SLOVENSKÉ ELEKTRÁRNE

2019

Annual operation & safety report of Mochovce and Bohunice NPPs

Table of content

Technical data

Reactor type

VVER 440/V-213

pressurized water / PWR

Reactor thermal power	1 471 MWt
Reactor rated power	470 MWe (EMO) / 505 MWe (EBO)
In-house consumption	~7.2 % (EMO) / ~6.8 % (EBO)
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 t/h
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)

Cooling towers	**4 (per 2 units)**
Height	**125 m (EMO) / 120 m (EBO)**

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

*1st criticality

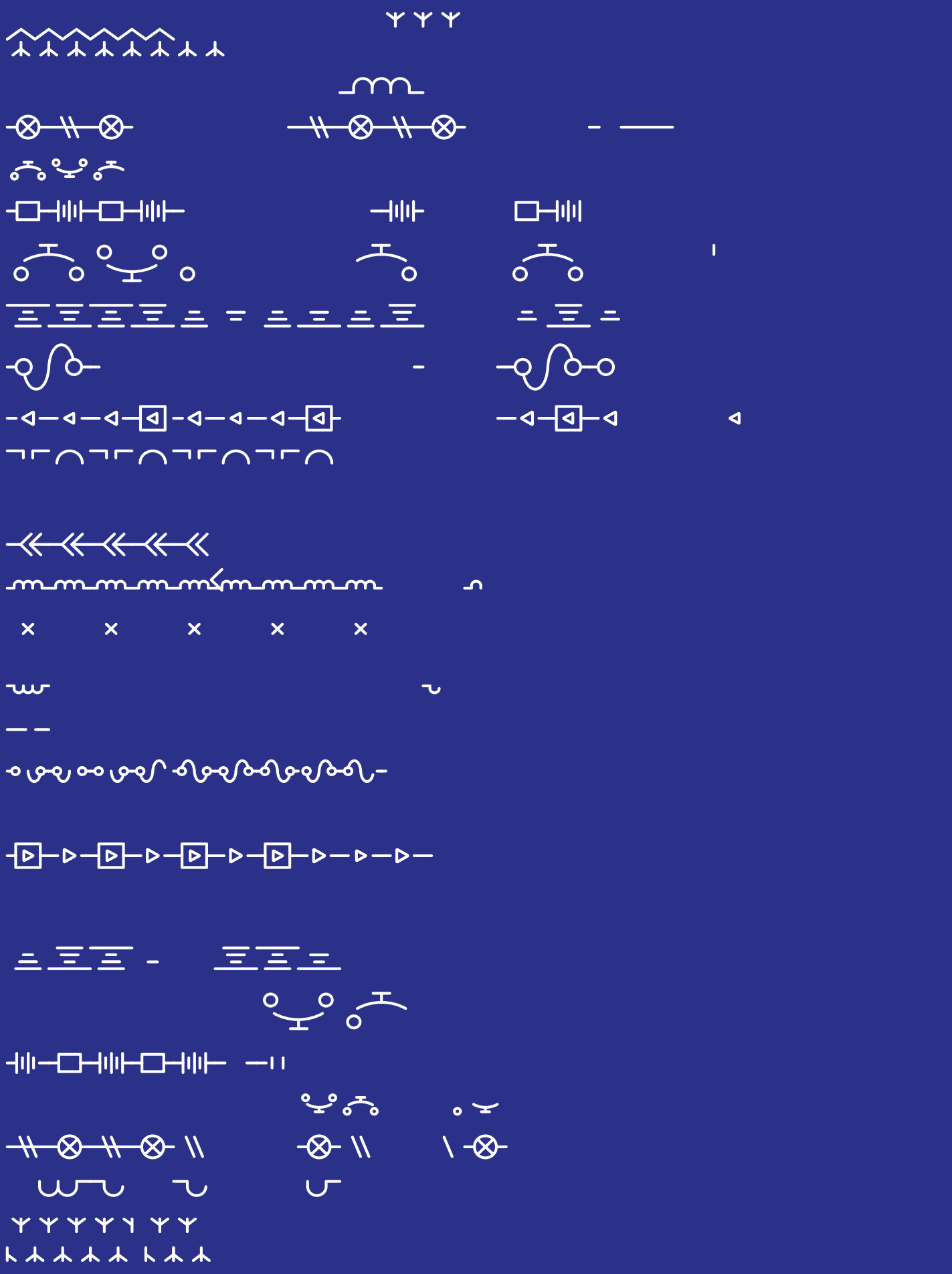
Probability of reactor core damage

(according to PSA - probabilistic safety assessment)

	EBO	EMO
at full power	2.60E-06	7.39E-06
at the shutdown reactor	5.03E-06	7.92E-06

Abbreviations:

EBO - Bohunice V2 Nuclear Power Plant (Units 3&4)
EMO - Mochovce Nuclear Power Plant (Units 1&2)
NRA SR - Nuclear Regulatory Authority of the Slovak Republic
IAEA - International Atomic Energy Agency
WANO - Word Association of Nuclear Operators
INES - International Nuclear Event Scale
NI - nuclear installation
RAW - radioactive waste

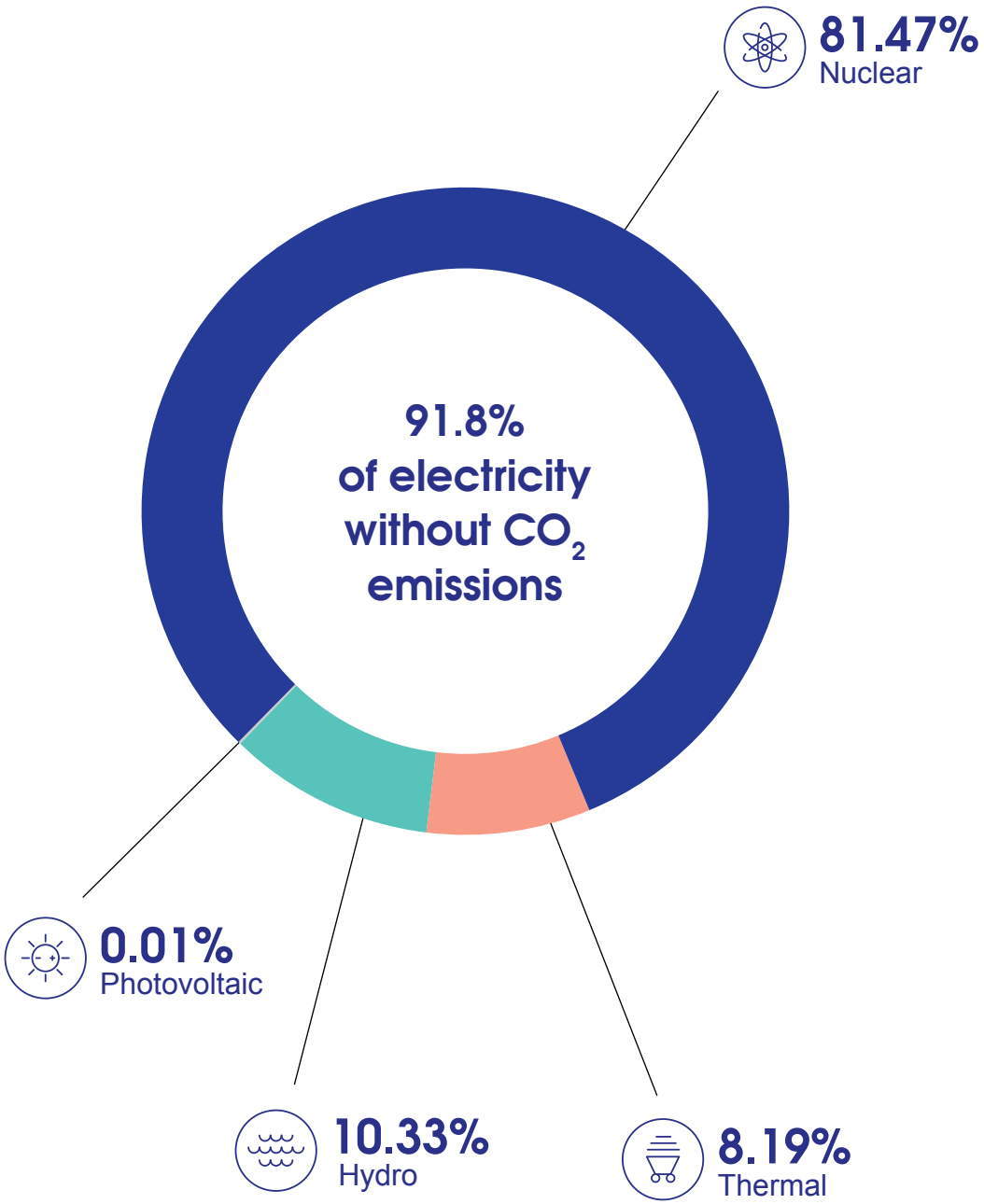


Share of resources in electricity generation

	GWh
EBO	7 890.608
EMO	7 478.279

	GWh
SE - nuclear	15 368.887
SE - thermal	1 544.865
SE - hydro	1 949.569
SE - photovoltaic	2.039
SE total	18 865.360

Share of resources in electricity generation



Electricity & heat supply

Indicator	Unit		2015	2016	2017	2018	2019	Since start of operation
Gross supply	MWh	3	3 649 596	3 689 520	3 895 857	3 894 701	3 905 997	112 712 854
		4	3 972 948	3 542 216	3 918 441	3 619 811	3 984 611	111 383 734
		EBO	7 622 544	7 231 736	7 814 298	7 514 512	7 890 608	224 096 588
		1	3 703 388	3 752 314	3 467 084	3 819 341	3 820 434	72 882 785
		2	3 819 742	3 789 715	3 799 846	3 509 222	3 657 845	67 446 278
		EMO	7 523 130	7 542 029	7 266 930	7 328 563	7 478 279	140 329 063
Gross supply	MWh	3	3 400 201	3 437 679	3 615 515	3 609 995	3 625 031	104 618 515
		4	3 707 017	3 306 663	3 648 542	3 367 927	3 711 180	103 567 465
		EBO	7 107 218	6 744 342	7 264 057	6 975 307	7 310 217	208 185 980
		1	3 447 569	3 489 319	3 219 219	3 539 853	3 551 508	67 522 774
		2	3 565 101	3 539 853	3 547 785	3 266 323	3 399 309	62 666 370
		EMO	7 012 670	7 029 172	6 767 004	6 806 176	6 950 817	130 189 144
Heat supply	GJ	3	975 303	850 984	924 529	1 050 438	921 598	25 327 446
		4	753 254	878 074	902 179	625 451	680 759	24 121 783
		EBO	1 728 557	1 729 058	1 826 708	1 675 889	1 602 357	49 449 229
		1	195 961	200 200	101 066	206 660	205 467	3 416 314
		2	43 054	46 861	168 049	34 938	31 345	1 962 968
		EMO	239 015	247 061	269 115	241 598	236 812	5 379 282
Operation period	hrs	3	7 635	7 739	8 231	8 288	8 135	264 501
		4	8 285	7 371	8 115	7 550	8 157	260 782
		1	8 071	8 185	7 543	8 277	8 225	167 886
		2	8 299	8 268	8 280	7 643	7 923	156 143
General overhaul period	days	3	46.36	43.59	22.09	19.45	26.04	1 636.90
		4	19.8	58.89	20.51	39.93	25.12	1 614.80
		1	27.2	24.2	50.1	18.5	22.3	764.3
		2	19.3	20.5	20.0	46.6	23.8	681.0
Gross efficiency	%	3	33.73	33.94	33.73	33.43	33.81	32.18
		4	34.0	33.96	33.89	33.43	33.89	32.23
		EBO	33.87	33.95	33.81	33.43	33.85	32.20
		1	32.71	32.31	32.16	31.97	32.18	32.26
		2	32.48	32.47	32.49	32.25	32.17	32.01
		EMO	32.60	32.39	32.32	32.10	32.18	32.14

Evaluation of operational safety of SE nuclear installations

This chapter fulfils requirements defined in the Atomic Act No. 541/2004. 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 elektrarne as the 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 consider nuclear safety and radiation protection as a priority permanently superior to 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 level of impact on safety.

Operational events reported to NRA SR

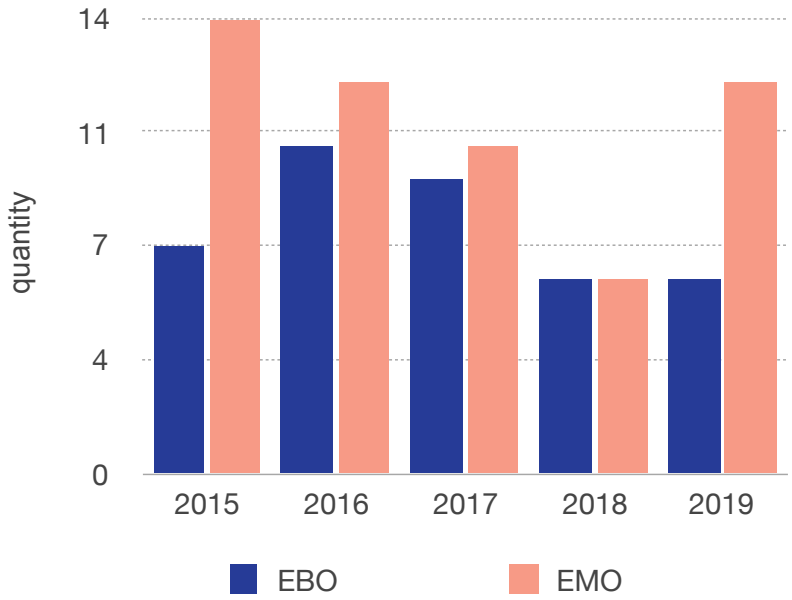
In EBO a total of 6 and in EMO a total of 12 lowest-category events failure were recorded, reportable to the NRA SR. There were no incident or accident events recorded.

Assessment of operational events using the INES scale

In the IAEA instructions for assessment of operational events at nuclear installations (NI) according to the INES scale, there are seven severity degrees of 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 2019, there was no event classified INES1 and more in EBO and EMO.


14
11
7
4
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quantity
2015
2016
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EBO
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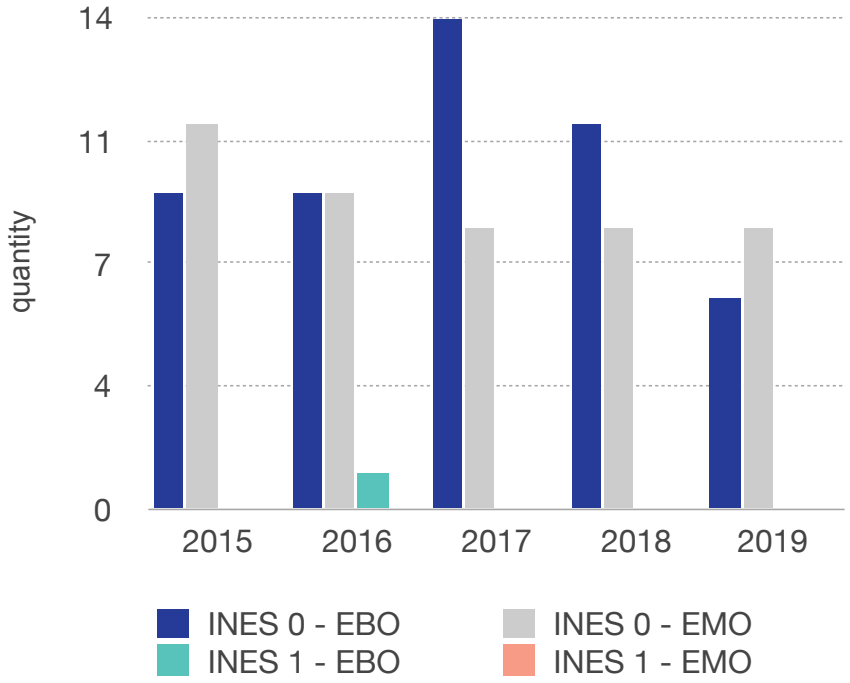
14
11
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quantity
2015
2016
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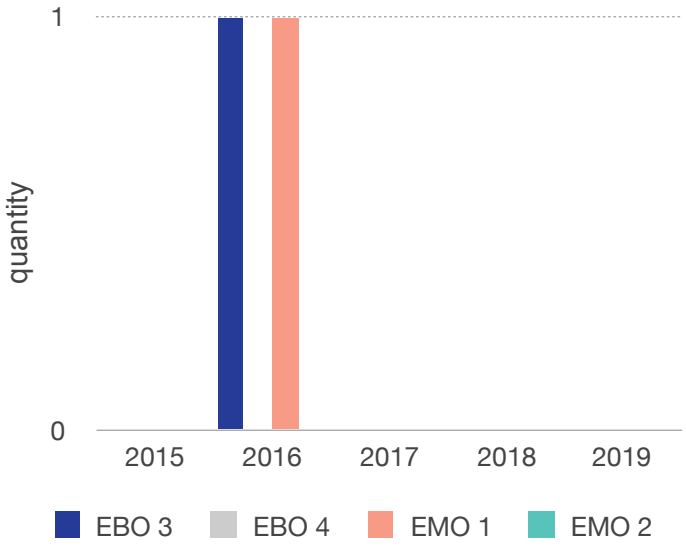
INES 0 - EBO
INES 1 - EBO
INES 0 - EMO
INES 1 - EMO

Breach of limits and conditions for nuclear installation operation

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 management level, organization of nuclear installation (nuclear power plant) operation, correctness and conformity of operating regulations and instructions with the aim of ensuring fulfilment of I&C requirements.

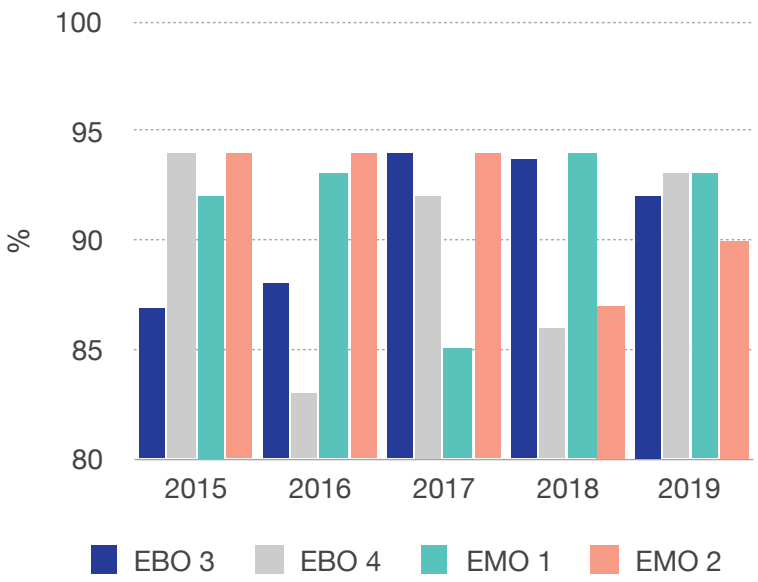


Operation

Slovenské elektrárne, as a nuclear installation operator, performs comprehensive assessments of 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.

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.).



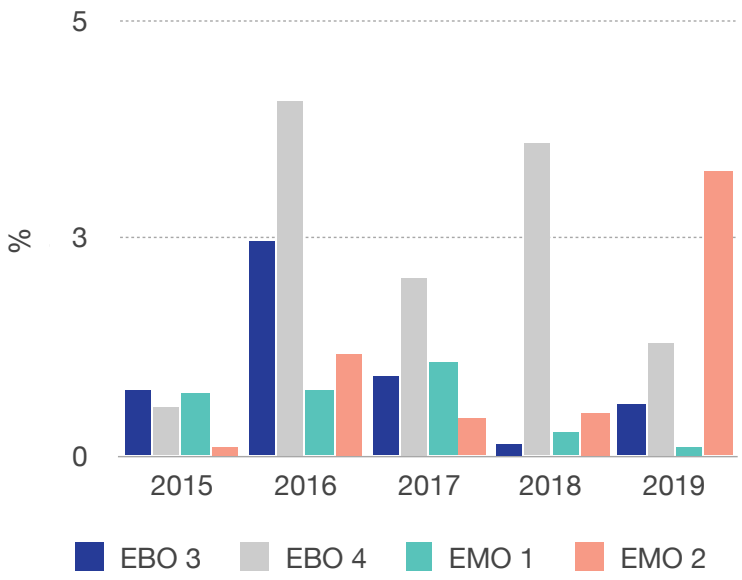
4Q 2019 WANO PWR:

3-year median	86.72%
best quartile	91.55%
best decile	91.55%

	2015	2016	2017	2018	2019
EBO 3	86.81	87.53	93.73	94.39	92.26
EBO 4	94.40	83.23	92.33	85.75	92.85
EMO 1	91.59	92.67	84.97	94.37	93.44
EMO 2	94.40	93.67	94.16	86.66	89.79

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.



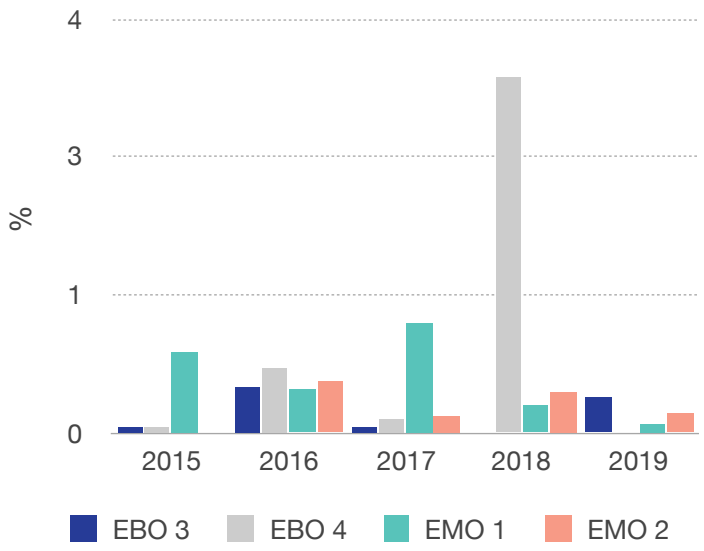
4Q 2019 WANO PWR:

3-year median	1.47%
best quartile	0.37%
best decile	0.02%

	2015	2016	2017	2018	2019
EBO 3	0.73	2.46	0.89	0.12	0.59
EBO 4	0.54	4.05	2.03	3.57	1.28
EMO 1	0.71	0.73	1.07	0.25	0.09
EMO 2	0.10	1.15	0.41	0.48	3.26

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.

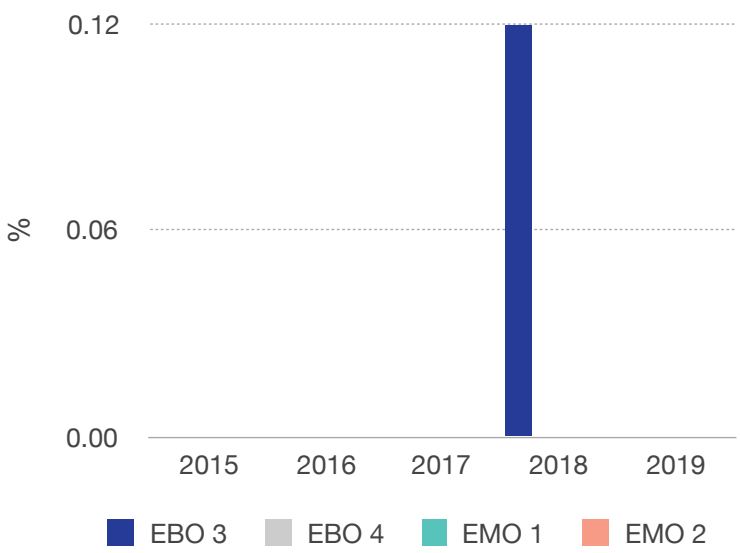


4Q 2019 WANO PWR:

3-year median	0.99%
best quartile	0.17%
best decile	0

	2015	2016	2017	2018	2019
EBO 3	0.04	0.45	0.05	0	0.33
EBO 4	0.05	0.63	0.12	3.42	0.01
EMO 1	0.77	0.42	1.05	0.27	0.09
EMO 2	0.01	0.49	0.15	0.38	0.18

Grid-Related Loss Factor



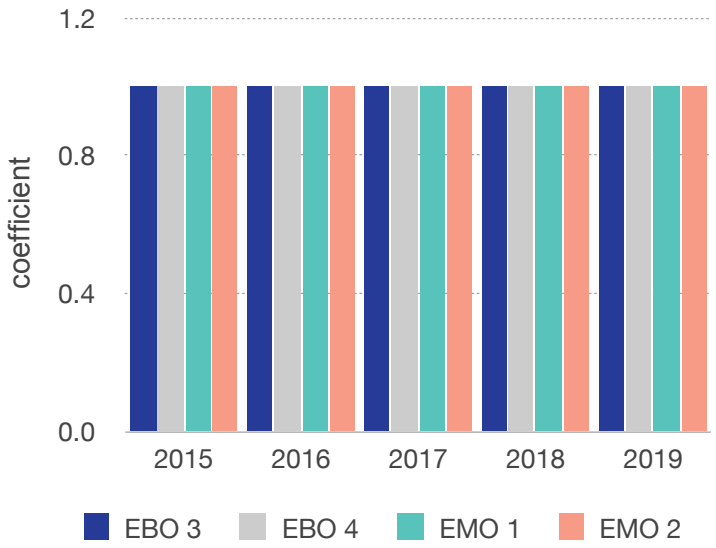
The indicator is defined as the ratio of production loss due to grid instability of trip without the possibility of power plant impact during tha monitored period, to the reference production value in the given quarter, expressed in %.

4Q 2019 WANO PWR:
3-year median is 0

	2015	2016	2017	2018	2019
EBO 3	0	0	0	0.12	0
EBO 4	0	0	0	0	0
EMO 1	0	0	0	0	0
EMO 2	0	0	0	0	0

Chemistry index

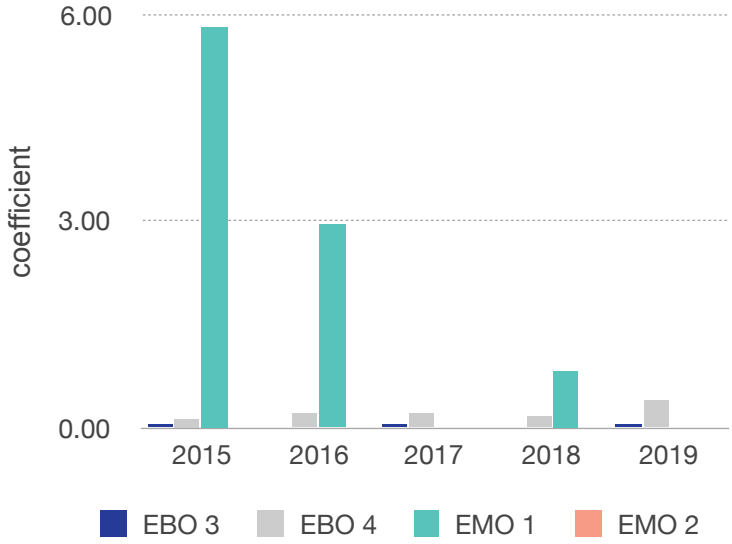
This indicator assesses the efficiency of chemical mode in the steam generators. The best attainable value of the chemistry index is 1.0. The indicator compares the concentration of selected impurities against limit values. Each value is divided by the limit value and the sum of their proportions is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



4Q 2019 WANO PWR:
3-year median 1

	2015	2016	2017	2018	2019
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



4Q 2019 WANO PWR:
3-year median 0.037

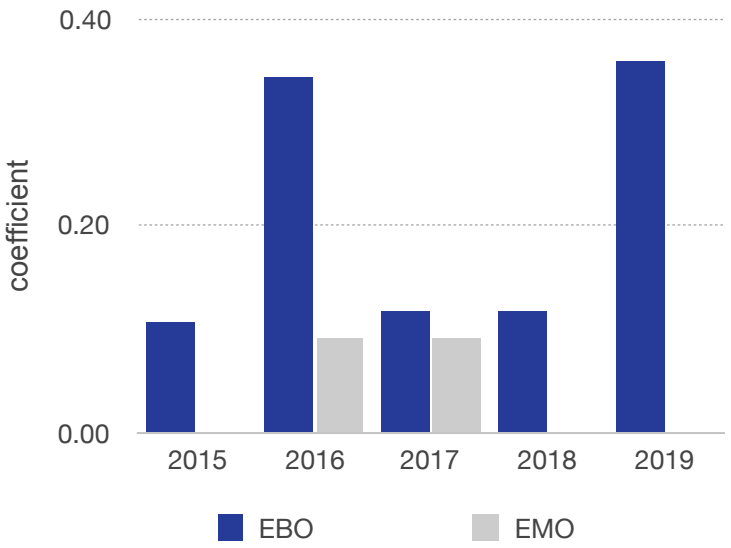
This indicator monitors the improvement and maintenance of high tightness of fuel. It is a general measure of fuel leakage. The indicator is defined as the balanced activity of the primary circuit given by iodine 131 activity in kBq/l and corrected by the uranium contribution and normalized by the coolant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

	2015	2016	2017	2018	2019
EBO 3	0.043	0.037	0.049	0.037	0.04
EBO 4	0.134	0.191	0.194	0.164	0.378
EMO 1	5.801	2.936	0.037	0.795	0.037
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 accidents per 200 000 man-hours worked by NPP personnel. Contractors' employees are not included in this indicator.

In 2019, there were three occupational accidents at EBO and none at EMO.

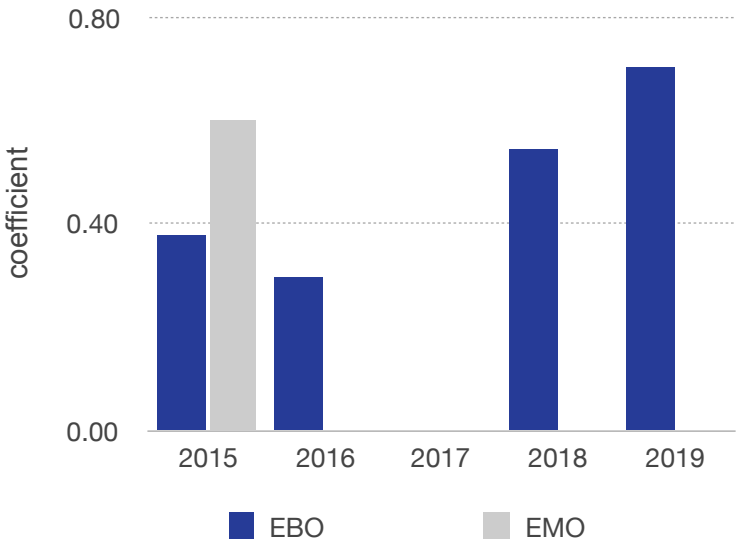


4Q 2019 WANO PWR:

3-year median	0.04
best quartile	0

	2015	2016	2017	2018	2019
EBO	0.105	0.342	0.115	0.115	0.359
EMO	0	0.09	0.09	0	0

Contractor Industrial Safety Accident Rate – CISA



4Q 2019 WANO PWR:
3-year median 0.08
best quartile 0

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.

During 2019 there was 1 occupational accident of contractor at EBO and none at EMO.

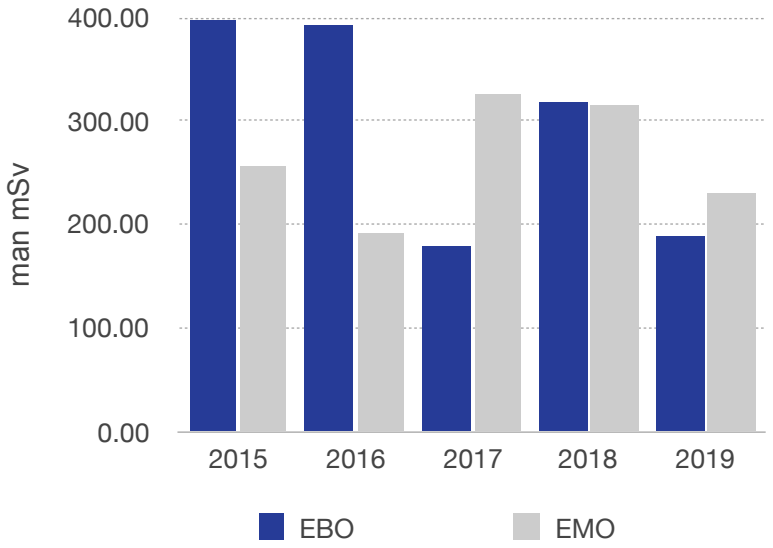
	2015	2016	2017	2018	2019
EBO	0.377	0.293	0	0.54	0.703
EMO	0.6	0	0	0	0

Collective Radiation Exposure – CRE

(mean value of collective radiation exposure per unit)

This indicator monitors the decreasing trend of overall radiation exposure of both NPP personnel and contractors. The indicator is a benchmark of radiation protection efficiency and application of the ALARA.

KED values for EBO and EMO refer to all power plant (two units). WANO values refer to a single unit.

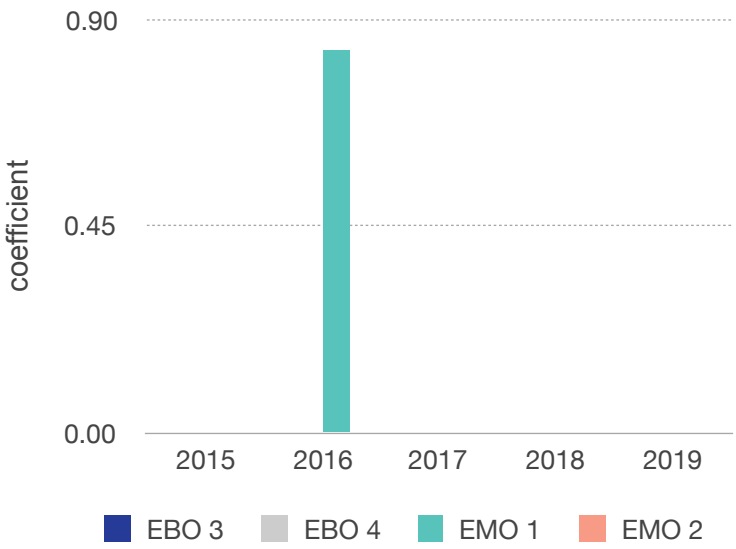


4Q 2019 WANO PWR:

3-year median	365.5
best quartile	226.4
best decile	151.1

	2015	2016	2017	2018	2019
EBO	398.3	392	178.5	317.7	188.09
EMO	255.6	192	326.1	315.1	228.55

Unplanned Automatic Scrams per 7000 Critical Hours

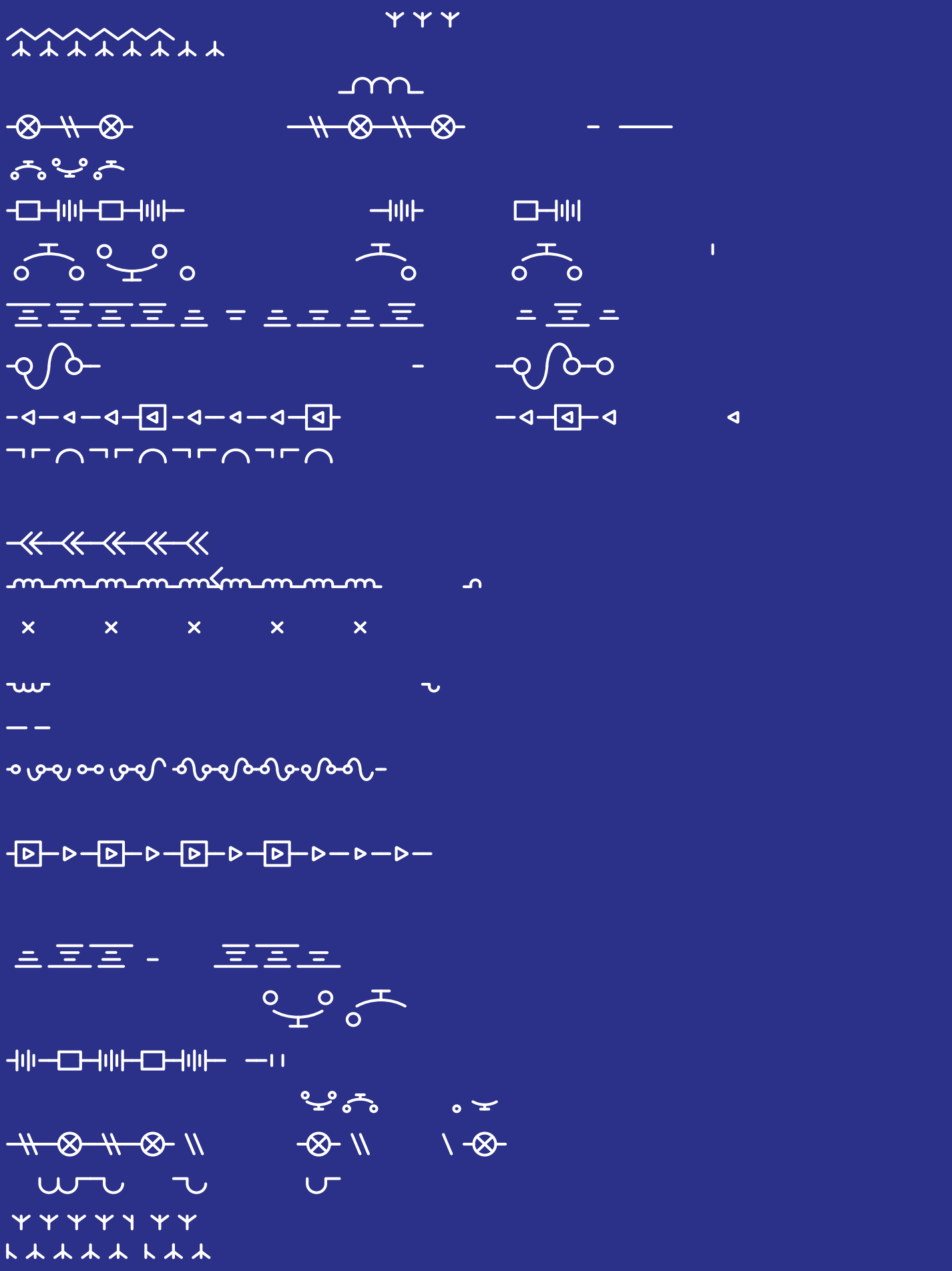


4Q 2019 WANO PWR:
3-year median 0
best quartile 0

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

At EBO and EMO there were no automatic reactor scrams in 2019.

	2015	2016	2017	2018	2019
EBO 3	0	0	0	0	0
EBO 4	0	0	0	0	0
EMO 1	0	0.83	0	0	0
EMO 2	0	0	0	0	0

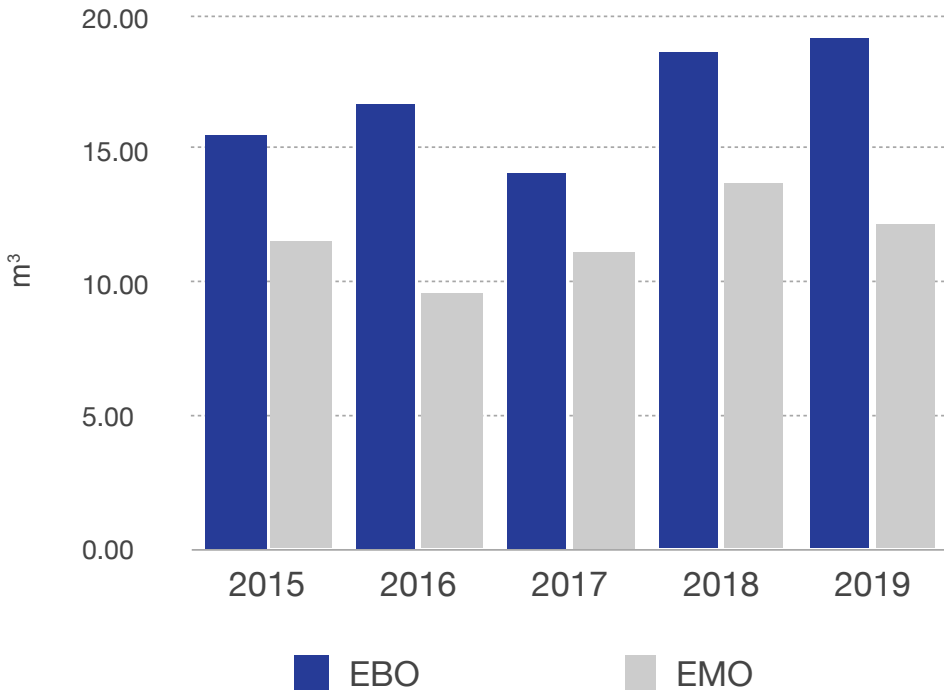


Waste production and releases to atmosphere and hydrosphere

A small quantity of radioactive wastes (RAW) is produced during operation of nuclear installations. 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 ubstances and their limit values are set by state supervision authorities.

Production of liquid RAW

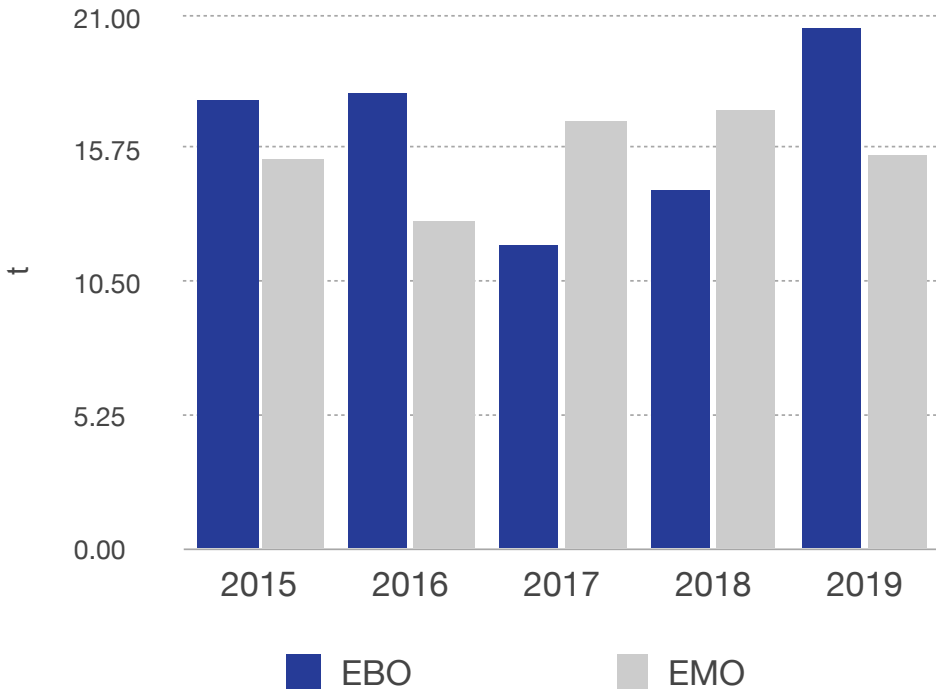
This indicator is defined as volume of liquid RAW in cubic metres generated by the nuclear installation operation converted to the boric acid content of 120g/kg.



	2015	2016	2017	2018	2019
EBO	15.538	16.694	14.08	18.543	19.064
EMO	11.514	9.554	11.078	13.645	12.159

Production of solid RAW

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



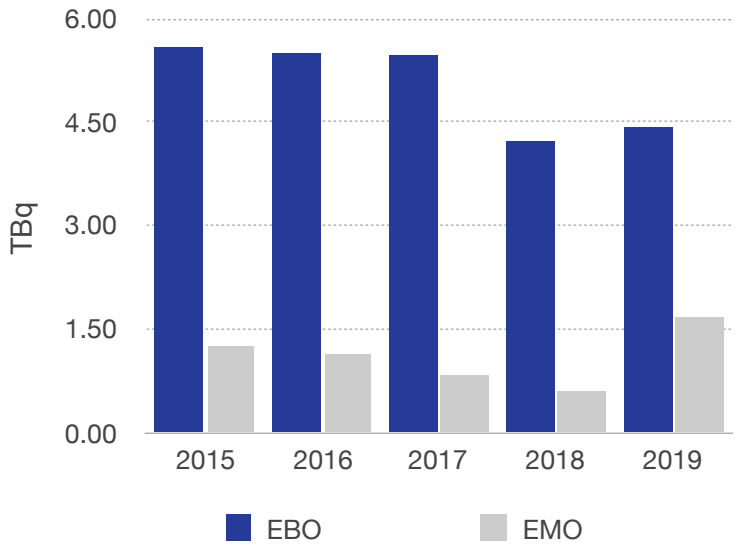
	2015	2016	2017	2018	2019
EBO	17.6	17.847	11.89	14.156	20.408
EMO	15.34	12.935	16.807	17.211	15.469

Emissions to atmosphere

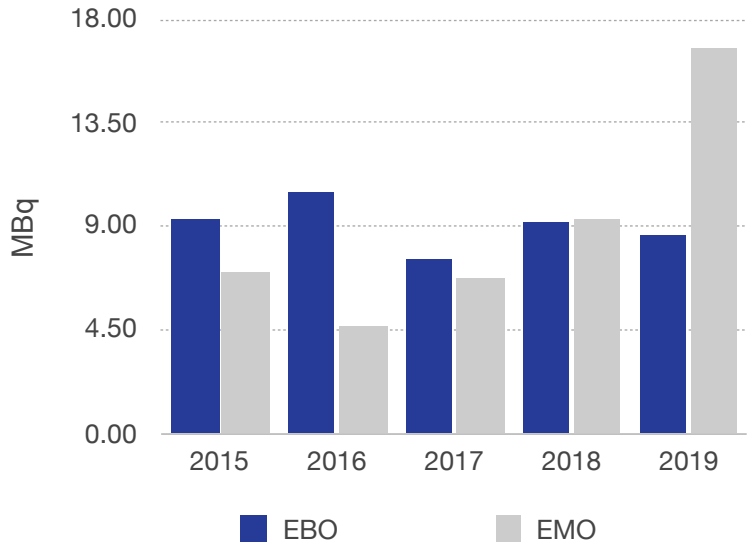
	Type of release	Activity	Unit	Share in target value for 2019 (%)*
EBO	Noble gases	4.418	TBq	0.22
EMO	Noble gases	1.67	TBq	0.041
EBO	Aerosols	8.6	MBq	0.0107
EMO	Aerosols	16.92	MBq	0.01
EBO	Iodine 131	0.365	MBq	0.000562
EMO	Iodine 131	55.27	MBq	0.08

*TV – target value determined by the Public Health Authority

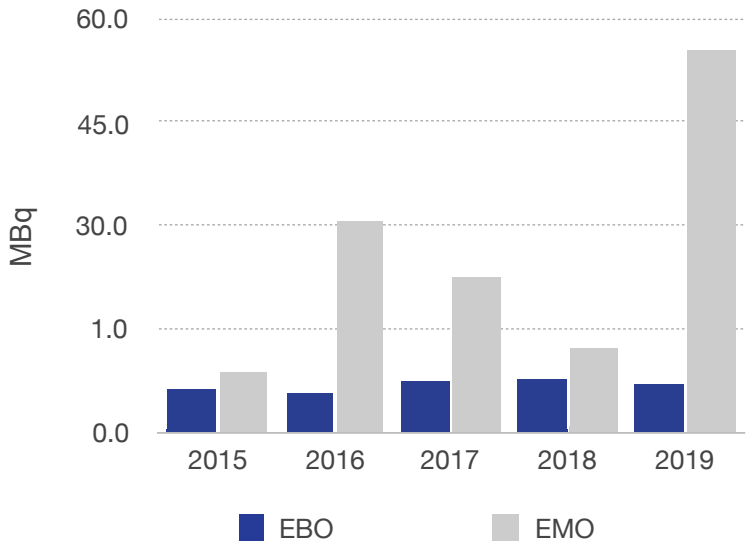
Emissions to atmosphere – noble gases



Emissions to atmosphere – aerosols

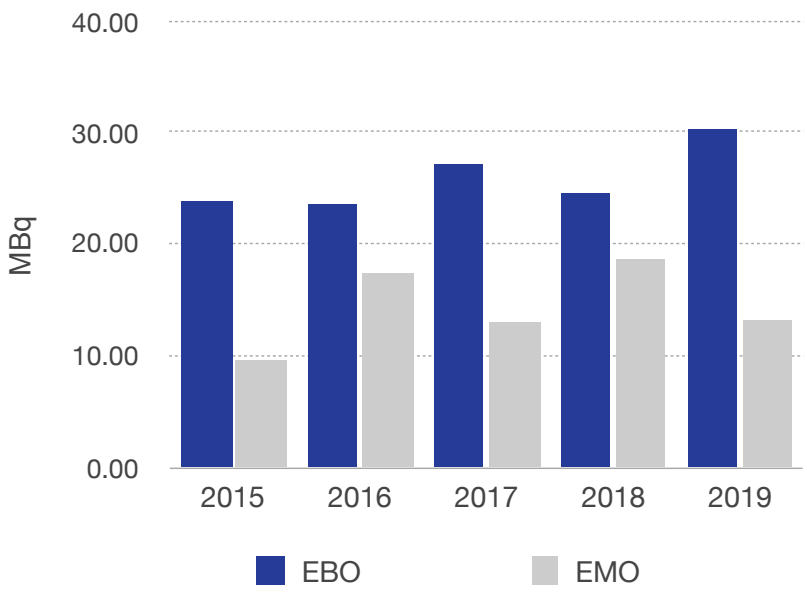


Emissions to atmosphere – iodine



Releases to hydrosphere

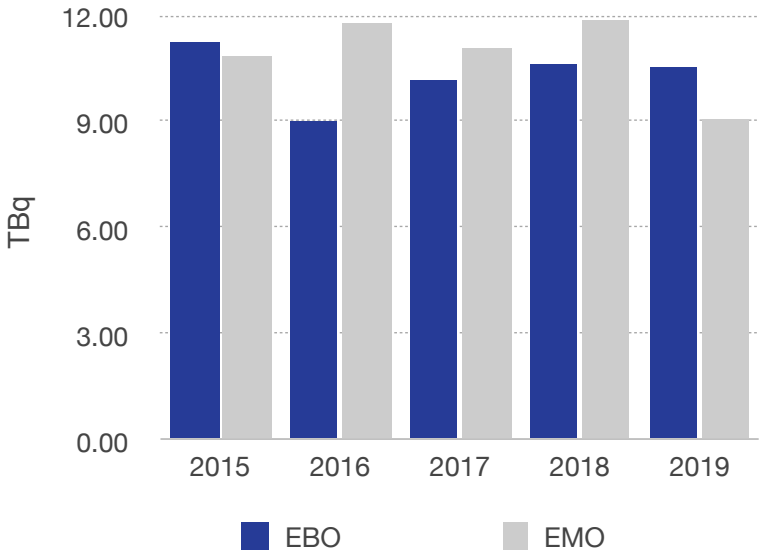
Releases to hydrosphere – activation and fission products



	Type of release	Activity	Unit	Share in target value for 2019 (%)
EBO	Activation and fission products	30.286	MBq	0.233
EMO	Activation and fission products	13.13	MBq	1.2

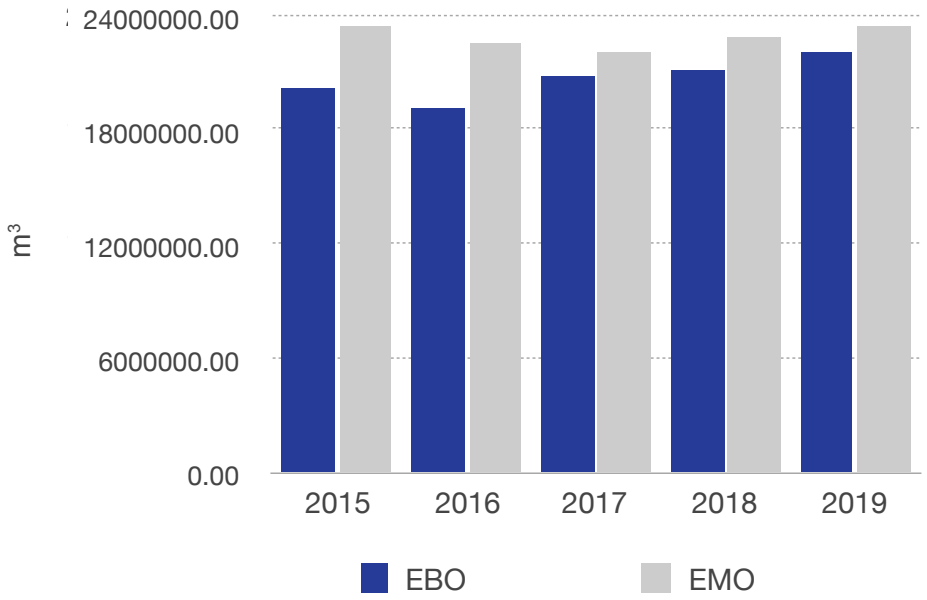
Releases to hydrosphere – tritium

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 200 times lower than the permitted limit of 20 microsievert (μSv) determined by the Public Health Authority of the Slovak Republic.



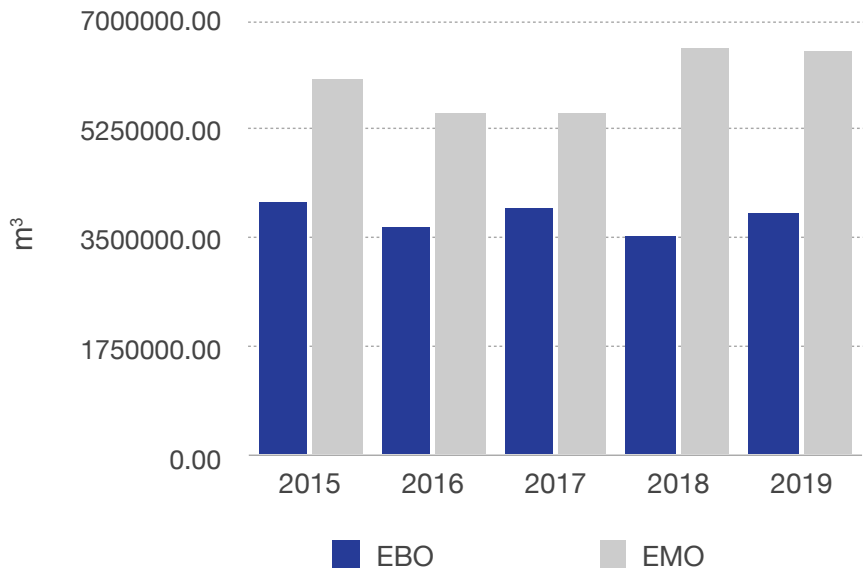
	Type of release	Activity	Unit	Share in target value for 2019 (%)
EBO	Tritium	10.502	TBq	52.51
EMO	Tritium	9.054	TBq	75.5

Surface water intake (m^3)



	EBO	EMO
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
2019	21 973 583	23 309 000

Wastewater discharge - Total volume (m^3)



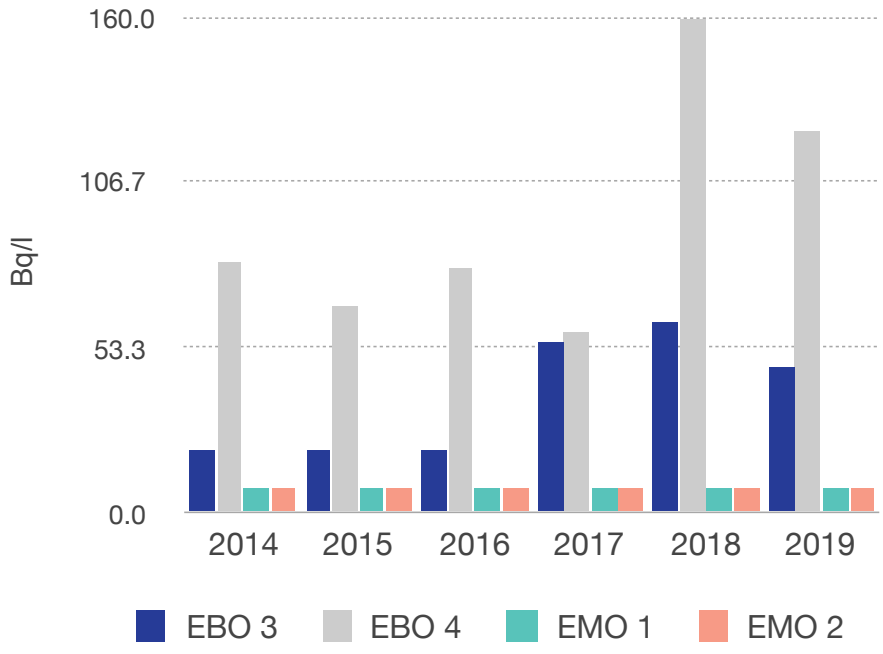
		2015	2016	2017	2018	2019
Total volume	EBO	4 051 887	3 638 429	3 952 691	3 543 241	3 897 666
	EMO	6 068 588	5 497 405	5 942 185	6 554 961	6 493 433
Industrial waste waters	EBO	4 010 005	3 607 734	3 917 886	3 507 707	3 852 955
	EMO	6 010 806	5 444 252	5 904 441	6 518 925	3 673 673
Treated sewage waters	EBO	41 882	30 695	34 805	35 534	44 711
	EMO	57 782	53 153	37 744	36 036	23 838
Allowed annual limits of discharged waters for 2 units	EBO			4 200 000		
	EMO			7 000 000		

Tightness of barriers and containment

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.

In both Bohunice NPP units, there were recorded, controlled and later eliminated small leakages of the steam generator pipelines. Radioactivity in the conventional island has been increased slightly and still below the permitted Limiting Conditions of Operation for the NPP defined at 370 Bq/l. In the Mochovce NPP, activity in the blow-down waters of both units is in the long-term at the lowest possible detection level, i.e. 7Bq/l.

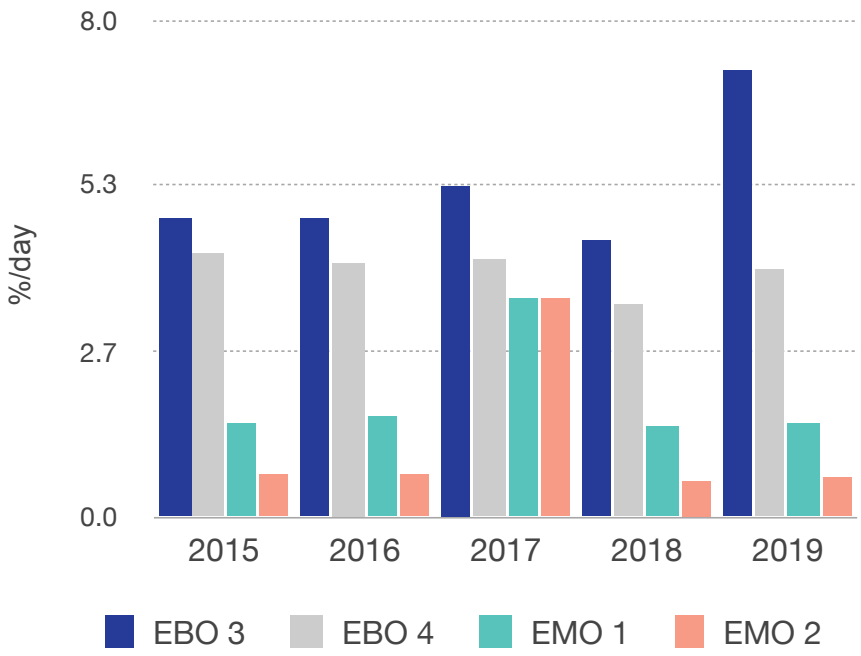


Containment tightness

This indicator monitors the containment tightness as the third physical barrier against release of 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.

The containment tightness is set by the limits and conditions.

For both Bohunice NPP units containment leakage must not exceed 13% per 24 hours.
For Mochovce NPP this value is 5% per 24 hours.



Emergency planning and preparesness

Slovenské elektrárne fulfils requirements for permanent preparedness for carrying out planned measures in the field of emergency planning in case of an extraordinary event with a very low probability of occurrence. The company's emergency preparedness system is constantly maintained and tested.

The aim of emergency preparedness is to ensure the preparedness of nuclear power plant staff and of external organisations (suppliers) for dealing with extraordinary events, with an emphasis on reducing the occurrence of the risk of an emergency/accident, mitigating their consequences, averting harm to health and reducing their effects on human health.

Activities carried out in 2019 create the basis for further development and improvement of the emergency planning process within Slovenské elektrárne: self-assessments were also carried out according to IAEA requirements for emergency planning. This assessment reported no findings of safety significance.

In June 2019, a major cooperation exercise took place at Mochovce with the units of the Firefighting Corps. The procedures and activities for ensuring the supply of raw water from the river Hron were practised by creating a 7.6 km long hose line using special firefighting technology for high-capacity pumping of water, which was unique (also within the Slovak Republic). Significantly better water supply times than planned were achieved. The participating units of the Firefighting Corps demonstrated the ability to ensure the supply of raw water for SE-EMO needs in another possible way (using new firefighting gear included in the equipment during 2016 – 2018), which significantly contributes to improving the emergency response even in the case of other extreme external events.

The functionality of the whole emergency response organisation in cooperation with crisis staffs of selected regions and municipalities and units of the integrated rescue system was verified during the premises-wide emergency exercises at both power plants. In the framework of the exercises at the nuclear power plants, the response of personnel to a severe accident was also practised.

Safety enhancement

Investment projects and modifications implemented at Bohunice NPP in 2019:

Valves modification in the nuclear island

Refurbishment of internal distribution pipes of the essential service water and non-essential service water in the conventional island

Replacement of emergency arresters in 6 kV switchgear

Replacement of the reactor protection and control system

Repair of the service station for both the nuclear and conventional island regulators by replacement

Cooling towers refurbishment

Modification of oil sampling devices

Supplementation of deaeration to cool-down lines

Investment projects and modifications implemented at Mochovce NPP in 2019:

Seismic reinforcement of the tank for the emergency feed water to steam generators of Unit 1

Additional venting in the emergency feed water system to steam generators of Unit 1

Elimination of vibration on the discharge line of emergency feed water pumps

Seismic reinforcement of the pumping station for essential service water

Seismic reinforcement of reactor coolant pump tripods at the Unit 1

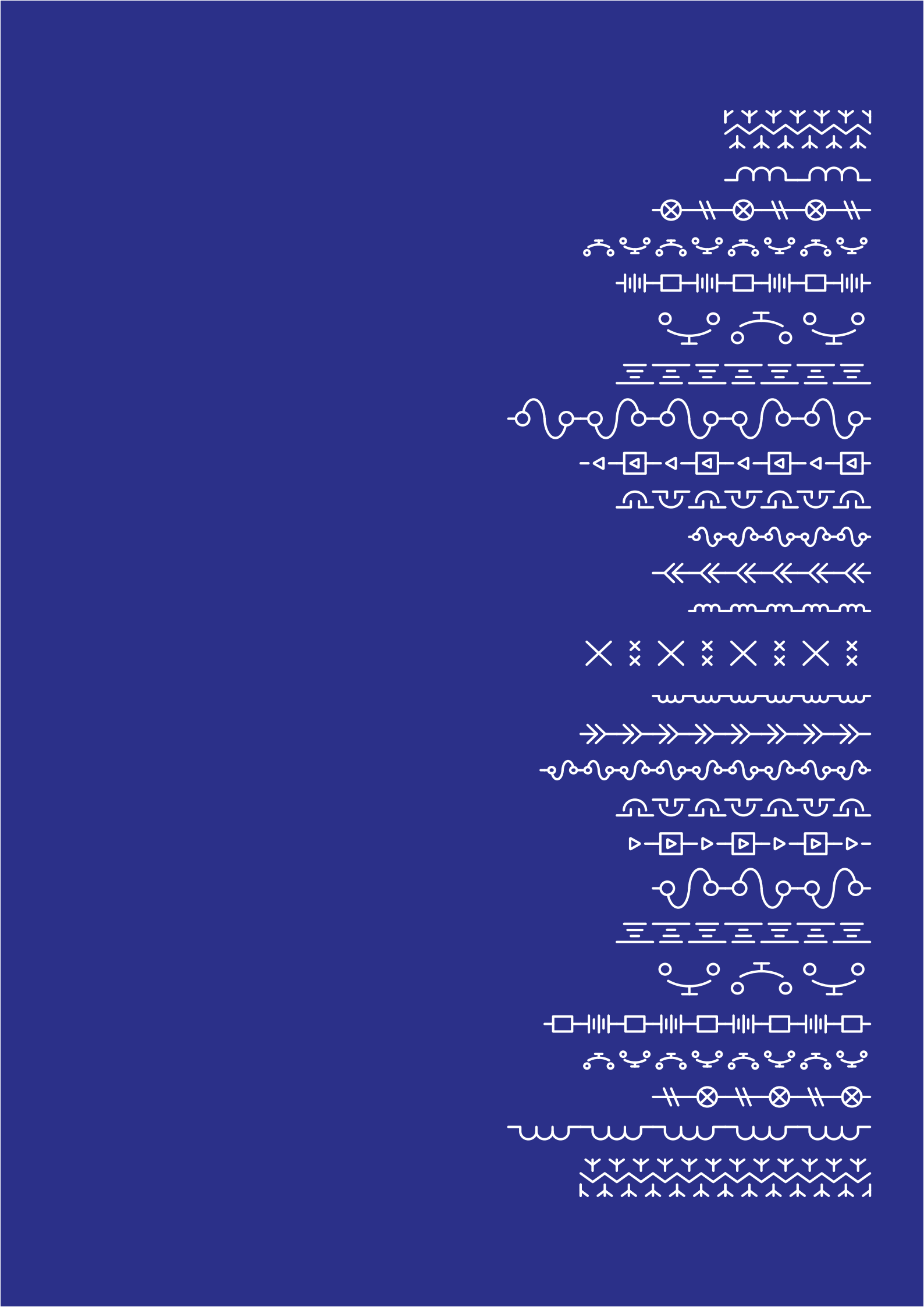
Seismic reinforcement of the platform under the reactor coolant pump internal cooling circuit exchanger

Seismic reinforcement of Unit 2 pressurizer

Seismic resistance of the Unit 2 reactor coolant pumps

Overall assessment of nuclear safety of nuclear installations

Based on the assessment of the set of operation safety indicators, the operation of nuclear installations of Slovenské elektrárne in 2019 can be considered safe and compliant to legislation concerning the use of atomic energy, while fulfilling 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.



ISO 9001
ISO 14001
OHSAS 18001
BUREAU VERITAS
Certification

The Slovenske elektrarne 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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