SLOVENSKÉ ELEKTRÁRNE

2022

Operation & Safety Report of Mochovce and Bohunice Nuclear Power Plants

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Technical data

Reactor type

VVER 440/V-213

pressurised water reactor (PWR)

Reactor thermal power	1 471 MWt
Unit nominal power	500 MWe EMO / 500 MWe EBO
In-house consumption	~7 %
Fuel	UO_2 (42 t)
Fuel enrichment	4.87 % U-235

Nuclear steam supply system

Number of cooling loops	6
Coolant flowrate	43 000 ± 2 000 m^3/h
Total volume	226 m^3
Working pressure and temperature	12.26 MPa / 258 ˚C – 298 ˚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 – 485 tonnes per hour
Steam pressure and temperature at outlet	4.61 MPa / 259 ˚C
Turbine generator	**2 per unit**
Type	ŠKODA 250 MWe
Rated speed	3 000 rpm
Generator rated power	277 MVA EMO 273 MVA EBO
Terminal voltage	15.75 kV
Rated current	3 x 10 160 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**
Min. / Max. temperature of cooling water	**13 ˚C / 33 ˚C**

Start of operation

	First 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
EMO3	22.10.2022	

Probability of reactor code damage

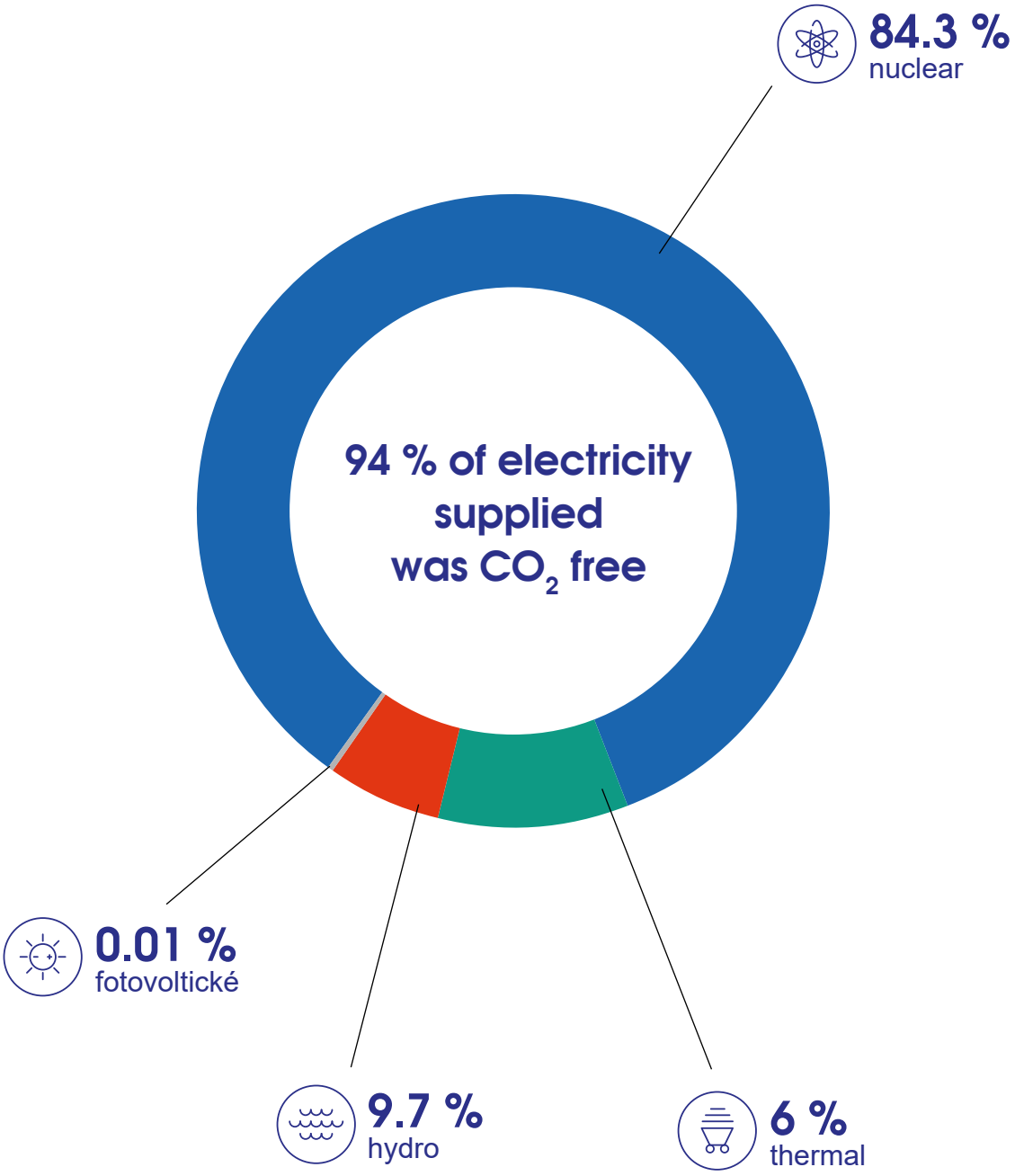
(according to PSA - probabilistic safety assessment)

	EBO	EMO
at full power	2.60E-06	2.12E-06
at shutdown reactor	5.03E-06	1.77E-06

Abbreviations:

ALARA	As Low As Reasonably Achievable
EBO	Bohunice V2 Nuclear Power Plant (Units 3&4)
EMO	Mochovce Nuclear Power Plant (Units 1&2)
IAEA	International Atomic Energy Agency
INES	International nuclear event scale
L&C	operational limits and conditions
NI	nuclear installation
NPP	nuclear power plant
NRA SR	Nuclear Regulatory Authority of the Slovak Republic
RAW	radioactive wastes
WANO	World Association of Nuclear Operators

Share of sources in electricity supplies



Annual gross electricity production

	GWh
EBO	7 829
EMO	8 091

	GWh
SE – nuclear	15 920
SE – thermal	1 136
SE – hydro	1 830
SE – photovoltaic	2
SE total	18 888

Electricity & heat supply

Indicator	Unit	2018	2019	2020	2021	2022	Since the start of operation
Electricity gross supply	MWh						
	3	3 894 701	3 905 997	3 971 956	3 991 106	3 923 549	
	4	3 619 811	3 984 611	4 003 391	4 029 899	3 905 422	
	EBO	7 514 512	7 890 608	7 975 347	8 021 005	7 828 971	
	1	3 819 341	3 820 434	3 885 941	3 700 807	4 030 392	
	2	3 509 222	3 657 845	3 583 053	4 008 210	4 060 838	
	EMO	7 328 563	7 478 279	7 468 994	7 709 017	8 091 230	
Net electricity generation	MWh						
	3	3 609 995	3 625 031	3 683 587	3 699 611	3 637 806	
	4	3 367 927	3 711 180	3 730 792	3 760 179	3 638 003	
	EBO	6 975 307	7 310 217	7 389 862	7 449 168	7 275 809	
	1	3 539 853	3 547 113	3 610 015	3 438 549	3 75 3954	
	2	3 266 323	3 398 925	3 332 800	3 747 560	3 800 497	
	EMO	6 806 176	6 946 038	6 942 815	7 186 109	7 554 451	
Heat supply	GJ						
	3	1 050 438	921 598	906 509	1 100 606	975 393	
	4	625 451	680 759	705 454	637 239	61 5942	
	EBO	1 675 889	1 602 357	1 611 963	1 737 845	1 591 335	
	1	206 660	205 467	177 952	148 032	188 787	
	2	34 938	31 345	58 122	123 112	61 582	
	EMO	241 598	236 812	236 074	271 144	250 369	
Operation period	h						
	3	8 288	8 135	8 257	8 305	8 154	
	4	7 550	8 157	8 163	8 227	8 146	
	1	8 277	8 225	8 324	8 084	8 254	
	2	7 643	7 923	8 110	8 156	8 249	
General overhaul period	days						
	3	19.45	26.04	22.81	18.89	21.3	
	4	39.93	25.12	25.85	22.20	25.3	
	1	18.5	22.3	19.2	28.2	21.1	
	2	46.6	23.8	27.6	24.4	21.3	
Gross efficiency	%						
	3	33.43	33.81	33.89	33.98	34.5	
	4	33.43	33.89	34.06	33.87	34.3	
	EBO V2	33.43	33.85	33.97	33.92	34.4	
	1	32.14	32.18	32.34	33.36	33.7	
	2	32.25	32.17	32.61	33.94	33.7	
	EMO	32.19	32.18	32.47	33.66	33.7	

Evaluation of operational safety of nuclear installations

Pursuant to the Act 541/2004 – „Atomic Act“, nuclear safety shall be understood as technical conditions and capability of a nuclear installation (NI) or transport equipment, as well as capability of their attendance staff to prevent uncontrolled release of radioactive substances or ionizing radiation to the working or natural environment, and the ability to prevent events and mitigate consequences of such events in nuclear installations or during transport of radioactive materials.

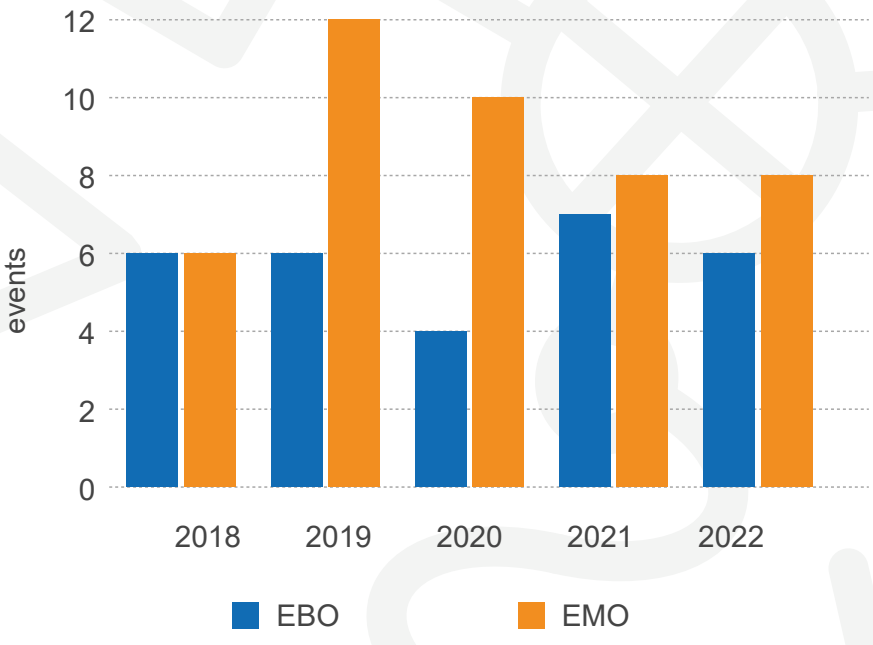
Slovenské elektrárne as the nuclear installation licensee considers nuclear safety and radiation protection as the priority permanently superior to production requirements and commercial profit.

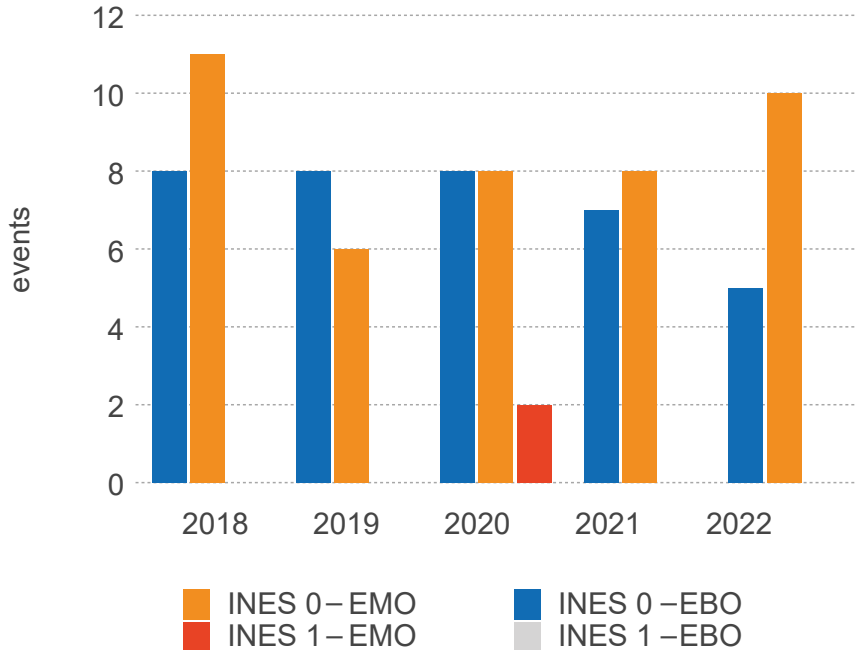
Operational events

Nuclear installation failures described in the Atomic 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 different nature and different level of impact on safety.

Operational events reported to the NRA SR:

There were 6 events of the lowest-category (failure) at EBO and 8 events at EMO recorded, which were reportable to the NRA SR. No incident or accident category events were recorded.





Assessment of operational events (INES)

IAEA guide for assessment of operational events at nuclear installation (NI) according to the INES scale provides seven degrees of severity with impact on nuclear safety and the environment.

Number of events evaluated according to the INES scale as INES 0 (below scale – deviation of no safety significance) and INES 1 (anomaly).

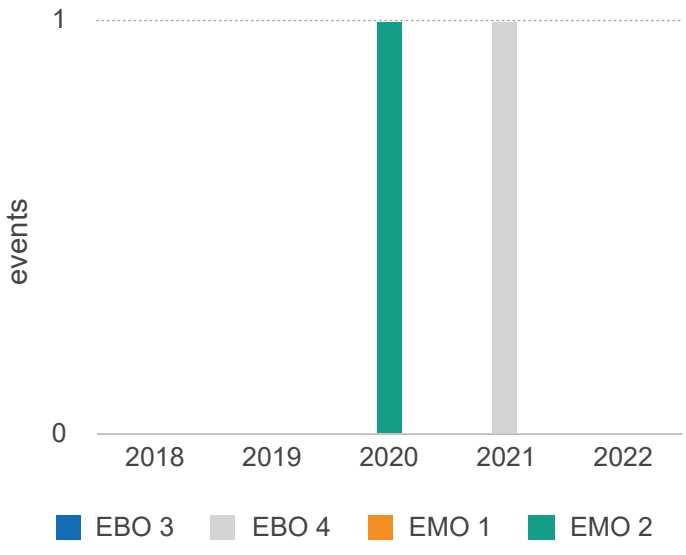
In 2022, there was no event classified as INES1 or higher at EBO or EMO.

Breach of limits and conditions of nuclear installation operation

The basic document for the operation of nuclear installations is the “Limits & Conditions of NPP safe operation” (L&C) approved by the NRA SR. The operator’s duty is to monitor and evaluate compliance with the conditions set out in the document.

The indicator monitors the management level, nuclear installation (nuclear power plant) operation organization, correctness, and adherence to operating regulations and instructions with the aim of ensuring the L&C requirements fulfilment.

In 2023, no breach of the Limits and Conditions occurred at EBO and EMO.

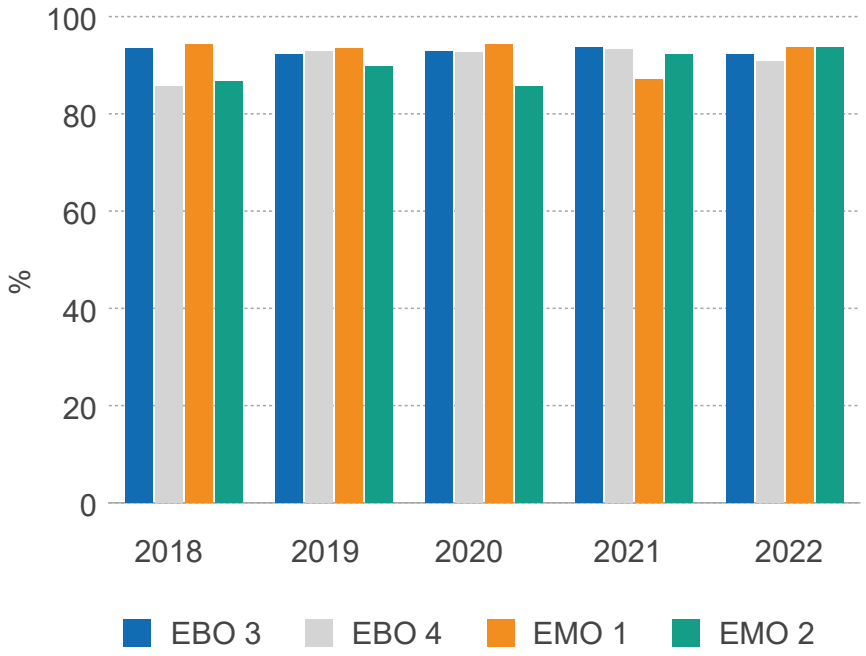


Operation

Slovenské elektrárne performs comprehensive assessment of nuclear installation safety and reliability, 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 electricity the power plant is capable to generate over monitored period, and reference energy production expressed as percentage considering external limiting factors, e.g. grid control.

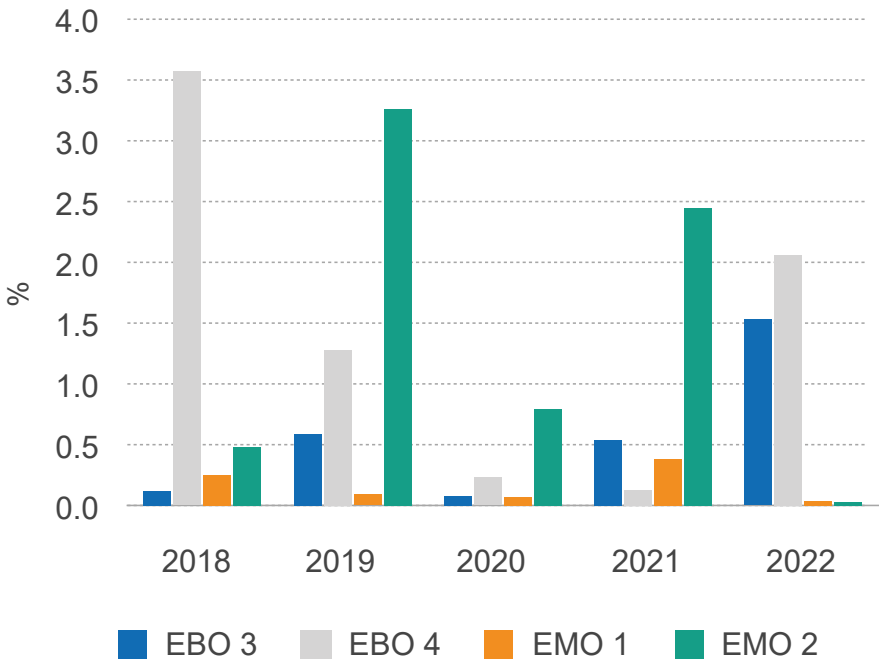


Note: WANO PWR 2022 3th quarter values for pressurised-water reactors (PWR) are presented above the graphs:
Median – middle point; 50% of all monitored cases
Quartile – 25% of the best in the monitored aggregate
Decile – 10% of the best in the monitored aggregate

Q3 2022 WANO PWR 3-year values:
median: 88.37 %
quartile: 92.74 %
decile: 94.153 %

	2018	2019	2020	2021	2022
EBO 3	94.39	92.26	92.79	93.67	92.26
EBO 4	85.75	92.85	92.71	93.37	90.84
EMO 1	94.37	93.44	92.52	87.02	93.64
EMO 2	86.66	89.79	85.76	92.34	93.74

Unplanned Capability Loss Factor – UCLF



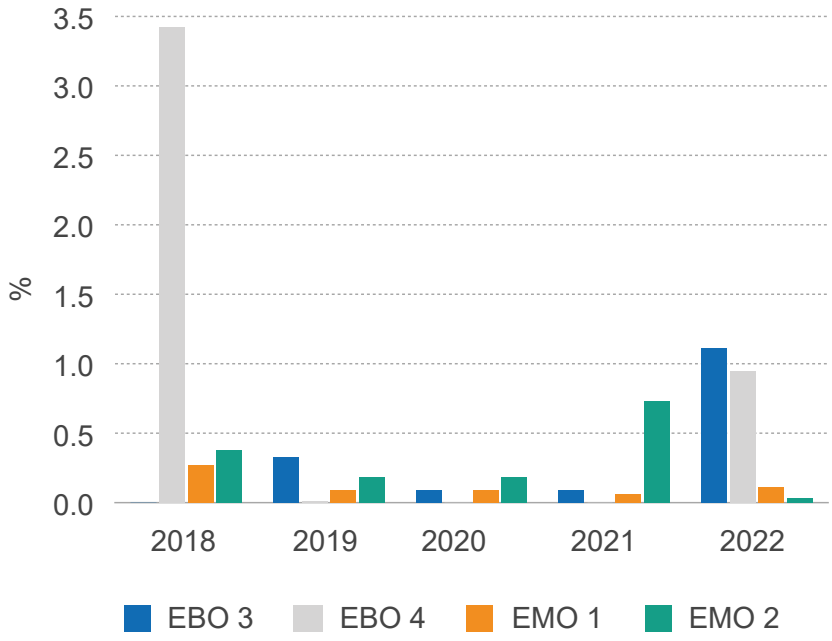
This factor monitors progress in minimization of outages and unit power reductions resulting from equipment failures and other unplanned events. The indicator is defined as the ratio between the mean value of unplanned power reductions and reference production.

Q3 2022 WANO PWR UCLF:
3-yr. median: 1.315%
best quartile: 0.298%
best decile: 0.00%

	2018	2019	2020	2021	2022
EBO 3	0.12	0.59	0.08	0.54	1.53
EBO 4	3.57	1.28	0.23	0.13	2.06
EMO 1	0.25	0.09	0.07	0.38	0.1
EMO 2	0.48	3.26	0.79	2.45	0.03

Forced Loss Rate – FLR

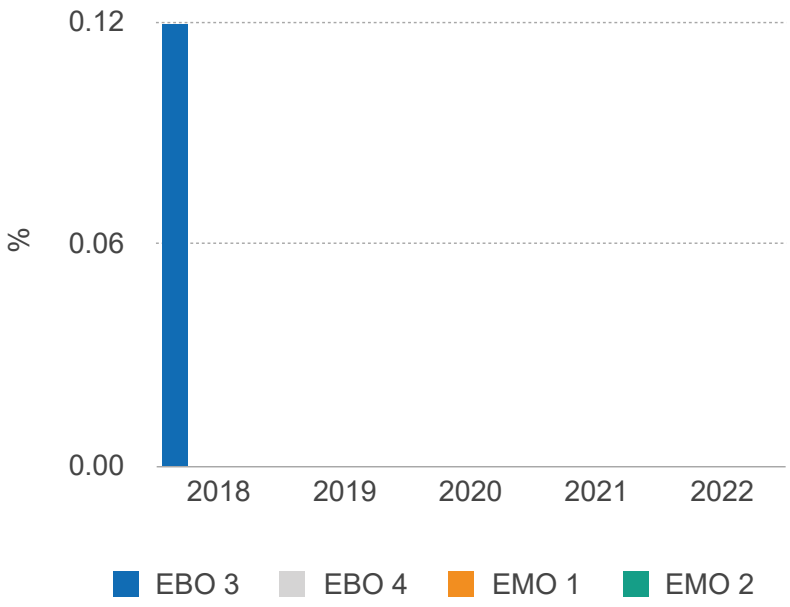
This factor is defined as the ratio of unplanned losses in electricity generation minus losses caused by unplanned extensions of planned outages, considering only the operating period to the reference electricity generation minus generation losses corresponding to planned outages and their possible unplanned extensions.



3Q2022 WANO PWR FLR:
3-yr. median: 0.85%
best quartile: 0.145%
best decile: 0.000%

	2018	2019	2020	2021	2022
EBO 3	0.00	0.33	0.09	0.09	1.11
EBO 4	3.42	0.01	0.00	0.00	0.95
EMO 1	0.27	0.09	0.09	0.06	0.11
EMO 2	0.38	0.18	0.18	0.73	0.03

Grid-Related Loss Factor – GRLF



2022 WANO – PWR GRLF
3-yr. median: 0.00

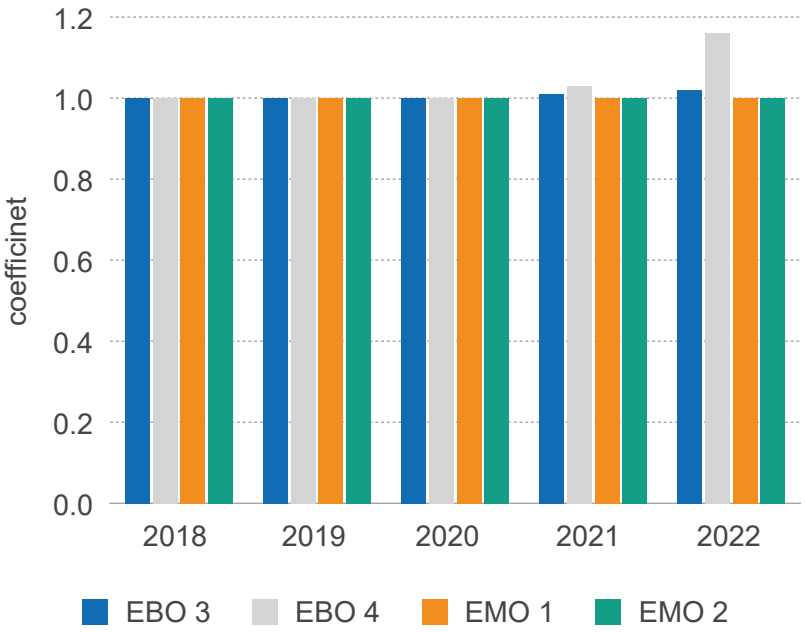
The indicator is defined as a ratio of production loss due to grid instability or grid blackout with no possibility of power plant impact during the monitored period, to the reference production value in the given quarter, expressed in %.

	2018	2019	2020	2021	2022
EBO 3	0.12	0	0	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 chemical mode efficiency in steam generators. The best achievable value of the chemistry index is 1.0. The indicator compares 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.

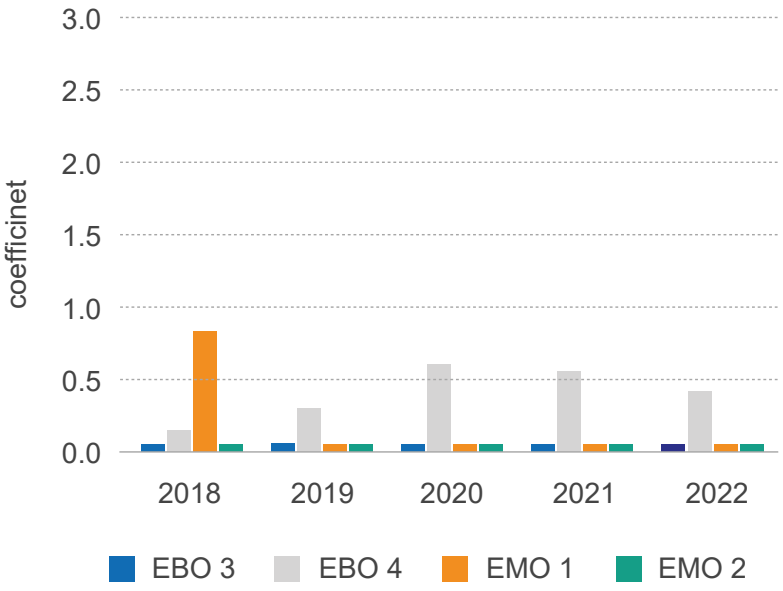
In EBO, the chemistry index values were slightly worsened due to the impact of recurring leaks in the main condensers of the turbine generators. In EMO, the best achievable values of the WANO chemistry index were reached.



2022 WANO PWR CPI:
3-yr. median: 1.00

	2018	2019	2020	2021	2022
EBO 3	1	1	1	1.01	1.02
EBO 4	1	1	1	1.03	1.16
EMO 1	1	1	1	1	1
EMO 2	1	1	1	1	1

Fuel Reliability



2022 WANO PWR FRI
median: 0.037 %
best quartile: 0.037 %

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

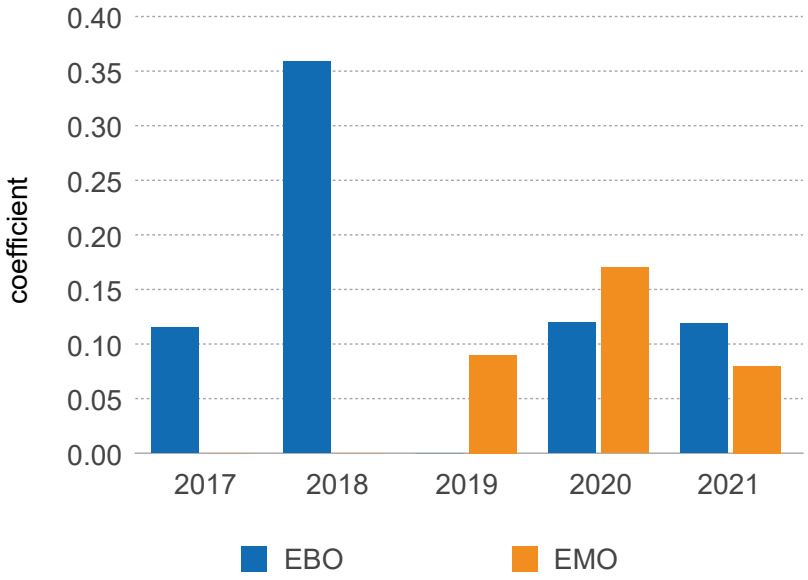
The indicator demonstrates that fuel in all SE Units is leak-tight.

	2018	2019	2020	2021	2022
EBO 3	0.037	0.04	0.038	0.037	0.037
EBO 4	0.164	0.378	0.561	0.506	0.407
EMO 1	0.795	0.037	0.037	0.037	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.

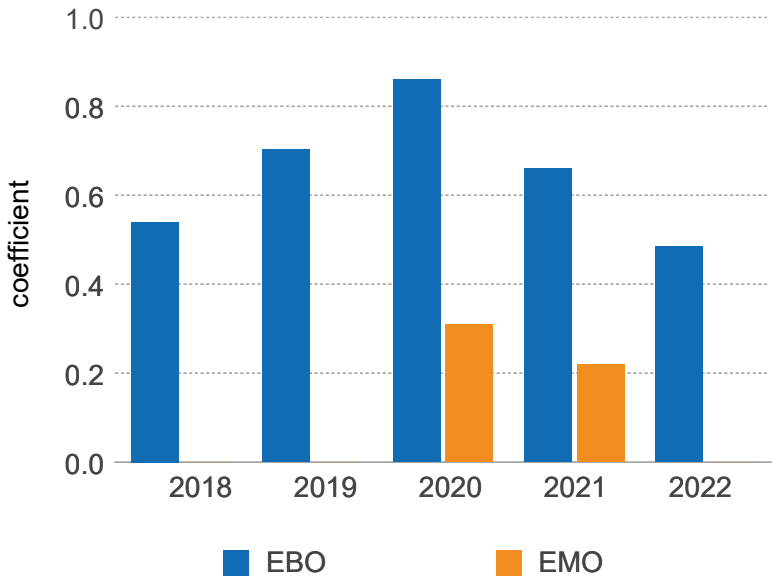
In 2022, there was one lost-time occupational injury in EBO and one registered occupational injury with impact on ISA2 coefficient in EMO.



3Q2022 WANO PWR ISA2:
3-yr. median: 0.03
best quartile: 0.00

	2018	2019	2020	2021	2022
EBO	0.115	0.359	0	0.12	0.119
EMO	0	0	0.09	0.17	0.08

Contractor Industrial Safety Accident rate – CISA



3Q2022 WANO PWR CRE:
3-yr. median: 0.05
best quartile: 0.00

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 accident day) or fatalities per 200,000 man-hours worked.

In 2022, there was one lost-time occupational injury of a contractor in EBO. No lost-time occupational injury was recorded in EMO.

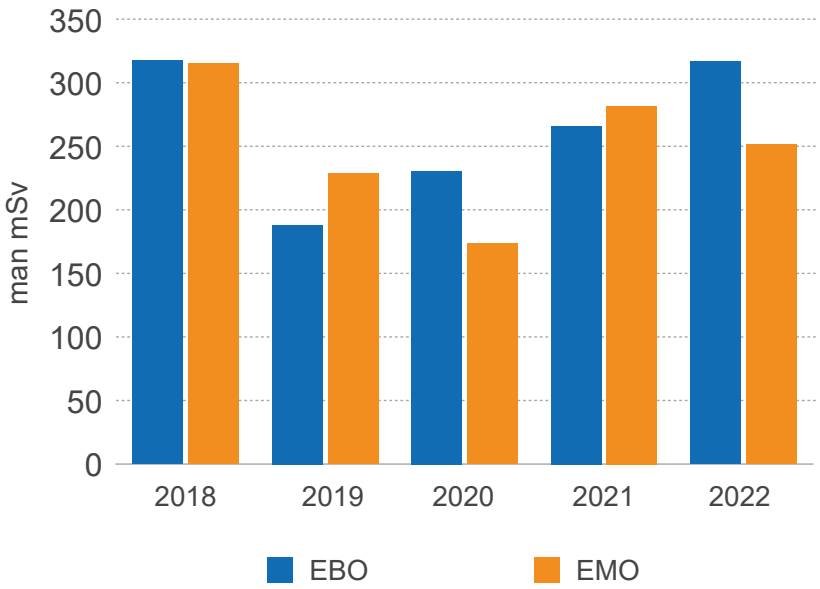
	2018	2019	2020	2021	2022
EBO	0.54	0.703	0.86	0.66	0.485
EMO	0	0	0,31	0,22	0

Collective Radiation Exposure – CRE

(average value of collective radiation exposure per unit)

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

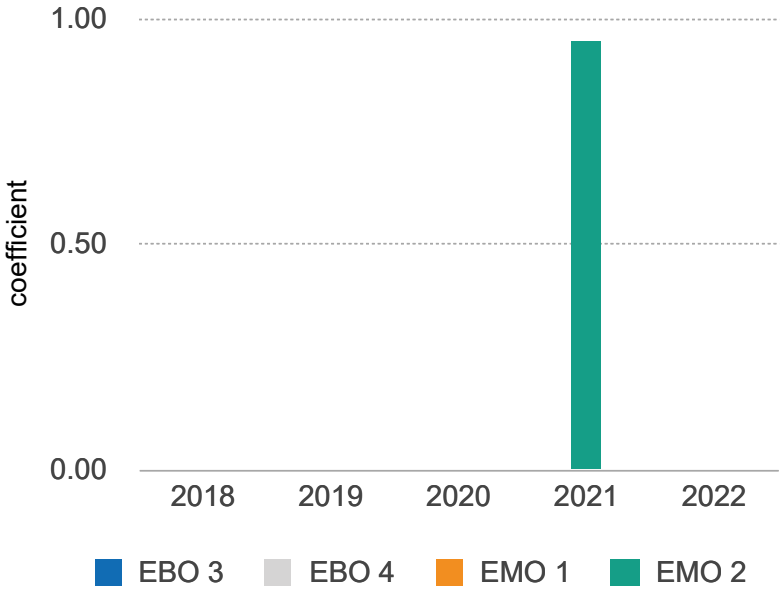
Note: CRE values for EBO and EMO refer to the whole power plant (two units). WANO values refer to a single unit.



3Q2022 WANO PWR CRE
3-yr. median: 338.45
best quartile: 241.07
best decile: 159

	2018	2019	2020	2021	2022
EBO	317.7	188.09	230.576	265.94	316.8
EMO	315.1	228.55	173.55	281.7	251.7

Unplanned Automatic Scrams per 7000 critical hours



This indicator shows number of unplanned automatic unit scrams caused by reactor protection activation per 7,000 critical reactor-hours.

There was no automatic reactor scram in EBO or EMO in 2022

3Q2022 WANO PWR UA7
3-yr. median: 0

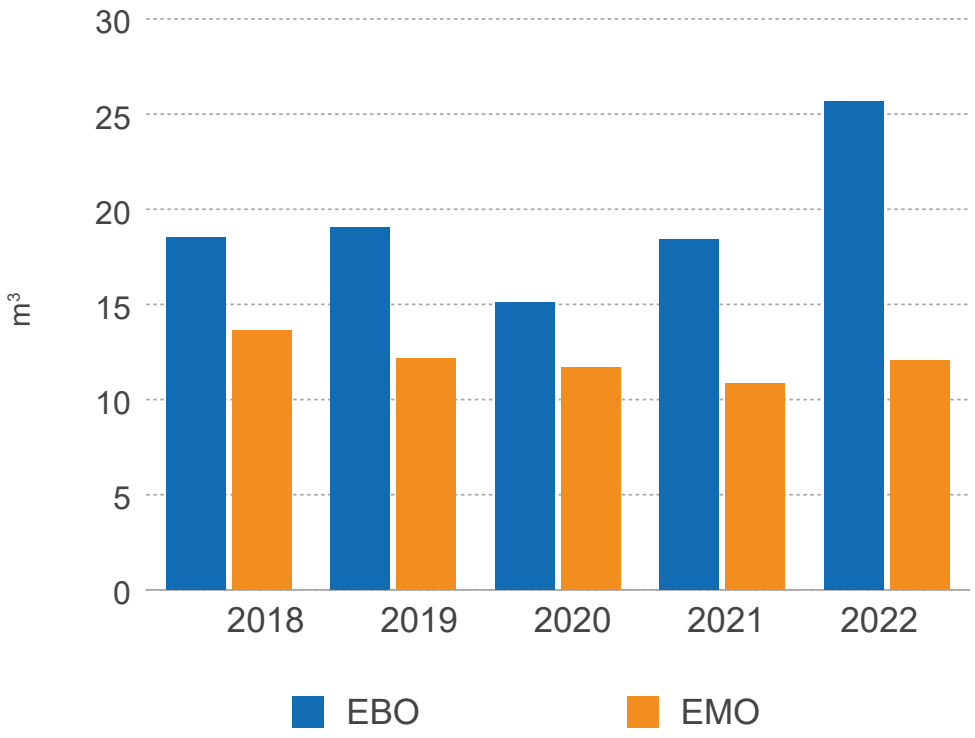
	2017	2019	2020	2021	2022
EBO 3	0	0	0	0	0
EBO 4	0	0	0	0	0
EMO 1	0	0	0	0	0
EMO 2	0	0	0	0.853	0

Waste production and releases to atmosphere and hydrosphere

Small quantities of radioactive wastes (RAW) are produced during nuclear installation operation. Liquid and solid wastes are treated and stored in the radioactive waste repository at Mochovce. In addition to this, small volumes of radioactive substances are released into the environment in the form of liquid and gaseous discharges. Slovenske elektrarne tries to minimize production of RAW as well as the environmental discharges. Discharge values, types of substances and their limit values are set by state regulatory authorities.

Production of liquid RAW

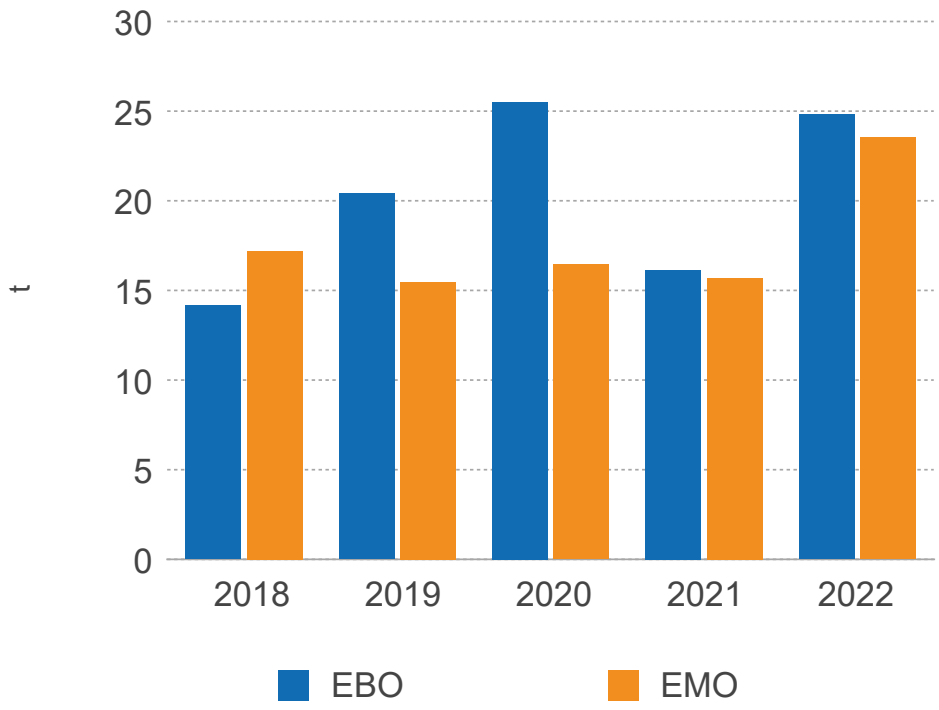
This indicator is defined as volume of liquid RAW in cubic metres generated by the nuclear installation operation converted to the boric acid content of 120g/kg.



	2018	2019	2020	2021	2022
EBO	18.543	19.064	15.126	18.398	25.683
EMO	13.645	12.159	11.7	10.84	12.066

Production solid RAW

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



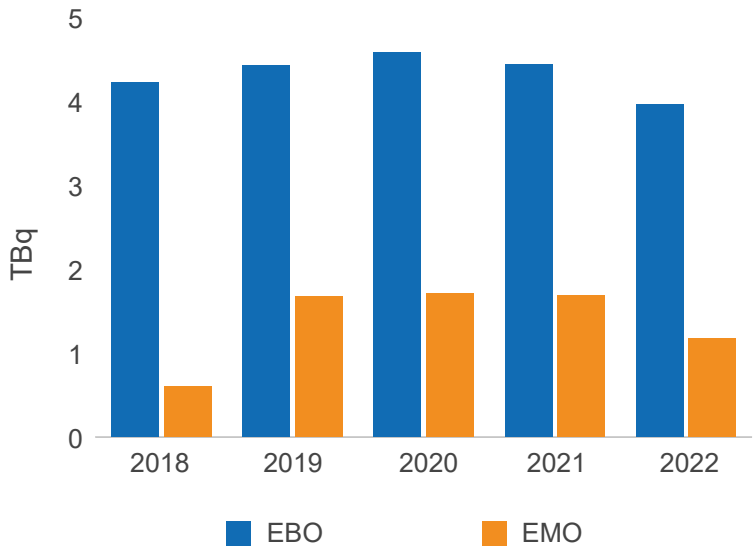
	2018	2019	2020	2021	2022
EBO	14.156	20.408	25.502	16.154	24.82
EMO	17.211	15.469	16.45	15.681	23.53

Emissions to atmosphere

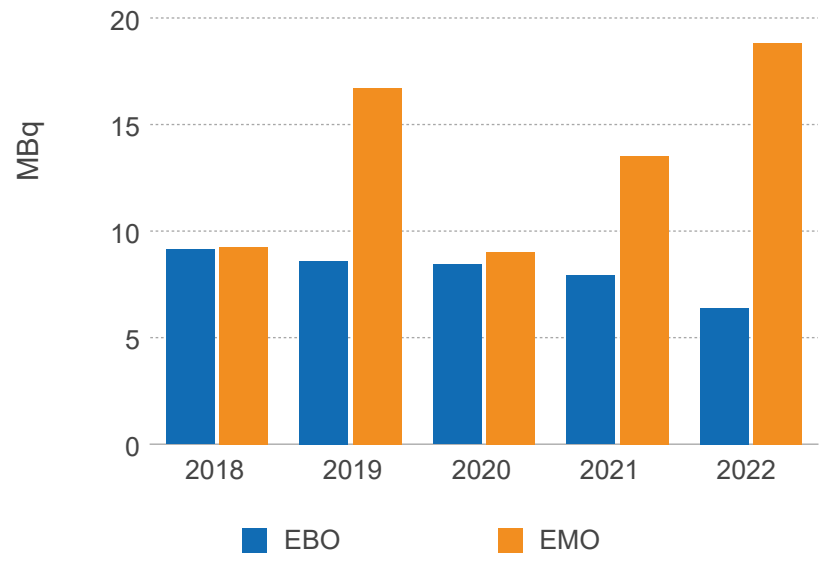
	Type of discharge	Activity	Unit	Share in ATV* for 2022 (%)
EBO	Noble gases	3.961	TBq	0.2
EMO	Noble gases	1.171	TBq	0.02
EBO	Aerosols	6.399	MBq	0.0079
EMO	Aerosols	18.83	MBq	0.0074
EBO	Iodine 131	0.258	MBq	0.0004
EMO	Iodine 131	0.679	MBq	0.000067

*ATV – annual target value set by the Public Health Authority

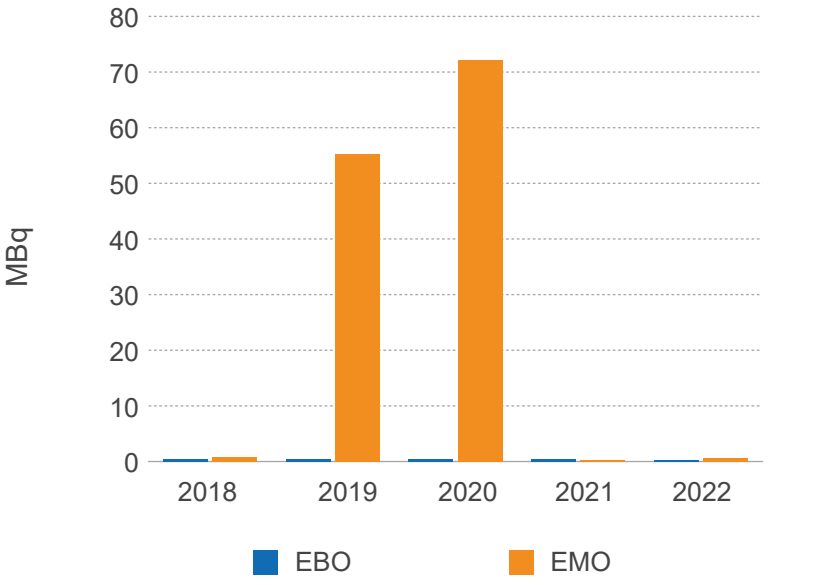
Emissions to atmosphere – noble gases



Emissions to atmosphere - aerosols

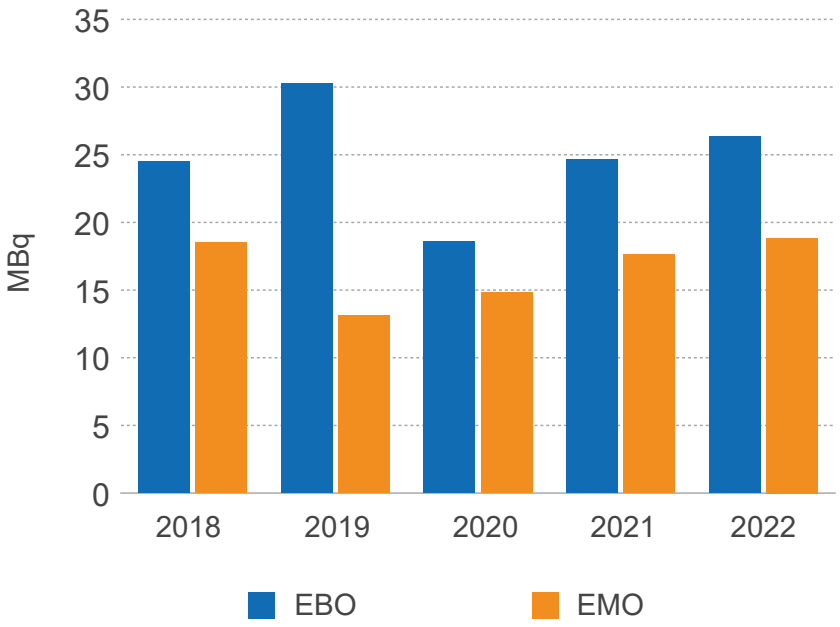


Emissions to atmosphere – Iodine



Releases to hydrosphere

Releases to hydrosphere – activation and fission products



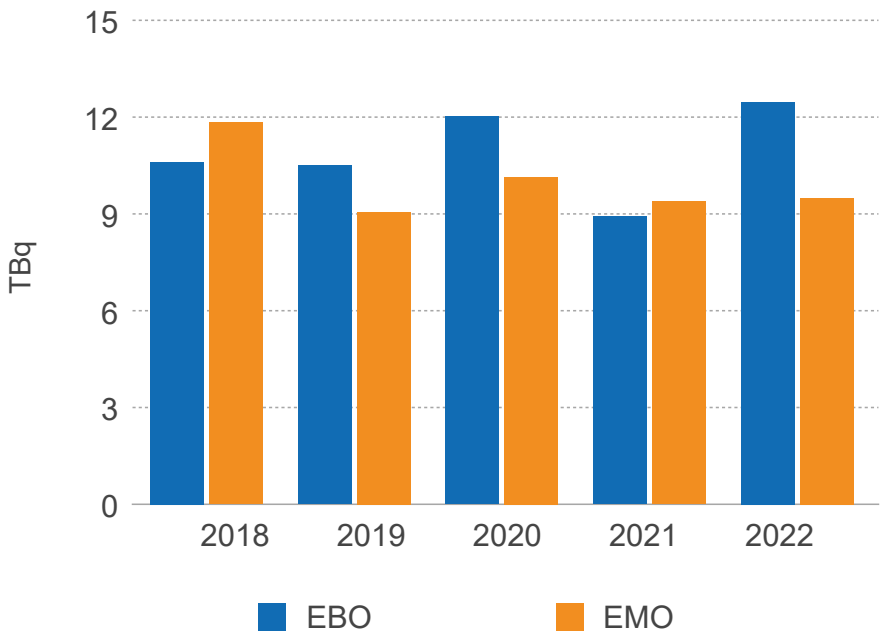
	Type of release	Activity	Unit	Share in target value for 2022 (%)*
EBO	Activation and fission products	26.362	MBq	0.20
EMO	Activation and fission products	18.85	MBq	1.14

*TV – target value determined by the Public Health Authority

Releases to hydrosphere – Tritium

The impact of NPP operation to the environment was minimal. It is verified by calculation of the annual dose for citizens in the power plant surroundings according to the approved conservative methodology.

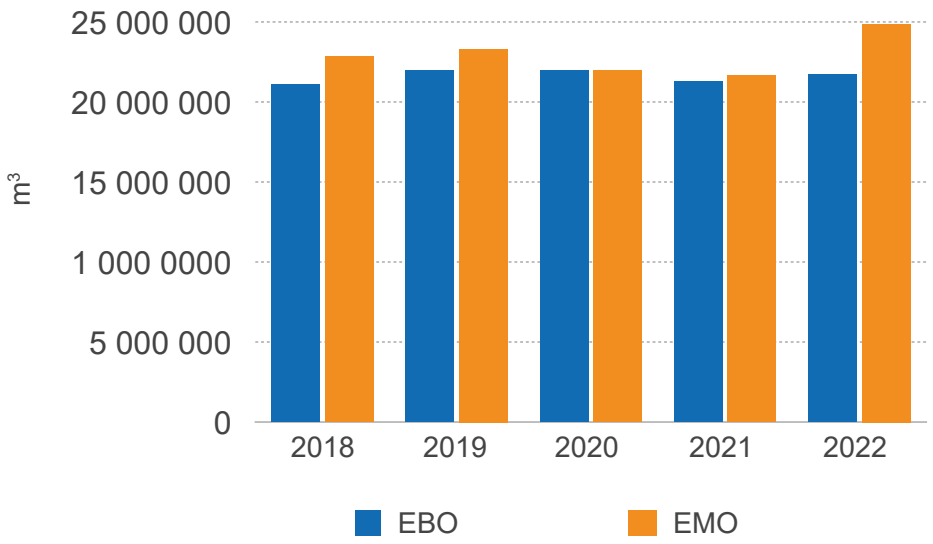
The calculated maximum values are approximately 200 times lower than the permitted limit of 20 micro Sievert (20μSv) set by the Public Health Authority of the Slovak Republic.



	Type of release	Activity	Unit	Share in target value for 2022 (%)*
EBO	Tritium	12.47	TBq	62.35
EMO	Tritium	9.492	TBq	52.7

*TV – target value determined by the Public Health Authority

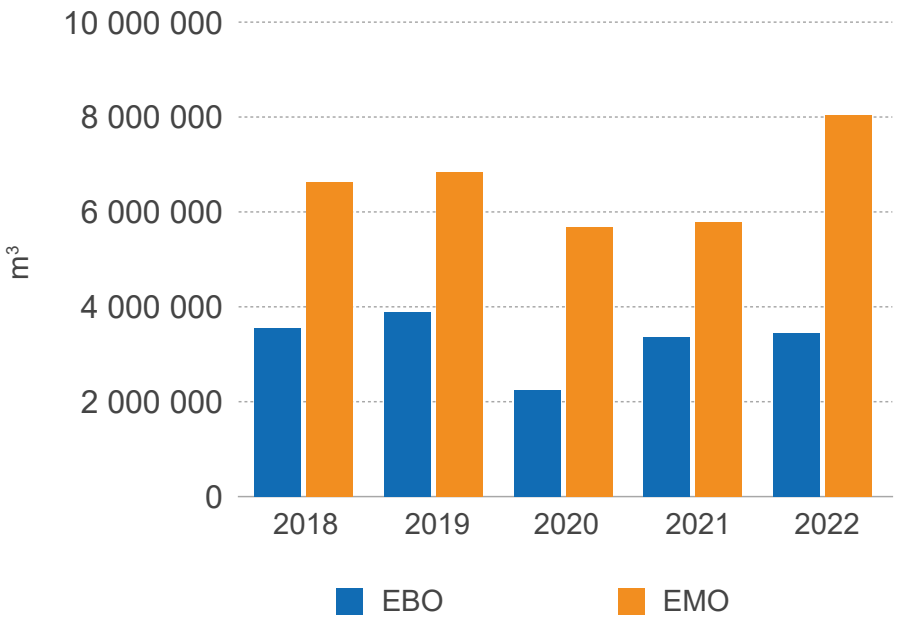
Surface water intake (m^3)



	EBO	EMO
2018	21 117 382	22 836 000
2019	21 973 583	23 309 000
2020	21 954 345	21 975 000
2021	21 288 165	21 647 281
2022	21 728 295	24 872 719*

* For 3 Units of Mochovce

Wastewater discharge - Total volume (m^3)



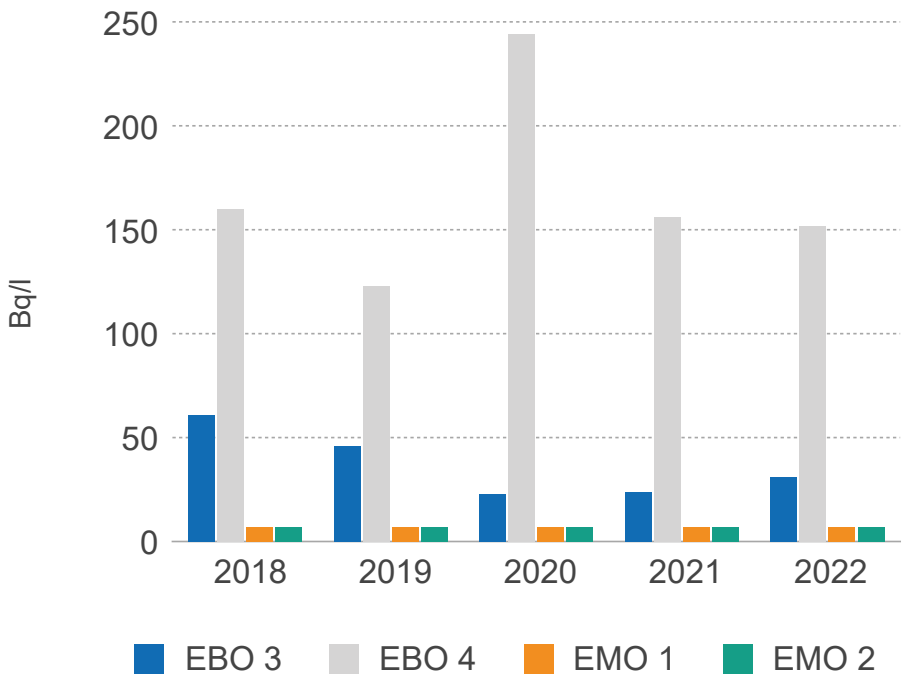
		2018	2019	2020	2021	2022
Total volume	EBO	3 543 241	3 897 666	2 241 638	3 366 926	3 435 944
	EMO	6 629 215	6 837 019	5 687 949	5 785 476	8 031 460
Industrial waste waters	EBO	3 507 707	3 852 955	2 204 200	3 336 502	3 406 262
	EMO	6 554 961	6 493 433	5 543 035	5 575 530	7 860 415
Treated sewage waters	EBO	35 534	44 711	37 438	30 424	29 682
	EMO	22 676	23 838	21 625	13 647	13 761
Allowed annual limits of discharged waters for 2 units of EBO or 3 units of EMO resp.	EBO			4 200 000		
	EMO			10 000 000		

Barrier and containment tightness

Barrier tightness

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

In EBO, small leaks of steam generator (SG) tubes were registered, inspected, and consequently eliminated. Activity in the secondary circuit of EBO Unit 3 increased only slightly, and it was below the values allowed by the Limits and Conditions of safe operation of NI that is 370 Bq/l. Activity in the secondary circuit of EBO Unit 4 was above the limit value, at which increased inspection activity is performed according to the Limits and Conditions; however, under the values allowed by the Limits and Conditions of safe operation.
Activity of blowdown water in both EMO units has been at the lowest possible detectable limit – 7 Bq/l for a long term.



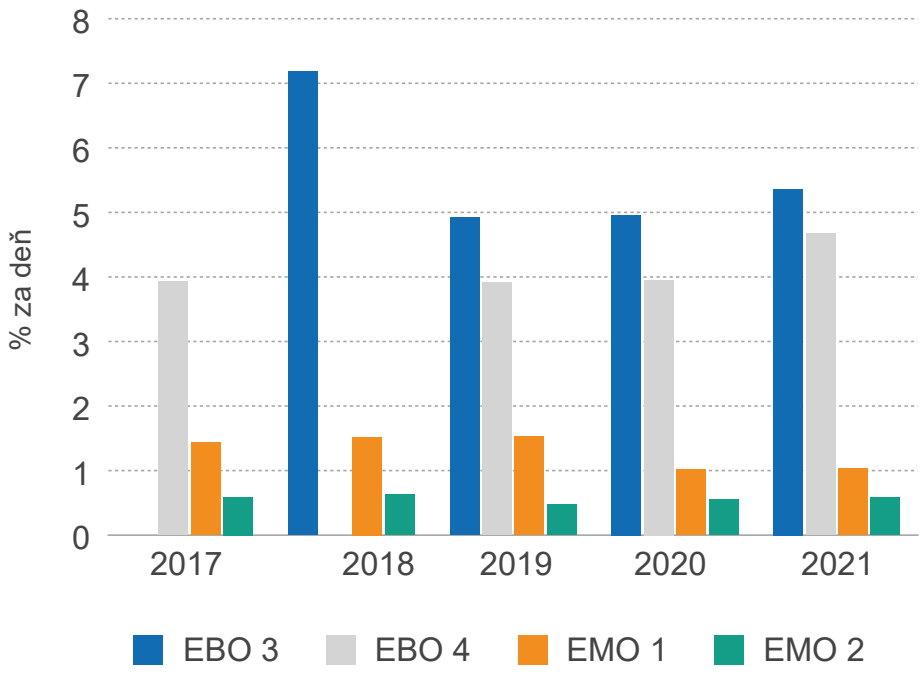
Containment tightness

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

Containment tightness is defined by the Limits and Conditions.

For both Bohunice NPP units containment leakage shall not exceed 13 % per 24 hours.

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



Emergency planning and preparedness

Slovenské elektrárne permanently maintains and regularly tests the emergency planning and preparedness system, incl. public warning and notification system, for a case of a radiation event or accident, probability of which is extremely low.

The aim of emergency preparedness is to be prepared for extraordinary events, focusing on reducing the risk of an event occurrence, mitigation of its consequences, prevention of harm to health and reducing the effects on human health

In 2022 emergency response drill were performed at Bohunice and Mochovce NPPs with university hospitals in the power plants buffer areas to review mutual procedures and activities for transport and reception of injured and contaminated persons.

Safety enhancement

Investment projects and modifications implemented at Bohunice NPP:

Replacement of main condenser tubes of turbine generators

Modification of steam generator heterogeneous welds

Restoration of design reliability of safety system coolers

Design modification of sealing nodes of safety system heat exchangers

Modification of special water treatment

Modification of cranes in the controlled zone

Modification of transformer door contacts and their function

Replacement of electrical protections on outlets of 6 kV switchgears of safety systems

Heating of the turbine hall heat-exchange station from turbine generator steam take-offs

Modification of control panel of stable fire-extinguishing system for extinguishing of main circulation pump deck

Investičné projekty a modifikácie zrealizované v AE Mochovce:

Completion of a multi-year project of plant seismic reinforcement to the new PGA of 0.15 g, including seismic reinforcement of electrical switchgears, electrical power supply for high-pressure boric acid injection pumps to reactor, boric acid tanks, other process equipment and structures

Repair and modernisation of cooling towers

Replacement of tubes in main condensers due to the unsatisfactory condition of tubes after many years of operation

Replacement of the last unit transformer at Unit 1 to increase the plant efficiency

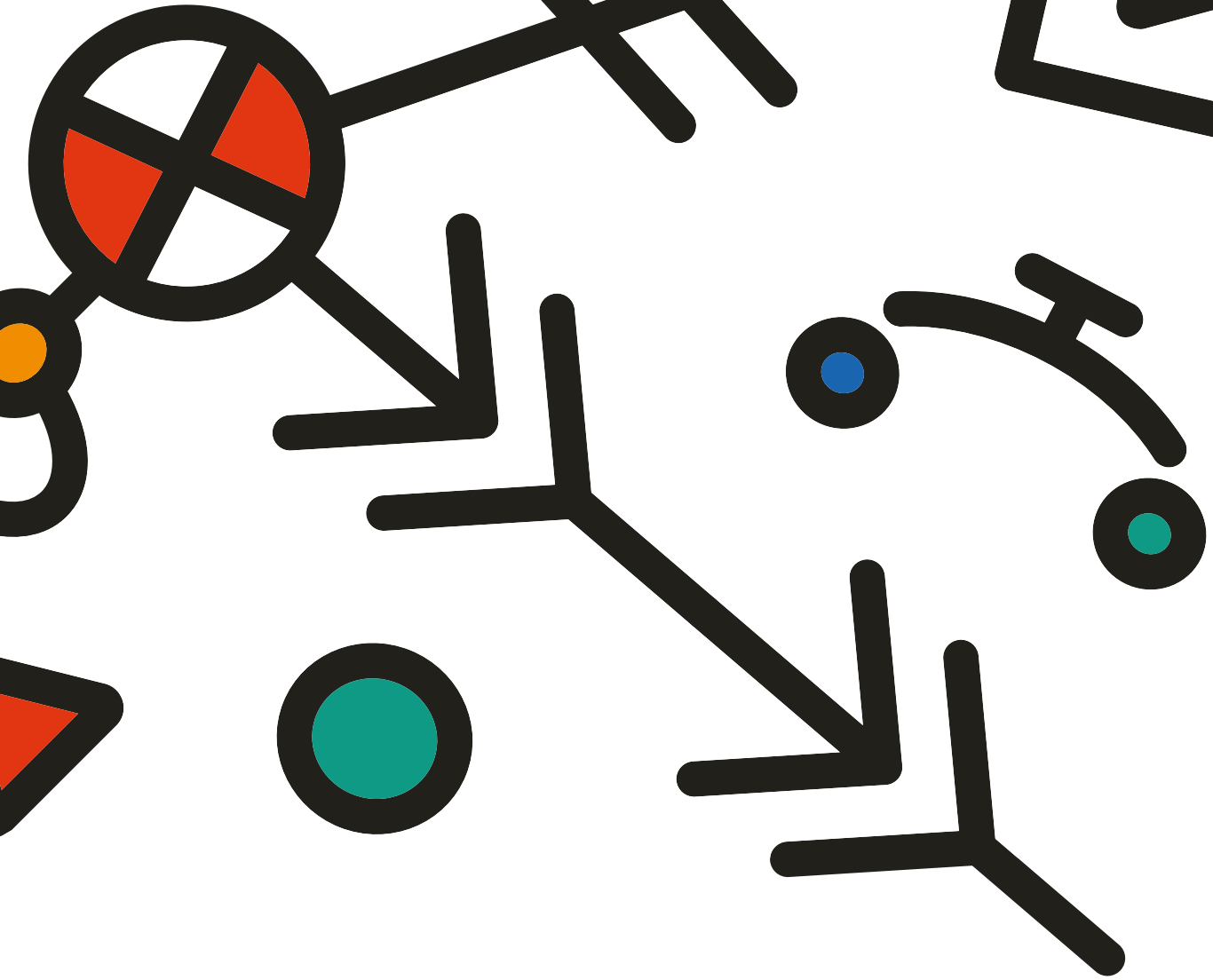
Modernisation of emergency system pumps - replacement of seals for higher operational reliability

Modification of fuel leakage monitoring system

Replacement of old door contacts of system transformers with new ones of increased seismic qualification; new safety features added, and transformer tripping logic modified

Modifications to the electric and instrumentation and control system

Service water for Units 1 to 4 of Mochovce NPP - addition of equipment due to planned commissioning of Unit 3



Overall assessment of nuclear safety

Based on the assessment of a set of operation safety indicators, the operation of nuclear installations of Slovenské elektrárne in 2022 is considered safe and in accordance with the legislation on the use of nuclear energy. Corrective measures have been adopted for events and indicators with negative trends. Operation of Slovenské elektrárne nuclear installations had minimal impact on the environment and negligible radiation exposure of personnel, public and environment.

The company is certified according to three management systems:

Certificate ISO 9001:2015
– Quality management system

Certificate ISO 14001:2015
– Environmental management system

Certificate ISO 45001:2018
– Occupational health and safety management

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