SLOVENSKÉ ELEKTRÁRNE

2018

Annual operation & safety report of Mochovce and Bohunice V2 NPPs

Table of content

Technical data

Reactor type

VVER 440/V-213

pressurized water / PWR

Reactor thermal power	1 471 MWt
Reactor rated power	484 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	472 t/h tonnes per hour
Steam pressure and temperature at outlet	4.70 MPa / 265 – 269 ˚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)

Cooling towers

Number	4 (per 2 units)
Height	125 m (EMO) / 120 m (EBO V2)

Condenser

Cooling water volume	35 000 m^3/h
Max. temperature of cooling water	33˚C

Start of operation

	1st criticality	Start of permanent operation
EBO3	07.08.1984	14.02.1985
EBO4	02.08.1985	18.12.1985
EMO1	09.06.1998	29.01.1999
EMO2	01.12.1999	11.07.2000

EBO - Bohunice V2 Nuclear Power Plant (Units 3&4)
EMO – Mochovce Nuclear Power Plant (Units 1&2)
*1st criticality

Core damage frequency

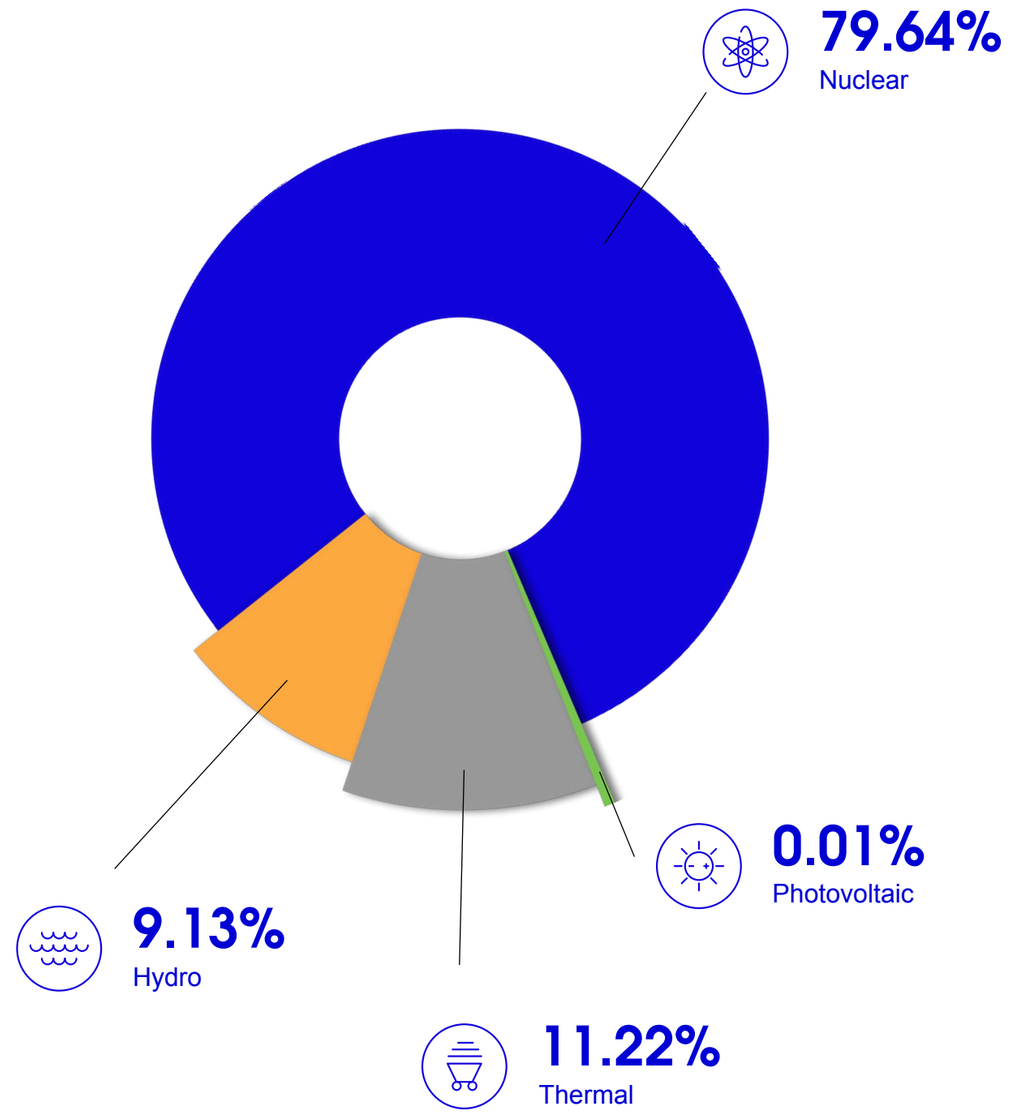
(according to PSA - probabilistic safety assessment)

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

Share of resources in electricity generation

	GWh
EBO V2	7 514.512
EMO	7 328.563

	GWh
SE - nuclear	14 843.075
SE - thermal	2 090.616
SE - hydro	1 702.731
SE - photovoltaic	1.848
SE total	18 638.27
90% of electricity is produced without CO2 emissions	



Electricity & heat supply

Indicator	Unit		2014	2015	2016	2017	2018	Since start of operation
Net generation	MWh	3	4 010 463	3 649 596	3 689 520	3 895 857	3 894 701	108 806 857
		4	4 045 787	3 972 948	3 542 216	3 918 441	3 619 811	107 399 123
		EBO	8 056 250	7 622 544	7 231 736	7 814 298	7 514 512	216 205 980
		1	3 803 613	3 703 388	3 752 314	3 467 084	3 819 341	65 595 267
		2	3 639 452	3 819 742	3 789 715	3 799 846	3 509 222	59 988 587
		EMO	7 443 065	7 523 130	7 542 029	7 266 930	7 328 563	125 583 854
Gross supply	MWh	3	3 740 880	3 400 201	3 437 679	3 615 515	3 609 995	100 993 484
		4	3 778 751	3 707 017	3 306 663	3 648 542	3 367 927	99 856 285
		EBO	7 519 631	7 107 218	6 744 342	7 264 057	6 975 307	200 849 769
		1	3 542 009	3 447 569	3 489 319	3 219 219	3 539 853	60 576 172
		2	3 395 671	3 565 101	3 539 853	3 547 785	3 266 323	55 665 499
		EMO	6 937 680	7 012 670	7 029 172	6 767 004	6 806 176	116 241 671
Heat supply	GJ	3	744 462	975 303	850 984	924 529	1 050 438	24 405 848
		4	819 031	753 254	878 074	902 179	625 451	23 441 024
		EBO	1 563 493	1 728 557	1 729 058	1 826 708	1 675 889	47 846 872
		1	212 205	195 961	200 200	101 066	206 660	3 109 781
		2	18 997	43 054	46 861	168 049	34 938	1 763 574
		EMO	231 202	239 015	247 061	269 115	241 598	4 873 355
Operation period	h	3	8 254	7 635	7 739	8 231	8 288	256 366
		4	8 314	8 285	7 371	8 115	7 550	252 625
		1	8 262	8 071	8 185	7 543	8 277	152 119
		2	7 844	8 299	8 268	8 280	7 643	139 940
General overhauls	Days	3	21.18	46.36	43.59	22.09	19.45	1 610.86
		4	18.6	19.8	58.89	20.51	39.93	1 589.68
		1	20.6	27.2	24.2	50.1	18.5	742
		2	38.3	19.3	20.5	20.0	46.6	657.2
Rough efficiency	%	3	31.71	33.73	33.94	33.73	33.43	32.10
		4	31.72	34.0	33.96	33.89	33.43	32.16
		EBO V2	31.71	33.87	33.95	33.81	33.43	32.13
		1	32.64	32.71	32.31	32.16	31.97	30.64
		2	32.24	32.48	32.47	32.49	32.25	30.10
		EMO	32.43	32.60	32.39	32.32	32.10	30.38

Evaluation of operational safety of SE nuclear installations

Act No. 541/2004 the “Atomic Act” defines nuclear safety as the technical conditions and capability of a nuclear installation and transport equipment, as well as the capability of their operating staff to prevent the uncontrolled release of radioactive substances or ionizing radiation to the working or natural environment and the ability to prevent events in nuclear installations or during transport of radioactive materials and to mitigate the consequences of such events.

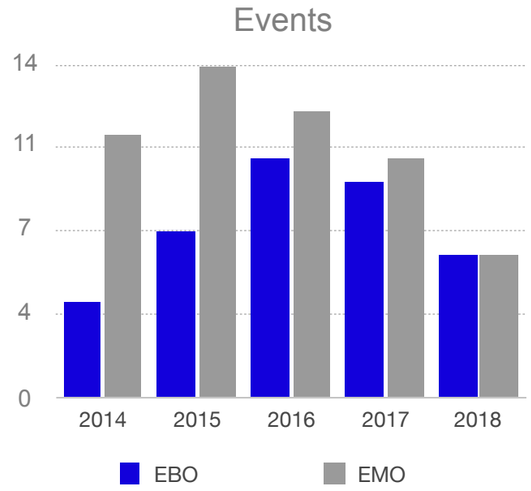
As the holder of an operation license for nuclear installations issued by the Nuclear Regulatory Authority of the Slovak Republic pursuant to Act No. 541/2004, Slovenské elektrárne defines safety, especially nuclear safety and radiation protection, as the priorities of its strategic vision permanently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

Operational events

The nuclear installation failures described in the above-mentioned act can be defined in general terms as any unplanned deviations from standard conditions. They are thus indicators of a power plant’s safety and reliability. There are various types of events with causes of a different nature and a differing level of impact on safety.

Operational events reported to the NRA SR by SE:

There were 6 events in EBO and another 6 in EMO. All were of the lowest category reportable to the Nuclear Regulatory Authority (NRA).. No incident or accident events were recorded.

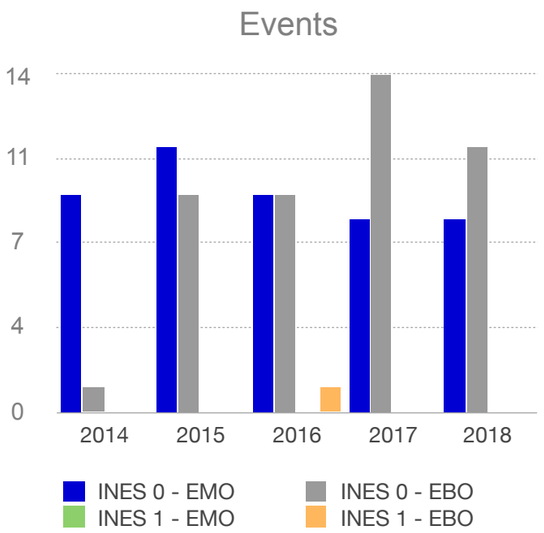


Assessment of operational events using the INES scale

The IAEA instructions for assessing operational events at nuclear installations (NI) according to the INES scale distinguish 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 2018, there was no event classified INES1 or higher in EBO or EMO.

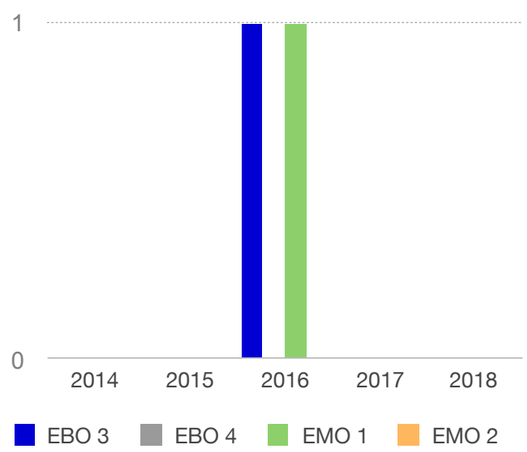


Violations of nuclear limiting conditions of operation

The basic document for the operation of nuclear installations is the “NPP limiting conditions of operation” (LCO) approved by the NRA SR. The operator must monitor and evaluate compliance with the conditions set out in the document.

The indicator monitors the management level, the operational organization of the nuclear installation (nuclear power plant), the correctness of operating regulations and instructions, and compliance with them, with the aim of ensuring the fulfilment of LCO requirements.

No LCO violation occurred at either EBO or EMO in 2018.

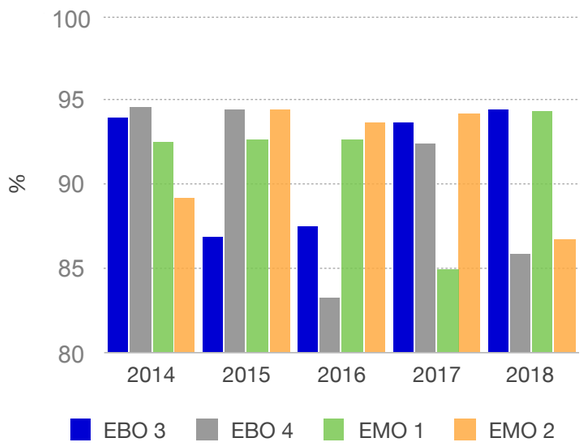


Operation

Slovenské elektrárne, as a nuclear installation operator, performs comprehensive assessments of the safety and reliability of its NIs, using specific indicators monitoring selected areas, including those defined by the World Association of Nuclear Operators (WANO), of which it is a member.

Unit Capability Factor – UCF

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



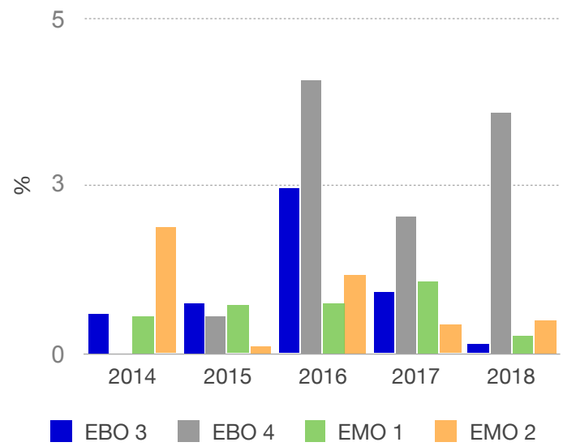
3Q 2018 WANO PWR, 3-yr. median 85.89%, best quartile 91.26% a best decile 93.26%.

Median – medium; 50% of all monitored cases
Quartile – 25% of the best in the monitored set
Decile – 10% of the best in the monitored set

	2014	2015	2016	2017	2018
EBO 3	93.9	86.81	87.53	93.73	94.39
EBO 4	94.56	94.4	83.23	92.33	85.75
EMO 1	92.55	91.59	92.67	84.97	94.37
EMO 2	89.18	94.4	93.67	94.16	86.66

Unplanned Capability Loss Factor – UCLF

This indicator monitors progress in minimising 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.

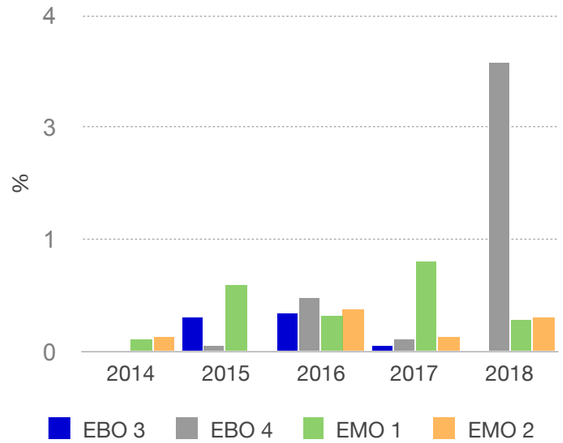


3Q 2018 WANO PWR, 3-yr. median 1.95% best quartile 0.515%, best decile 0.06%

	2014	2015	2016	2017	2018
EBO 3	0.58	0.73	2.46	0.89	0.12
EBO 4	0	0.54	4.05	2.03	3.57
EMO 1	0.55	0.71	0.73	1.07	0.25
EMO 2	1.86	0.1	1.15	0.41	0.48

Forced Loss Rate – FLR

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

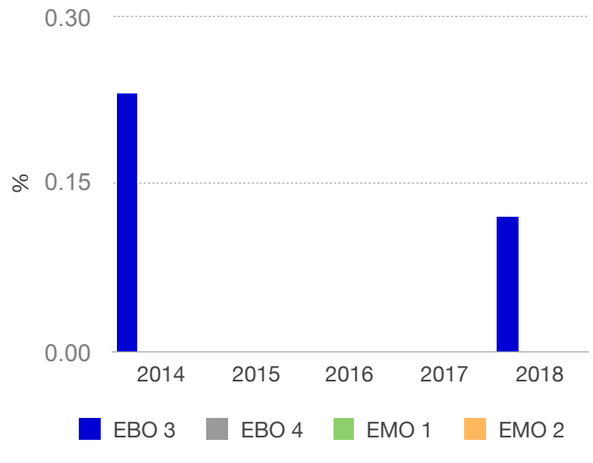


3Q 2018 WANO PWR, 3-yr - median 1.09%, best quartile 0.205% a best decile 0.04%.

	2014	2015	2016	2017	2018
EBO 3	0.01	0.04	0.45	0.05	0
EBO 4	0	0.05	0.63	0.12	3.42
EMO 1	0.13	0.77	0.42	1.05	0.27
EMO 2	0.16	0.01	0.49	0.15	0.38

Grid-Related Loss Factor

The indicator is defined as the percentage of maximum energy generation that a plant could not supply due to grid issues not under station management control during a quarter.

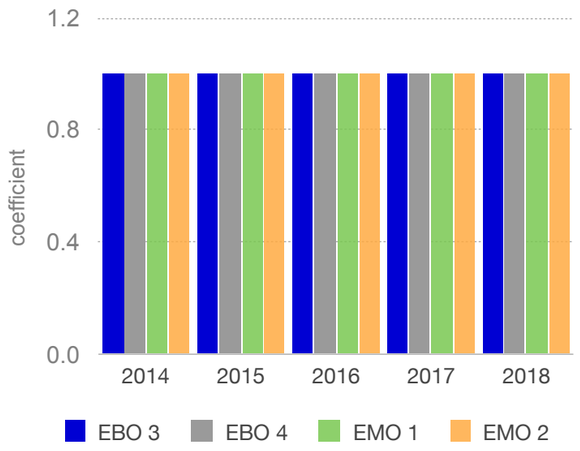


3Q 2017 WANO PWR, 3-yr - median 0.00%, best quartile 0.00%, best decile 0.00%

	2014	2015	2016	2017	2018
EBO 3	0.23	0	0	0	0.12
EBO 4	0	0	0	0	0
EMO 1	0	0	0	0	0
EMO 2	0	0	0	0	0

Chemistry performance index

This indicator assesses the efficiency of chemical parameters in the steam generators. The best attainable value of the chemistry performance 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.



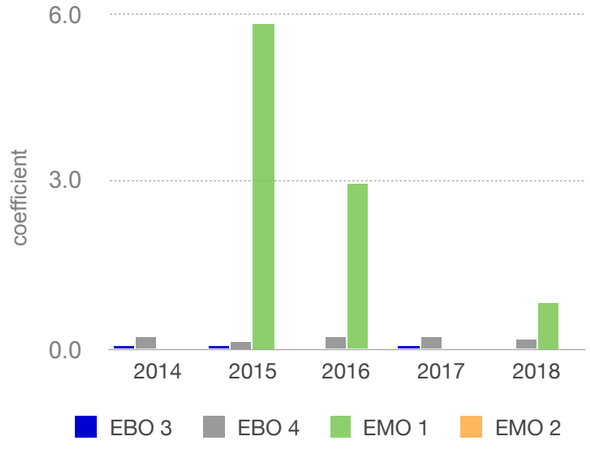
3Q 2018 WANO, PWR, 3-yr, median 1.00, best quartile 1.0

	2014	2015	2016	2017	2018
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 fuel cladding integrity. 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.

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



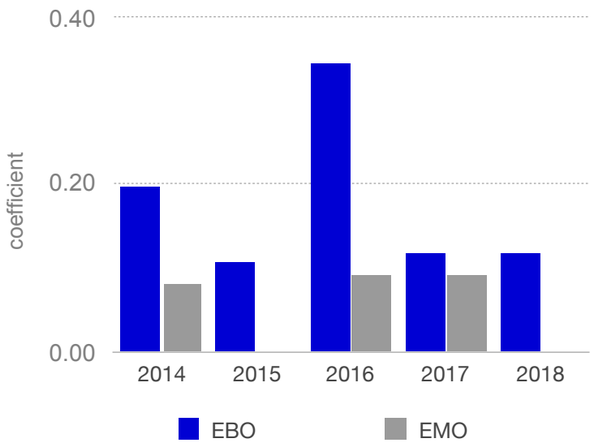
3Q 2018 WANO PWR, 3-yr, median 0.136, best quartile 0.037

	2014	2015	2016	2017	2018
EBO 3	0.04	0.043	0.037	0.049	0.037
EBO 4	0.21	0.134	0.191	0.194	0.164
EMO 1	0.037	5.801	2.936	0.037	0.795
EMO 2	0.037	0.037	0.037	0.037	0.037

Industrial Safety Accident Rate – ISA

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

In 2018, there was one registered occupational injury at EBO and there were no occupational injuries at EMO.



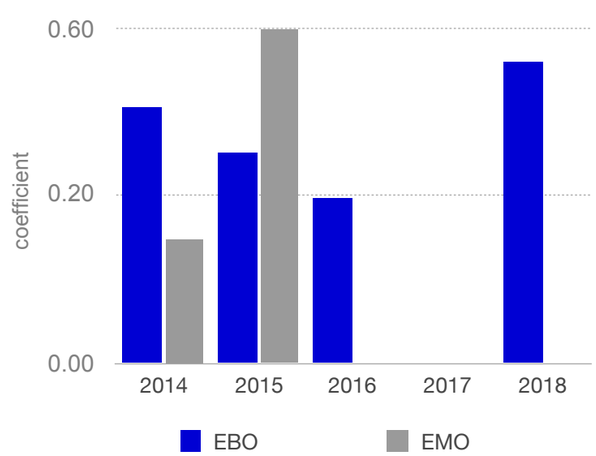
3Q 2018 WANO PWR, 3-yr, median 0.06, best quartile 0.00

	2014	2015	2016	2017	2018
EBO	0.197	0.105	0.342	0.115	0.115
EMO	0.08	0	0.09	0.09	0

Contractor Industrial Safety Accident Rate – CISA

This indicator is defined as the number of injuries of all employees working for contractor organizations, including all contractors working at the NPP, that result in lost worktime of one or more days (excluding the day of the injury) or fatalities per 200 000 man hours worked

During 2018 there was one registered occupational injury of a contractor at EBO. There were no contractor injuries at EMO.



3Q 2018 WANO PWR, 3-yr, median 0.10, best quartile 0.00

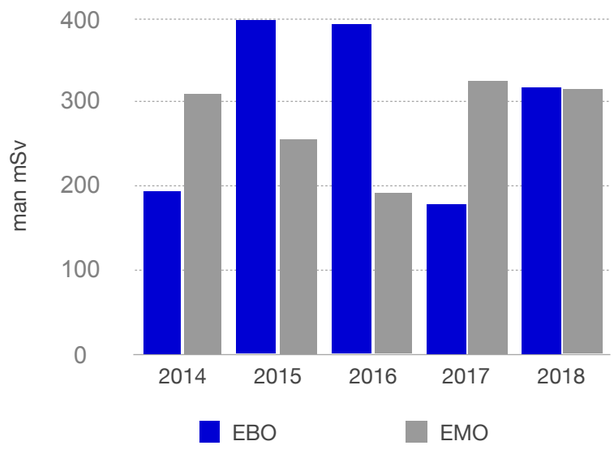
	2014	2015	2016	2017	2018
EBO	0.456	0.377	0.293	0	0.54
EMO	0.22	0.6	0	0	0

Collective Radiation Exposure – CRE

(mean value of collective radiation exposure per unit)

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 principle in order to minimize the exposure.

CRE values for EBO and EMO refer to the whole power plant (two units). WANO values refer to one single unit.



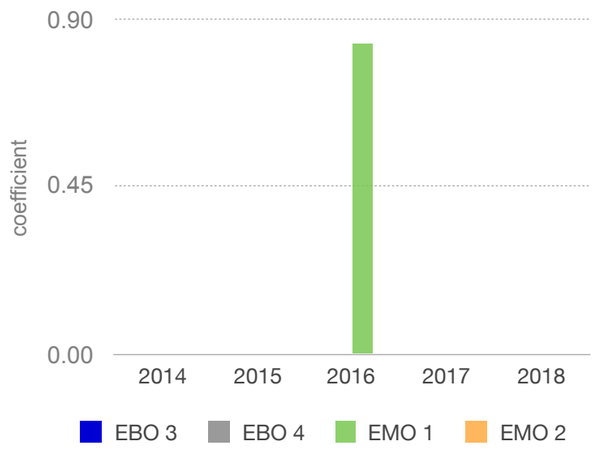
3Q 2018 WANO, PWR, 3-yr, median 422, best quartile 299, best decile 200

	2014	2015	2016	2017	2018
EBO	194	398.3	392	178.5	317.7
EMO	311	255.6	192	326.1	315.1

Unplanned automatic scrams per 7 000 critical hours

This indicator shows the number of unplanned automatic reactor scrams due to AO-1 activation per 7 000 critical reactor hours.

At EBO and EMO there were no automatic reactor scrams in 2018.



3Q 2018 WANO, PWR, 3-yr, median 0.00, best quartile 0.00

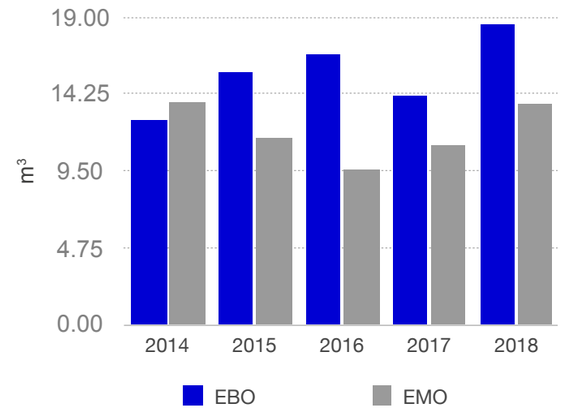
	2014	2015	2016	2017	2018
EBO 3	0	0	0	0	0
EBO 4	0	0	0	0	0
EMO 1	0	0	0.83	0	0
EMO 2	0	0	0	0	0

Waste production and emissions to the atmosphere and hydrosphere

Nuclear installations produce small quantity of radioactive waste (RAW). Liquid and solid waste types 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 for discharges, types of substances, and their limit values are set by state supervisory authorities.

Production of liquid RAW

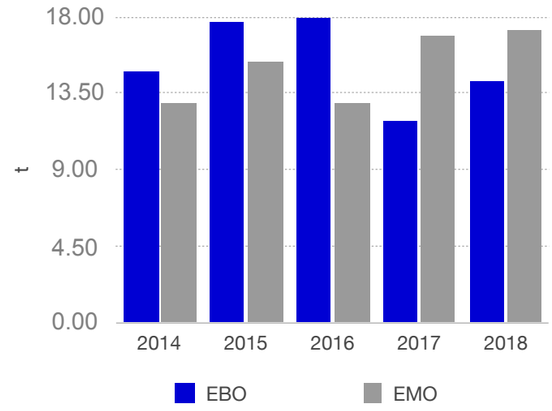
This indicator is defined as the volume of liquid RAW in cubic metres generated by a nuclear installation's operation calculated based on the concentration boric acid (120g/kg).



	2014	2015	2016	2017	2018
EBO	12.687	15.538	16.694	14.08	18.543
EMO	13.672	11.514	9.543	11.078	13.645

Production solid RAW

This indicator is defined as the volume of solid RAW in tonnes (t) generated by the nuclear installation's operation.



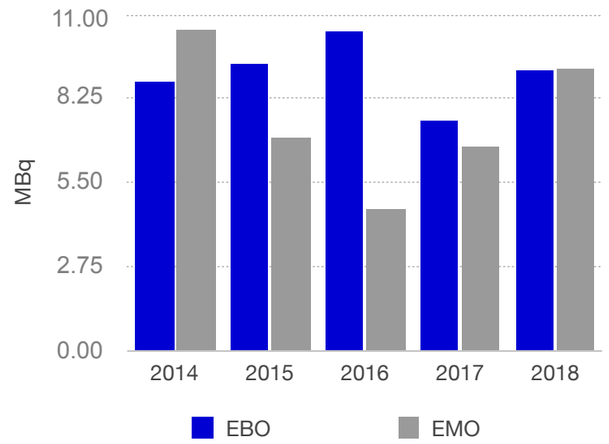
	2014	2015	2016	2017	2018
EBO	14.72	17.6	17.847	11.89	14.156
EMO	12.95	15.34	12.935	16.807	17.211

Emissions to the atmosphere

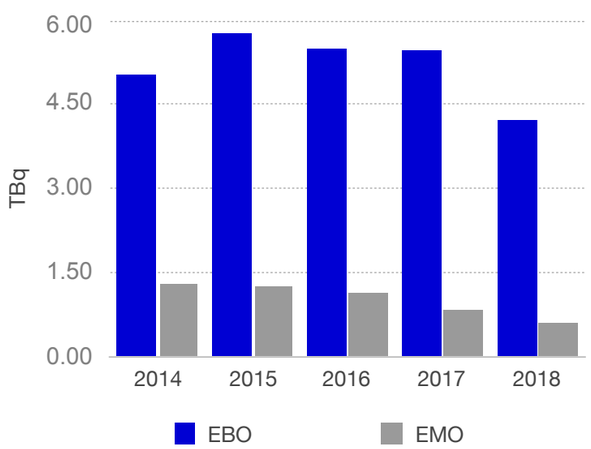
Installation	Type of release	Activity	Unit	percentage of the TV for 2018 (%)
EBO	Noble gases	4.216	TBq	0.211
EBO	Aerosols	9.156	MBq	0.01145
EBO	Iodine 131	0.518	MBq	0.00080
EMO	Noble gases	0.599	TBq	0.01461
EMO	Aerosols	9.251	MBq	0.00544
EMO	Iodine 131	0.867	MBq	0.00129

*TV – target value determined by the Public Health Authority

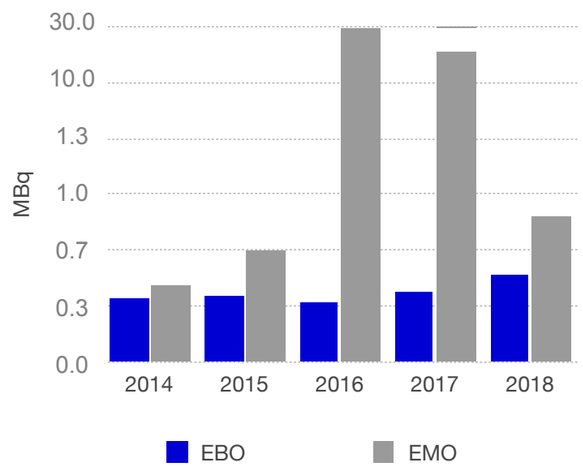
Emissions to the atmosphere – aerosols



Emissions to the atmosphere – noble gases

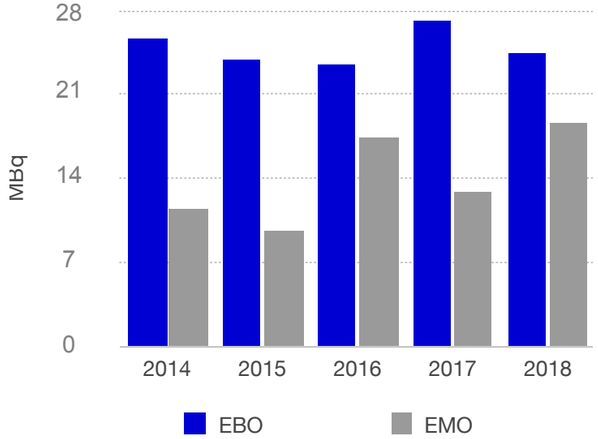


Emissions to the atmosphere – iodine



Emissions to the hydrosphere

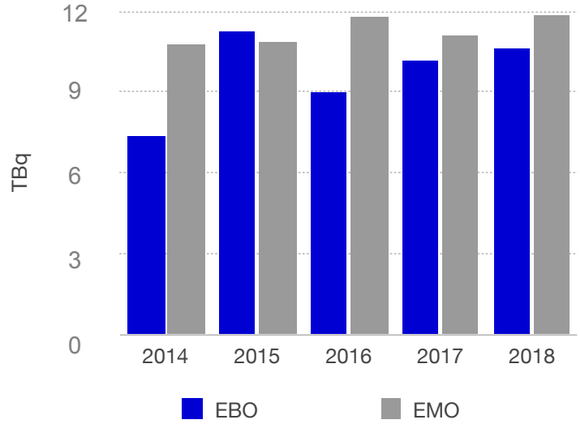
Emissions to the hydrosphere – activation and fission products



Installation	Type of release	Activity	Unit	Share in target value for 2018 (%)
EBO	Activation and fission products	24.48	MBq	0.188
EBO	Tritium	10.60	TBq	53.01
EMO	Activation and fission products	18.54	MBq	1.685
EMO	Tritium	11.837	TBq	98.64

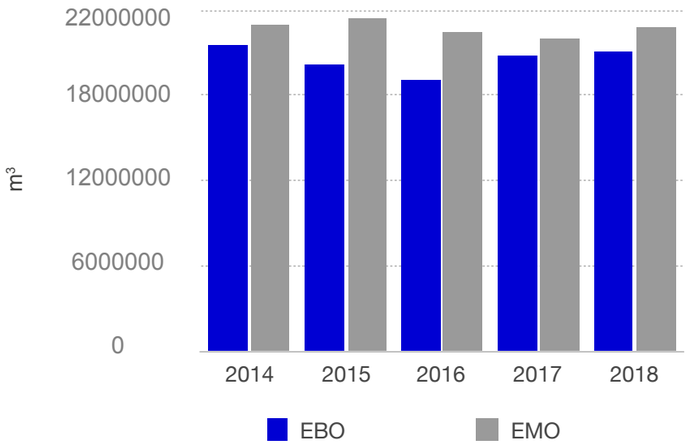
Emissions to the hydrosphere – tritium

The impact of NPP operation on their surroundings was minimal. It is verified by calculation of the annual dose for residents in the vicinity of the power plants based on an approved conservative methodology. The calculated maximum values are approximately 200 times lower than the permitted limit of 20 micro-Sievert (20 μSv) determined by the Public Health Authority of the Slovak Republic.



	2014	2015	2016	2017	2018
EBO	7.337	11.203	8.983	10.13	10.6
EMO	10.75	10.806	11.79	11.05	11.837

Surface water intake (m^3)



	EBO	EMO
2014	21 567 885	22 921 000
2015	20 204 682	23 443 251
2016	19 087 378	22 531 740
2017	20 765 059	21 986 000
2018	21 117 382	22 836 000

Wastewater discharge - Total volume (m^3)

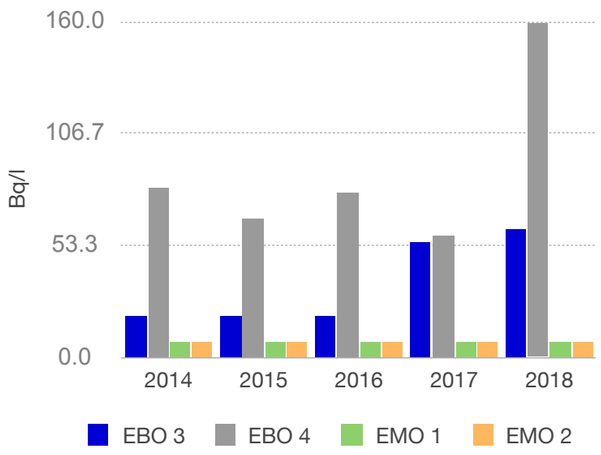
Year		2014	2015	2016	2017	2018
Total volume	EBO	3 623 622	4 051 887	3 638 429	3 952 691	3 543 241
	EMO	5 733 029	6 068 588	5 497 405	5 942 185	6 554 961
Industrial waste water	EBO	3 623 622	4 010 005	3 607 734	3 917 886	3 507 707
	EMO	5 662 984	6 010 806	5 444 252	5 904 441	6 518 925
Treated sewage water	EBO	45 933	41 882	30 695	34 805	35 534
	EMO	70 045	57 782	53 153	37 744	36 036
Allowed annual limits of discharged water per 2 units	EBO			4 200 000		
	EMO			7 000 000		

Tightness of barriers

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.

At EBO small leakages on SG pipes were recorded, controlled, and subsequently eliminated at both units. Activity on the secondary circuit was only moderately increased and did not exceed the values permitted by the LCO for NPP operation, which is 370 Bq/l. The activity of the blown-down water at EMO has long been at the lowest possible detectable limit i.e. 7 Bq/l.



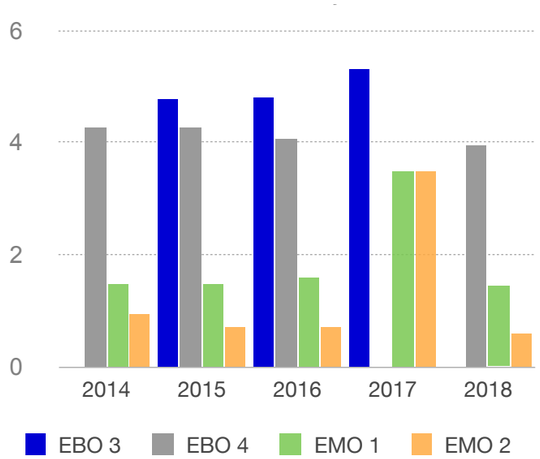
	2014	2015	2016	2017	2018
EBO 3	20	20	20	55	61
EBO 4	81	66	78	58	160
EMO 1	7	7	7	7	7
EMO 2	7	7	7	7	7

Containment tightness

This indicator monitors the containment tightness as the third physical barrier to prevent the release of fission products. The indicator is defined as the percentage of the volume of air in the containment lost in 24 hours at over-pressure of 150 kPa.

The containment tightness is prescribed by the Limiting Conditions of Operation. For both Bohunice NPP units, containment leakage must not exceed 13% per 24 hours.

For Mochovce NPP this value is set at 5% per 24 hours.



	2014	2015	2016	2017	2018
EBO 3		4.78	4.817	5.3	
EBO 4	4.25	4.25	4.07		3.93
EMO 1	1.491	1.488	1.583	3.5	1.44
EMO 2	0.946	0.679	0.686	3.5	0,59

Emergency planning and preparedness

Slovenské elektrárne complies with the requirements for permanent readiness to implement planned measures in the field of emergency planning even for extremely low-probability accidents or emergencies. Emergency preparedness systems at the Company are continuously maintained and tested.

The aim of emergency preparedness is to make sure that employees of the NPPs and external contractors are prepared to manage extraordinary events, focussing on reducing the risk of occurrence of emergencies/accidents, mitigating their consequences, avoiding damage to health, and mitigating the risks of impacts on human health.

The activities performed in 2018 establish a basis for further development and improvement of the emergency preparedness process in Slovenské elektrárne:

An “Improvement of Emergency Preparedness” project for the two NPPs was completed in 2018. Its purpose was to verify and modify the process of emergency preparedness at SE in compliance with WANO requirements concerning severe accidents, multiple-unit events, and events at nuclear power plants in the world, as well as applying best practice in EOPs (Emergency Operating Procedures).
The project did not lead to any findings of any safety significance, although areas for improvement were identified.

Functionality of the entire Emergency Response Organisation in cooperation with crisis centres of selected regions and municipalities as well as with segments of integrated rescue system was reviewed during emergency drills at both NPP sites. The drills also included training of staff response to severe accident.

Investment projects and modifications implemented in EBO:

Replacement of accumulator batteries in secured power supply systems of the 1st category

Replacement of inverters and rectifiers in secured power supply systems of the 1st category

Replacement of emergency arresters in the 6kV switchboards

Modification of selected valves and servomotors in the primary and secondary circuit

Reconstruction of the maintenance hall with the addition of a civil structure for Radiography

Completion of the warehouse and manipulation technology in the new civil structure: warehouse and maintenance hall

Replacement of wood structures inside two circulation cooling towers during complete replacement of cooling filling of the cooling towers

Implementation the 1st phase of the project “Replacement of the Auxiliary Boiler Room” – Electric Boiler

Investment projects and modifications implemented in EMO:

EMO1,2 seismic reassessment for a new seismic load value

Supplementation of 400 kV switches at Units 1&2

Waste water purification plant reconstruction

Replacement of stator in generator TG22

Modernisation of safety systems in the reactor protection system

Change in the Electric and Instrumentation and Control System interfaces with 6kV switchboard outputs; change in protection of 6kv transformer outputs

Replacement of hardware in the complex of the upper level of the in-core control system

Reconstruction of the Unit 1&2 TG protections part 1: Partial replacement of the turbine generator protection system

Complete reconstruction of the electric part of the refuelling machine

Replacement of the air conditioning units of KTN type

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 2018 was safe and in conformity with the legislation governing the use of atomic energy. Corrective actions were adopted for events and indicators with a negative trend. Operation of Slovenské elektrárne nuclear installations had minimal impact on the environment and caused negligible radiation exposure to the company's personnel,S public and environment.

The company is certified according to three management systems:
Certificate STN EN ISO 9001:2009 – Quality management system
Certificate STN OHSAS 18001:2009 – Occupational health and safety management certificate
Certificate STN EN ISO 14001:2005 – Environmental management system

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