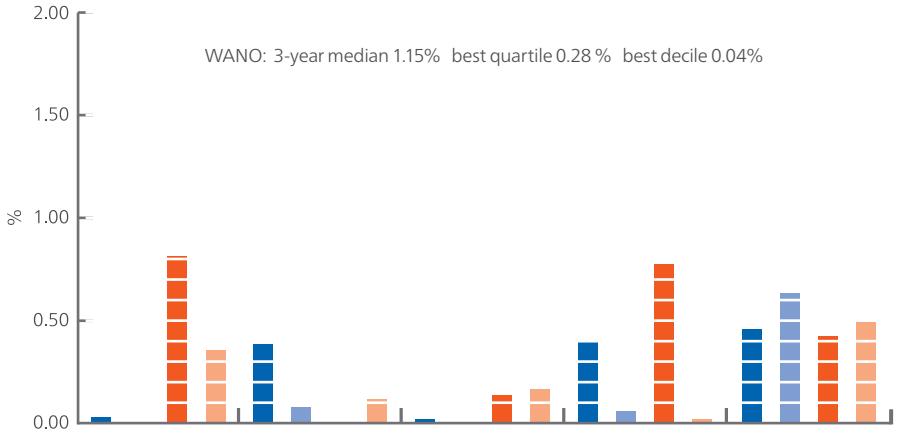
This coefficient monitors progress in minimization of outages and unit power reductions resulting from equipment failures and other unplanned events. the indicator is defined as the ratio between the mean value of unplanned power reductions and reference production.



	2012	2013	2014	2015	2016
EBO 3	0.02	0.36	0.58	0.73	2.46
EBO 4	0	0.07	0	0.54	4.05
EMO 1	0.82	0	0.55	0.71	0.73
EMO 2	1.1	0.1	1.86	0.1	1.15

Forced Loss Rate – FLR

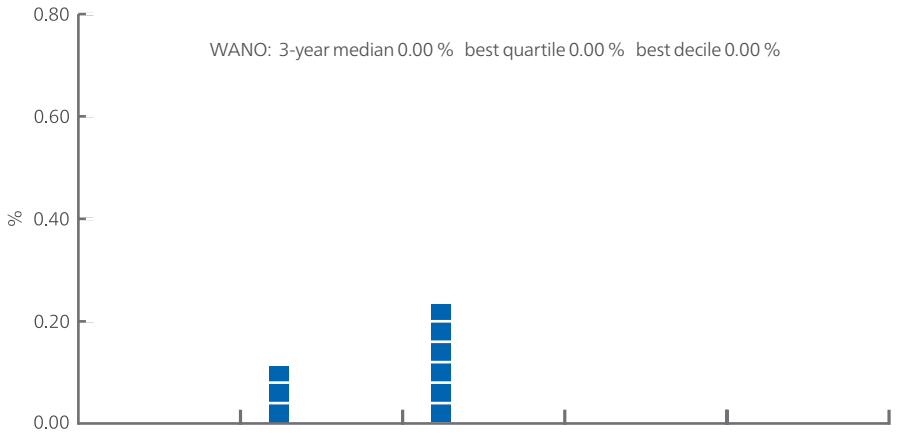
This coefficient is defined as the ratio of the unplanned energy losses during a given period of time, considering only the operating period, to the reference energy generation minus energy losses corresponding to planned outages and their possible unplanned extensions, during the same period.



	2012	2013	2014	2015	2016
EBO 3	0.02	0.38	0.01	0.4	0.45
EBO 4	0	0.07	0	0.05	0.63
EMO 1	0.81	0	0.13	0.77	0.42
EMO 2	0.35	0.11	0.16	0.01	0.49

Grid-Related Loss Factor – GRLF

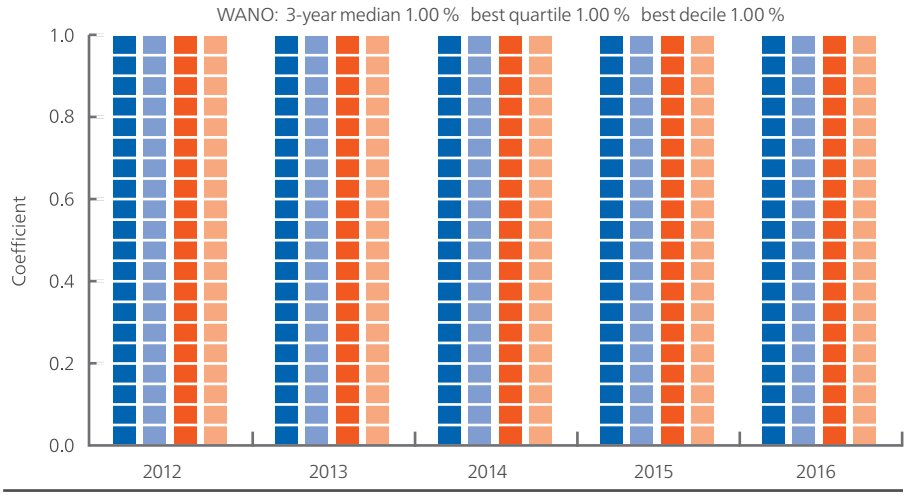
The indicator is defined as the loss on production due to grid instability or failure not under plant management control during the monitored period, to the reference production value in the given quarter, expressed in %.



	2012	2013	2014	2015	2016
EBO 3	0	0.11	0.23	0	0
EBO 4	0	0	0	0	0
EMO 1	0	0	0	0	0
EMO 2	0	0	0	0	0

Chemistry Index

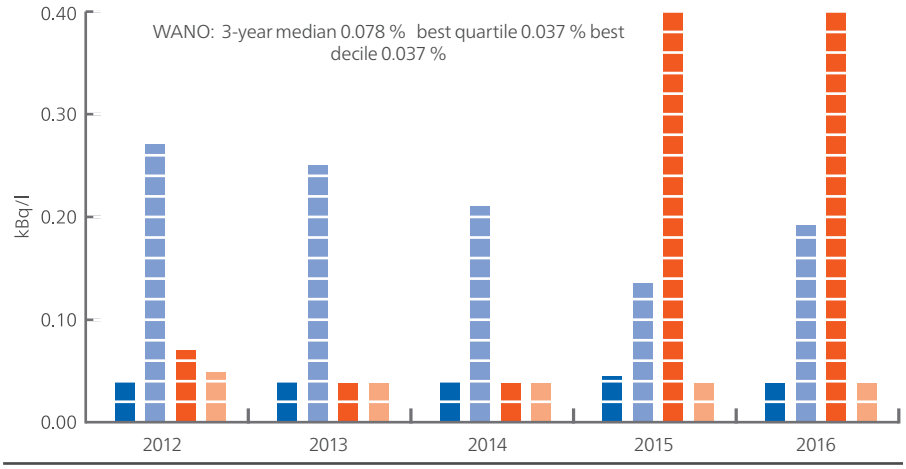
This indicator assesses the efficiency of the chemical regime management in the steam generators. The best attainable value of the chemistry index is 1.0. The indicator compares the concentration of selected impurities against limit values. Each value is divided by the limit value and the sum of their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



	2012	2013	2014	2015	2016
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.

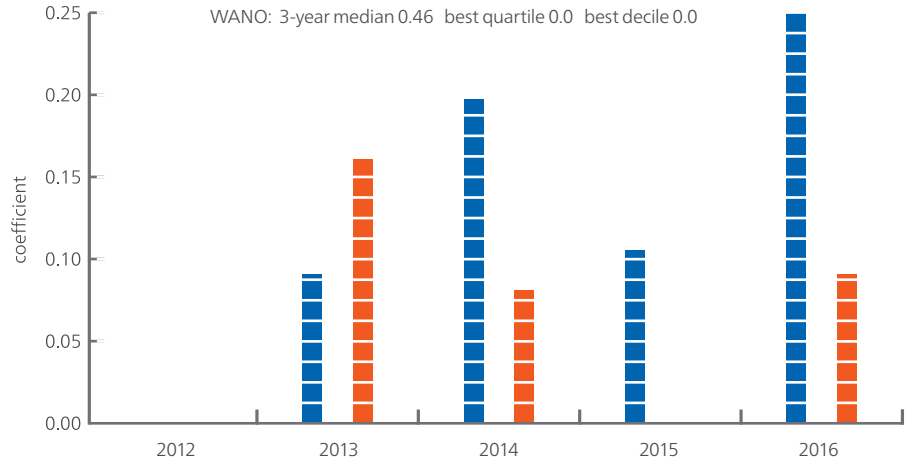


	2012	2013	2014	2015	2016
EBO 3	0.04	0.04	0.04	0.043	0.037
EBO 4	0.27	0.25	0.21	0.134	0.191
EMO 1	0.069	0.037	0.037	5.801	2.936
EMO 2	0.047	0.037	0.037	0.037	0.037

At EBO and EMO2 no problems with fuel tightness were recorded. AT EMO1 a small leak from fuel cladding was detected. Leaky fuel rod will be identified and unloaded from the reactor during general overhaul in 2017. Gradual reduction of values during the year can be seen in the behavior of quarterly values.

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.

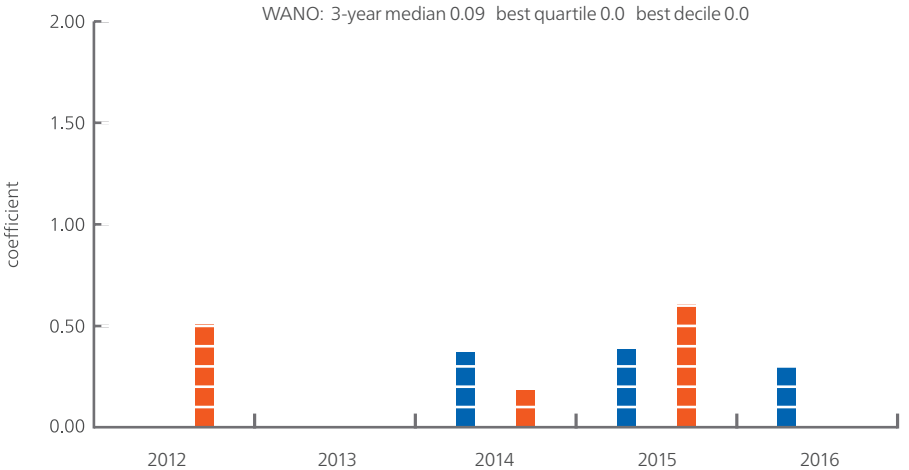


	2012	2013	2014	2015	2016
EBO	0	0.09	0.197	0.105	0.342
EMO	0	0.16	0.08	0	0.09

At EBO there were three registered industrial accidents; one at EMO.

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.

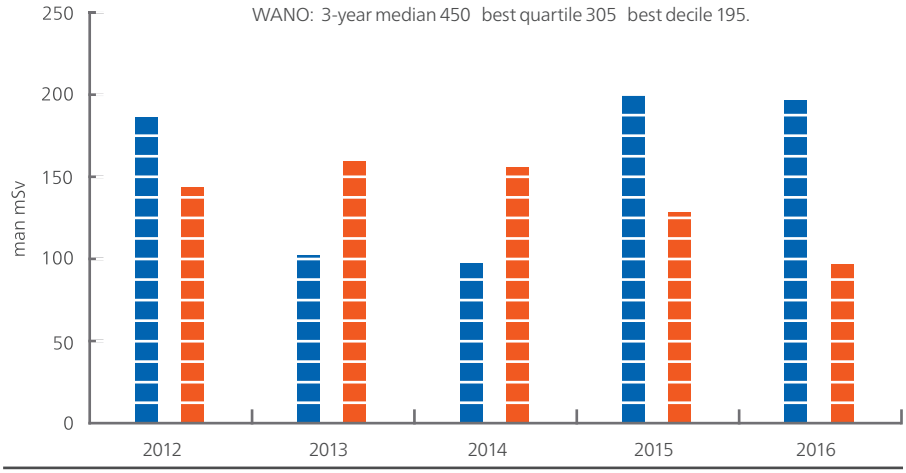


	2012	2013	2014	2015	2016
EBO	0	0	0.456	0.377	0.293
EMO	0.63	0	0.22	0.6	0

One industrial accident by an employee of a supplier company was recorded at EBO. At EMO there were none.

Collective Radiation Exposure – CRE

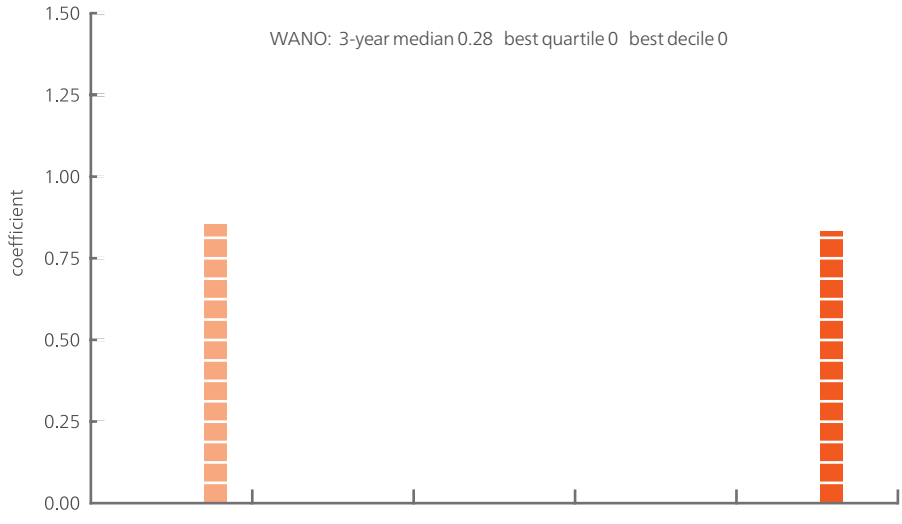
This indicator monitors the decreasing trend of the overall radiation exposure of both NPP personnel and contractors. The indicator is a benchmark of radiation protection efficiency and application of the ALARA system (as low as reasonably achievable) aimed at exposure minimization.



	2012	2013	2014	2015	2016
EBO	186	101.5	97	199.15	196
EMO	143	159	155.5	127.8	96

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.



	2012	2013	2014	2015	2016
EBO 3	0	0	0	0	0
EBO 4	0	0	0	0	0
EMO 1	0	0	0	0	0.83
EMO 2	0.85	0	0	0	0

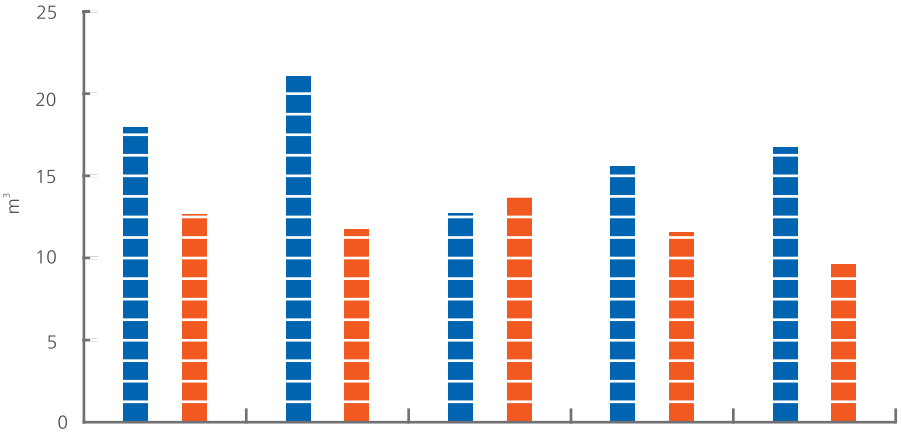
At EBO and EMO2 no automatic shutdown of the reactor was recorded in 2016. At EMO1 in 2016 one case of unplanned automatic actuation of A01 was recorded – on 16 September 2016. The unplanned actuation of AO1 was caused due to the shutdown of both steam generators, through the incorrect generation of signal indicating an increased level in the steam generator.

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

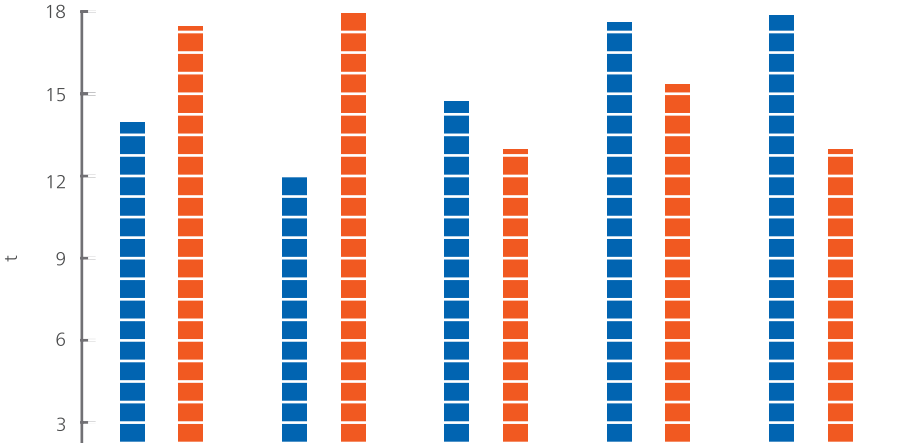
This indicator is defined as volume of liquid raw in cubic metres generated by the nuclear installation operation converted to the boric acid content of 120g/kg.



	2012	2013	2014	2015	2016
EBO	17.94	21.052	12.687	15.538	16.694
EMO	12.585	11.714	13.672	11.514	9.543

Production as the volume of liquid RAW

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

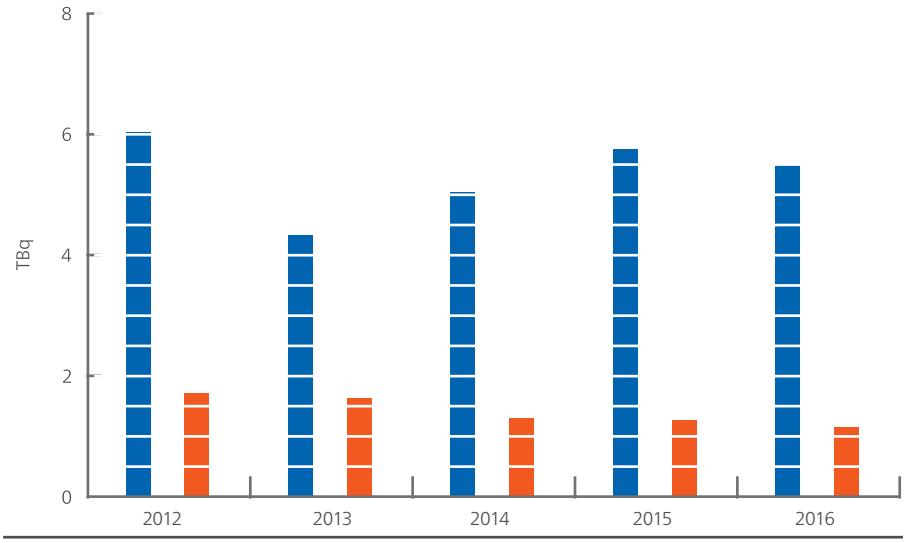


	2012	2013	2014	2015	2016
EBO	13.93	11.97	14.72	17.6	17.847
EMO	17.46	17.93	12.95	15.34	12.935

Emission to atmosphere

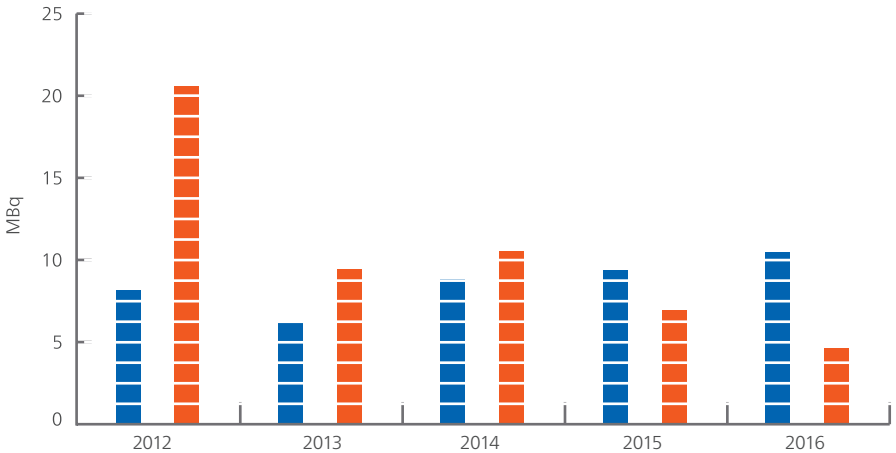
Installation	Type of release	Activity	Unit	Share on target value for 2016 (%)
EBO	Noble gases	5.481	TBq	0.274
	Aerosols	10.449	MBq	0.013
	Iodine 131	0.358	MBq	0.00055
EMO	Noble gases	1.129	TBq	0.0275
	Aerosols	4.616	MBq	0.0027
	Iodine 131	30.46	MBq	0.045

Emission to atmosphere – noble gases



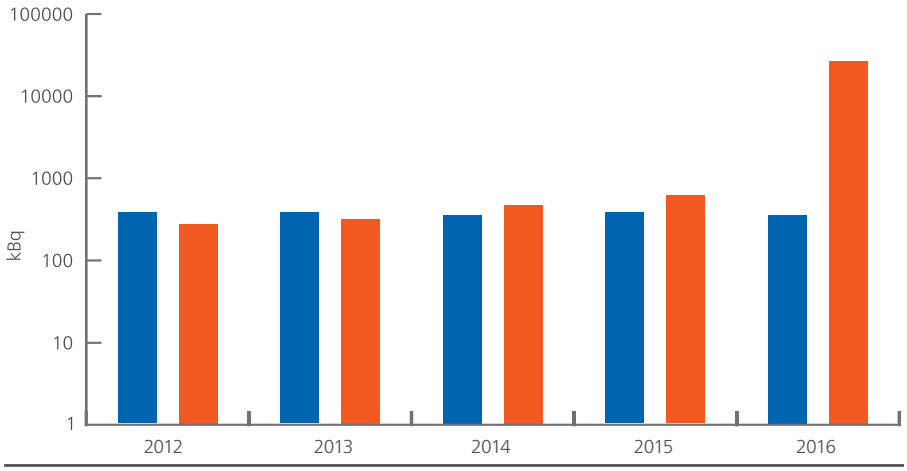
	2012	2013	2014	2015	2016
EBO	6.03	4.327	5.039	5.765	5.481
EMO	1.694	1.622	1.277	1.255	1.129

Emission to atmosphere – aerosols



	2012	2013	2014	2015	2016
EBO	8.17	6.194	8.829	9.34	10.449
EMO	20.575	9.447	10.53	6.951	4.616

Emission to atmosphere – iodine

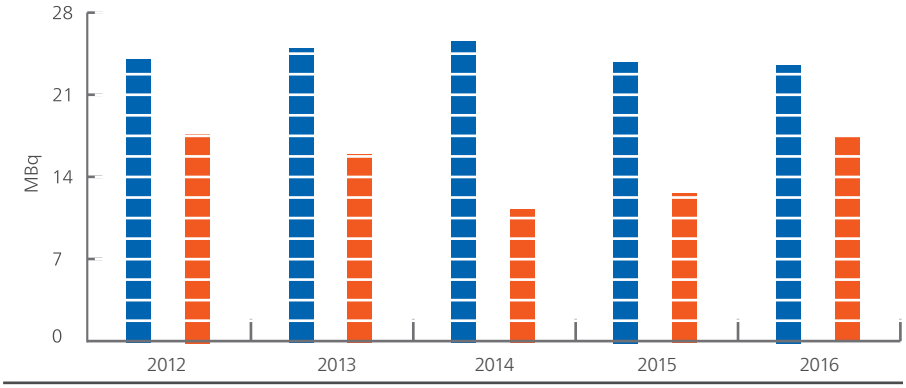


	2012	2013	2014	2015	2016
EBO	380	402	379	392	358
EMO	280	325	455	663,8	30460

Releases to hydrosphere

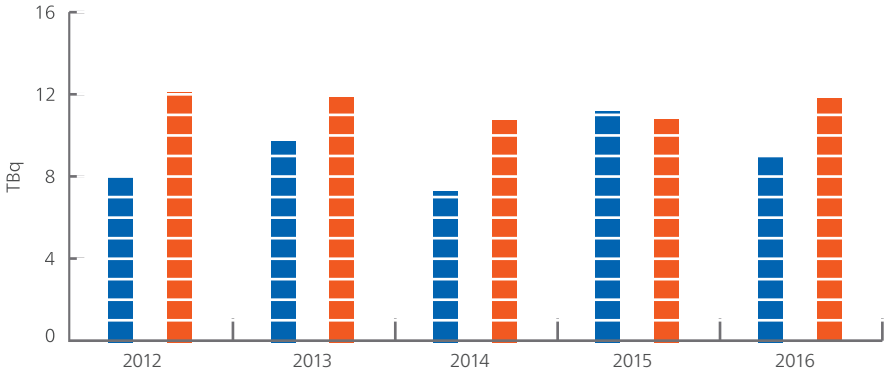
installation	Type of release	Activity	Unit	Share on target value for 2016 (%)
EBO	Activation and fission products	23.526	MBq	0.18
	Tritium	8.983	TBq	44.9
EMO	Activation and fission products	17.41	MBq	1.58
	Tritium	11.79	TBq	98.25

Releases to hydrosphere – activation and fission products



	2012	2013	2014	2015	2016
EBO	23.994	24.970	25.576	23.810	23.562
EMO	17.710	15.960	11.330	9.600	17.410

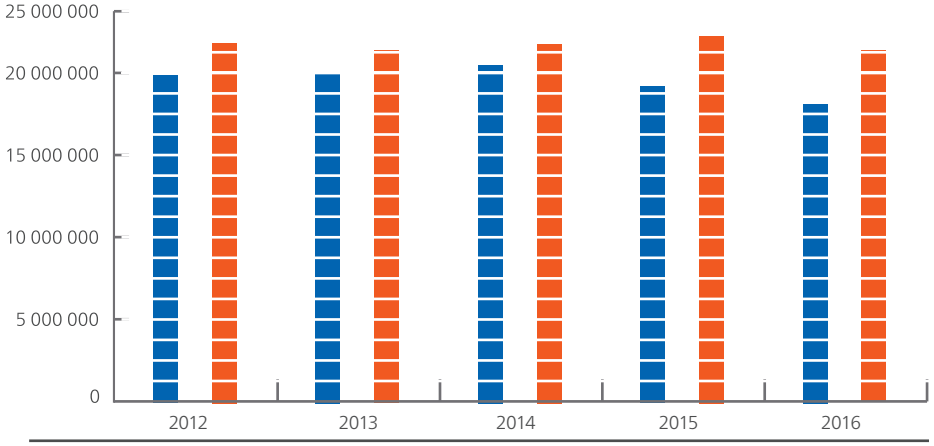
Releases to hydrosphere – tritium



	2012	2013	2014	2015	2016
EBO	9.19	9.762	7.337	11.203	8.983
EMO	12.13	11.87	10.75	10.806	11.79

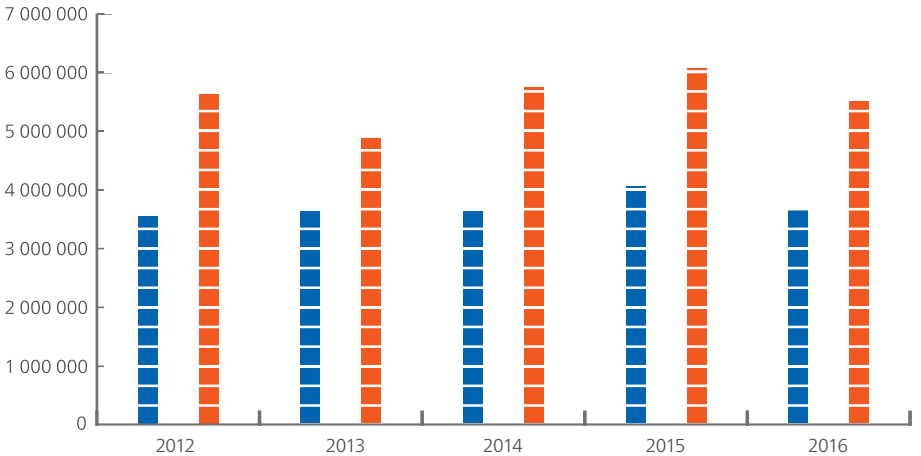
NPP operation has minimal impact on the environment. This impact is verified by calculation of annual doses to public living in the power plants vicinity using approved conservative method. calculated maximal values are approximately one hundred times lower than the limit value of 50 micro sievert defined by the public health authority of SR.

Surface water intake (m³)



	2012	2013	2014	2015	2016
EBO	20 963 176	21 096 662	21 567 885	20 204 682	19 087 378
EMO	23 003 000	22 491 000	22 921 000	23 443 251	22 531 740

Wastewater discharge (m³)



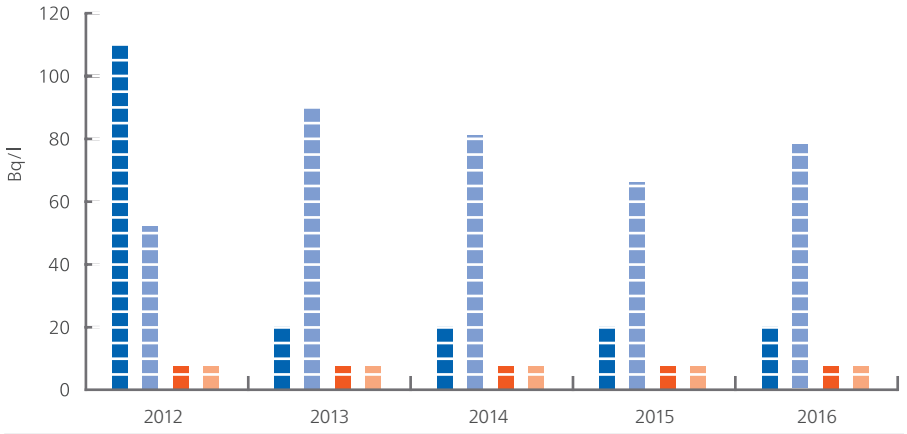
	2012	2013	2014	2015	2016
EBO	3 544 966	3 615 684	3 623 622	4 051 887	3 638 429
EMO	5 628 735	4 874 075	5 733 029	6 068 588	5 497 405

	Allowed annual limits
EBO	4 200 000
EMO	6 000 000

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.

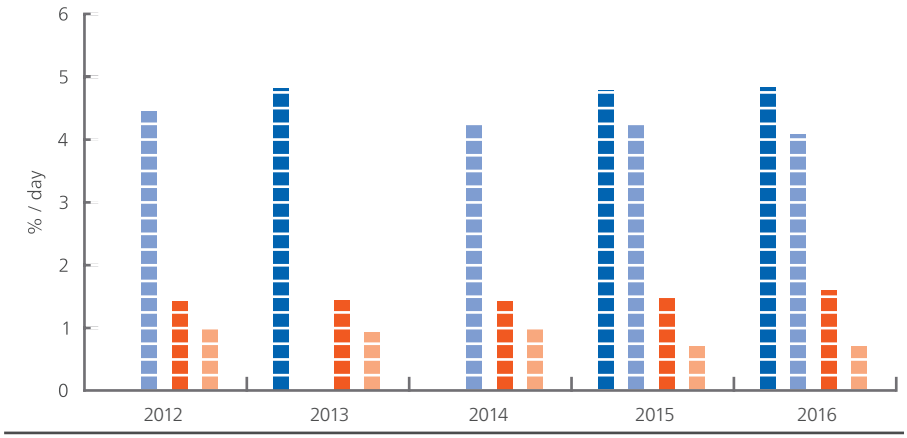


	2012	2013	2014	2015	2016
EBO 3	110	20	20	20	20
EBO 4	52	90	81	66	78
EMO 1	7	7	7	7	7
EMO 2	7	7	7	7	7

There was minor leakage of SG tubes registered, checked and consequently eliminated at both EBO units. Secondary circuit activity was just slightly increased, yet well below limits approved for a nuclear installation that is 370 Bq/l.
Blowdown water at both EMO units has been in long term at the minimum detectable threshold, i.e. 7 Bq/l.

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 150kPa .



	2012	2013	2014	2015	2016
EBO 3		4.81		4.78	4.817
EBO 4	4.44		4.25	4.25	4.07
EMO 1	1.41	1.424	1.491	1.488	1.583
EMO 2	0.996	0.915	0.946	0.679	0.686

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

Emergency planning and preparedness

Slovenské elektrárne complies with all requirements for permanent readiness to carry out planned measures in the area of emergency planning in the event of an incident or accident with very low probability of occurrence. The company's emergency preparedness system is continually maintained and tested.

The main objectives in the area of emergency preparedness is that the readiness of staff and external individuals for successful handling of emergencies are fulfilled, with an emphasis on reducing the risk of an accident or mitigating its consequences, preventing harm to public health and mitigating the risk of effects on human health resulting from emergencies.

The functionality of the emergency response organization of both nuclear power plants was tested during a emergency exercise covering the whole grounds of both nuclear power plants.

The exercise at NPP Mochovce and Bohunice NPP also tested cooperation with the Ministry of Defense and Ministry of Interior in transporting alternating plant personnel and the line set up for decontamination of staff, buses and firefighting equipment.

In accordance with the timetable started in 2013, stress tests are being implemented and new measures for raising the level of emergency preparedness are being specified.

The long-term strategic objective of Slovenské elektrárne in the area of emergency preparedness is continual improvement of processes by means of utilizing its own experience and that of other power plant operators around the world.

Increasing Safety

Investment projects and modernizations implemented at EBO in 2016:

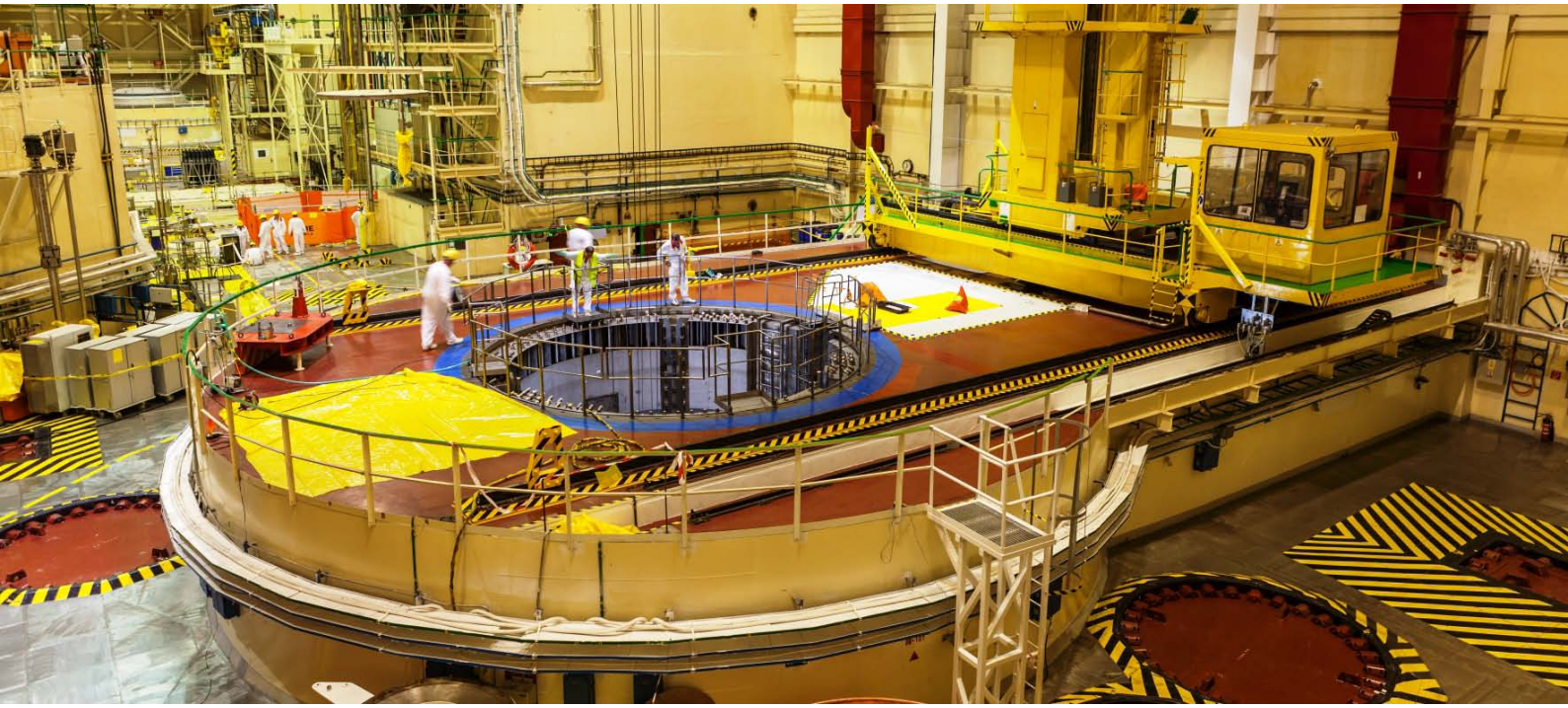
- Modification of chemical volume and control system pumps
- Replacement of 6 kV cables of primary and secondary circuit appliances
- Replacement of inverters and rectifiers of the 1st category emergency power supply
- Replacement of emergency/protections in 6 kV switchboards
- Replacement of accumulator batteries of the 1st category emergency power supply
- Replacement of the reactor protection and control system
- Mobile measuring unit for measuring selected technological parameters at the plant
- Autonomous cooling of existing diesel generators

Investment projects and modernizations implemented at EMO in 2016:

- Replacement of essential service water check valves
- Mobile measuring unit for measuring selected technological parameters at the plant
- Reconstruction of diesel generator automatic devices
- Additional monitoring of accumulator batteries for EMO2
- Implementation of redundant temperature measurement in core outlet for open reactor
- Modification of control software of the refueling machine for moving fuel assemblies in the reactor with extended working and television rod
- Implementation of measures for a serious accident
- Modernization and addition of 400 kV switches on units 1 and 2
- Modification of the AE EMO teledosimetric system
- Change to connection of electrical equipment and control & management system at 6 kV terminals
- Supplementing of the control & management system for additional pumps
- Modification and replacement of components and radiation protection systems
- Modification of unit transformers, addition of diagnostics for transformers into the existing electrical diagnostics system

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 2016 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