

Reykjavík Energy

2023 Annual Report

Appendices



Release of geothermal water from the Nesjavellir and Hellisheidi geothermal power plants. Groundwater monitoring.



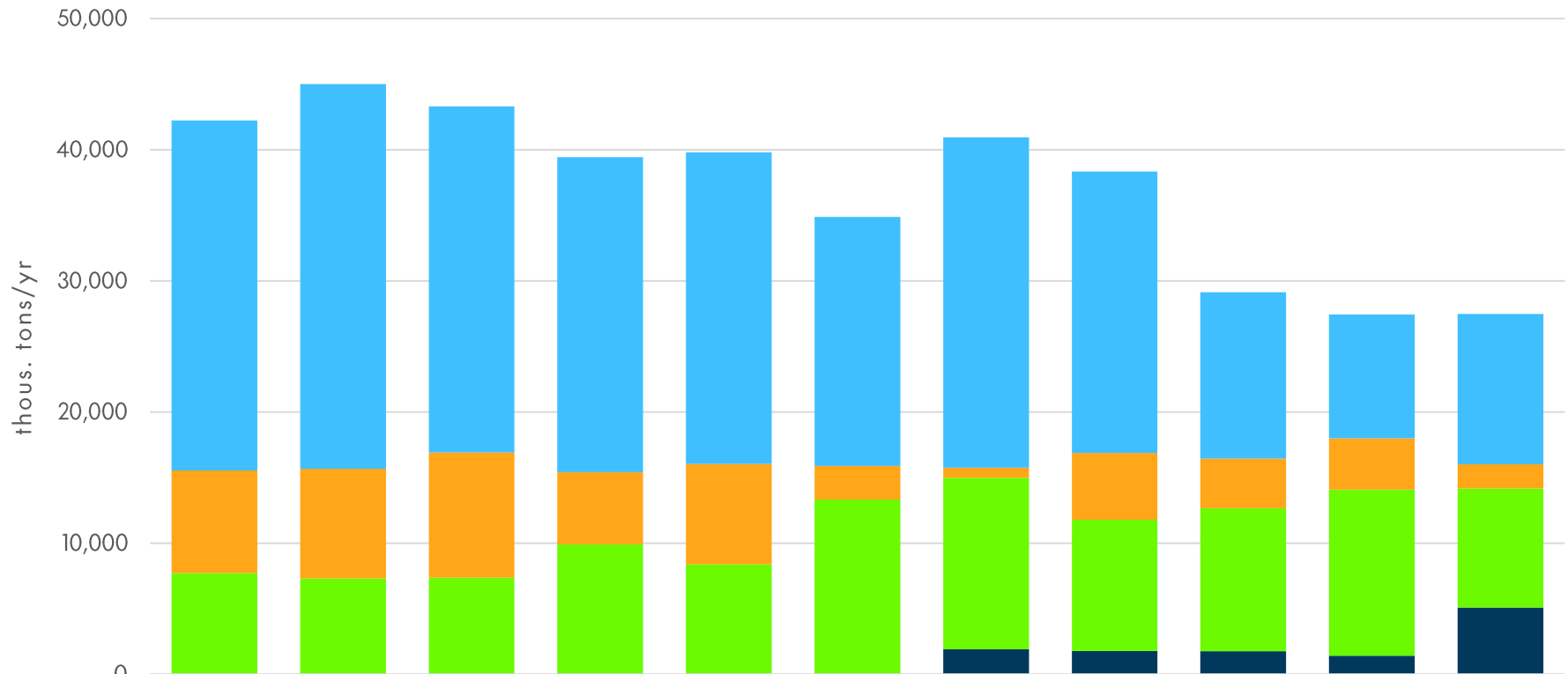
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Cover photo: Íris Eva Einarsdóttir

Volume of geothermal water from the Nesjavellir Geothermal Power Plant by release route

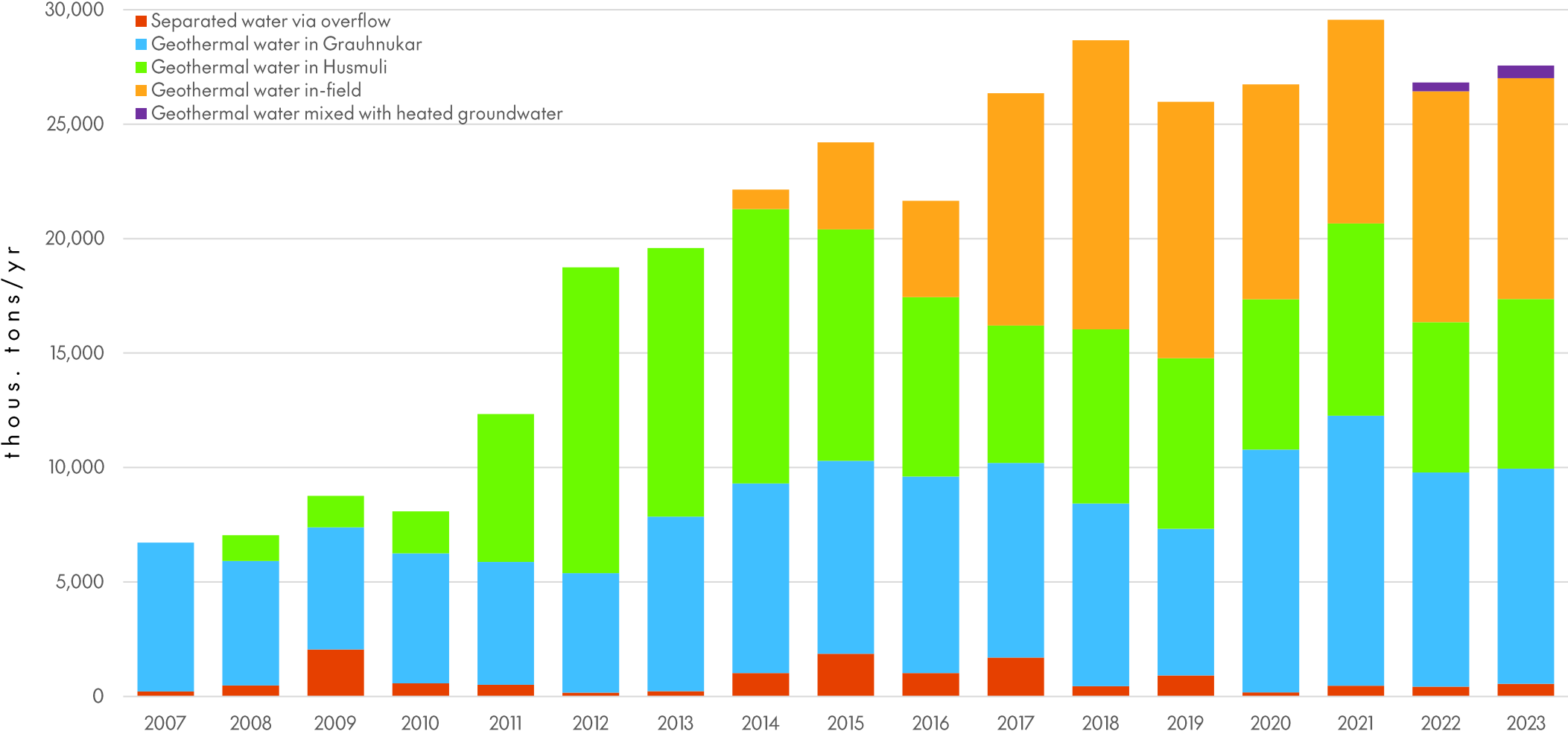
Geothermal water (thous.m³/year) from Nesjavellir Geothermal Power Plant 2013-2023 by release route. Volumes are rounded to thousands of tonnes.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
■ Heated groundwater on surface	26,687	29,333	26,371	24,009	23,760	18,993	25,183	21,472	12,669	9,440	11,450
■ Geothermal water on surface	7,824	8,367	9,545	5,504	7,649	2,556	754	5,083	3,790	3,909	1,846
■ Geothermal water in shallow reinjection	7,730	7,317	7,388	9,917	8,395	13,328	13,086	9,997	10,895	12,652	9,076
■ Geothermal water in deep reinjection							1,915	1,792	1,774	1,433	5,101

Volume of geothermal water from the Hellisheidi Geothermal Power Plant by release route 2007 – 2023

Until September 2011, the largest part of geothermal water was reinjected through wells in Gráuhnúkar. Geothermal water from the plant increased when the Sleggjan plant was launched in autumn 2011, but the reinjection field at Húsmúli was then put into full operation. Since then, the geothermal water from the plant has increased. Reinjection in discontinued production wells within the production field started in 2014 and in boreholes in Threngsli in 2016. 2022 saw the start of project that involves mixing geothermal water with heated groundwater for district heating for a better utilization of the geothermal resource, reducing the extraction of groundwater at Engidalur and the reinjection utility.



Year	Separated water via overflow	Geothermal water in Grauhnukar	Geothermal water in Husmuli	Geothermal water in-field	Geothermal water mixed with heated groundwater	Total geothermal water
	thous. tons/yr	thous. tons/yr	thous. tons/yr	thous. tons/yr	thous. tons/yr	thous. tons/yr
2007	215	6,502				6,718
2008	483	5,439	1,123			7,045
2009	2,050	5,335	1,382			8,767
2010	572	5,684	1,826			8,082
2011	506	5,374	6,461			12,341
2012	163	5,224	13,358			18,745
2013	233	7,620	11,733			19,586
2014	1,024	8,281	11,982	860		22,147
2015	1,870	8,422	10,107	3,803		24,202
2016	1,025	8,585	7,831	4,213		21,654
2017	1,699	8,506	6,001	10,147		26,353
2018	447	7,982	7,611	12,625		28,665
2019	919	6,409	7,445	11,206		25,980
2020	21	10,610	6,558	9,394		26,583
2021	470	11,979	8,398	8,898		29,562
2022	430	9,352	6,572	10,086	380	26,819
2023	550	9,396	7,412	9,649	553	27,559
TOTAL	12,835	130,517	115,800	80,881	933	340,966

Volumes are rounded to thousands of tons

Geothermal fluids discharged via overflows at the Hellisheidi and Nesjavellir Geothermal Power Plants in 2023

The reinjection utility is vulnerable to any operational changes and approximately 1.4% of produced geothermal water at Hellisheidi Power Plant was released via overflow. Licensors have been kept informed on the situation, on actions available at any given time and of the ongoing projects to increase the reception of the reinjection utility.

Date	Type of disturbance	Maximum flow [l/s]
Hellisheidi power plant		
Hellisheidi		
January 18 th	Maintenance	100
May 10 th - 15 th	Maintenance	273
August 16 th – 22 nd	Construction	107
September 21 st	Maintenance	101
September 29 th	Maintenance	217
October 17 th	Maintenance	202
November 28 th – 29 th	Malfunction	250
Hverahlid		
March 1 st – 10 th	Malfunction	70

Date	Type of disturbance	Maximum flow [MW]
Nesjavellir power plant		
Nesjavellir		
May 31 st – June 29 th	Maintenance	266

Chemical composition of geothermal water and heated groundwater for space heating from geothermal power plants in the Hengill area

Typical concentrations ($\mu\text{g/L}$) of several trace elements in geothermal water (separated water) and heated groundwater (for space heating) from the Hellisheidi and Nesjavellir geothermal power plants and their maximum permissible concentrations ($\mu\text{g/L}$) for potable water. Values exceeding the maximum are indicated in bold.

Trace element	Unit	Max. recommended value for potable water	HELLISHEIDI			NESJAVELLIR		
			Separated water	Condensed water	Heated groundwater	Separated water	Condensed water	Heated groundwater
Arsenic (As)	$\mu\text{g/L}$	10	72.10	0.05	0.86	7.32	0.35	1.63
Barium (Ba)	$\mu\text{g/L}$	700	0.13	0.02	0.43	4.11	0.39	1.06
Cadmium (Cd)	$\mu\text{g/L}$	5	< 0.002	< 0.002	< 0.002	< 0.002	0.01	< 0.002
Cobalt (Co)	$\mu\text{g/L}$	*	<0.005	0.01	0.01	0.05	0.03	0.02
Chrome (Cr)	$\mu\text{g/L}$	50	0.04	0.32	0.03	0.91	0.56	0.58
Copper (Cu)	$\mu\text{g/L}$	2.000	0.23	0.50	0.25	2.22	0.58	0.84
Mercury (Hg)	$\mu\text{g/L}$	1	0.00	0.00	< 0.002	0.01	0.009	< 0.002
Manganese (Mn)	$\mu\text{g/L}$	50	0.40	0.85	0.74	1.22	2.80	2.26
Molybdenum (Mo)	$\mu\text{g/L}$	*	9.96	<0.05	0.25	0.55	<0.05	0.51
Nickel (Ni)	$\mu\text{g/L}$	20	0.31	1.39	3.45	1.09	19.70	0.74
Lead (Pb)	$\mu\text{g/L}$	10	0.03	0.01	0.02	0.10	1.51	0.02
Phosphorus (P)	$\mu\text{g/L}$	5,000	< 1	<1	40.00	1.03	1.20	51.60
Antimony (Sb)	$\mu\text{g/L}$	5	2.96	<0.01	0.02	0.14	<0.01	0.05
Selenium (Se)	$\mu\text{g/L}$	10	18.50	< 0.3	< 0.3	0.75	< 0.3	1.26
Strontium (Sr)	$\mu\text{g/L}$	*	< 10	< 2	10.50	< 10	< 2	19.70
Titanium (Ti)	$\mu\text{g/L}$	*	0.06	0.04	0.03	0.18	0.23	0.16
Vanadium (V)	$\mu\text{g/L}$	*	3.72	0.03	4.83	2.20	0.21	22.60
Zinc (Zn)	$\mu\text{g/L}$	3,000	3.41	4.02	17.20	667.00	137.00	18.10

* Maximum limits not specified in the potable water regulation

Chemical composition of geothermal water (separated water) and heated groundwater (for space heating) from the Hellisheidi and Nesjavellir Geothermal Power Plants and their maximum permissible concentrations (mg/kg) for potable water

Values exceeding the maximum are indicated in bold.

Chemical- and physiological factors	Unit	Max. recommended value for potable water	HELLISHEIDI			NESJAVELLIR		
			Separated water	Condensed water	Separated water	Condensed water	Separated water	Condensed water
Acidity	pH		9.37	4.73	8.35	8.33	5.25	8.42
T (pH)	°C		7.2	22.8	10.5	18.9	18.0	22.5
Carbon dioxide (CO ₂)	mg/kg	*	15.6	45.3	24.4	31.5	14.2	46.2
Hydrogen sulphide (H ₂ S)	mg/kg	*	23.4	3.4	0.49	67.3	15.2	0.54
Silica (SiO ₂)	mg/kg	*	-	0.29	32.3	-	0.29	40.1
Sodium (Na)	mg/kg	200	198.0	0.14	8.79	161.0	0.1	20.3
Potassium (K)	mg/kg	12	36.2	0.08	1.61	31.3	0.06	3.98
Calcium (Ca)	mg/kg	100	0.44	0.02	4.56	0.34	0.04	8.94
Magnesium (Mg)	mg/kg	50	0.011	0.007	2.51	0.007	0.00	4.64
Iron (Fe)	mg/kg	0.2	<0.003	0.022	0.004	0.03	0.100	0.160
Aluminium (Al)	mg/kg	0.2	1.72	0.002	0.010	1.76	0.00	0.07
Sulphate (SO ₄)	mg/kg	200	33.95	3.27	5.26	13.51	11.05	11.61
Chloride (Cl)	mg/kg	*	143.4	6.8	13.52	107.5	6.9	17.56
Fluoride (F)	mg/kg	1.5	1.08	0.0	0.10	0.91	0.11	0.15

* Maximum limits not specified in the potable water regulation

Chemical composition of groundwater in wells around the Hellisheidi Power Plant in 2023

The impact of the Hellisheidi Power Plant on groundwater is closely monitored in surveillance wells at and around the plant. Samples are collected to analyse overall chemical content and trace elements, in addition to measuring their temperature, conductivity and acidity.

Well	HK-07		KH-50		KH-12		KH-44		KH-06		KH-52		HK-29	
Groundwater flow	Selvogur flow				Selvogur flow Cooling towers overflow				Thingvellir flow				Olfus flow	
Sample no.	23-5190		23-5214		23-5245		23-5213		23-5186		23-5203		23-5185	
Date.	15.6.2023		6.7.2022		17.10.2023		6.7.2023		14.6.2023		27.6.2023		13.6.2023	
Chemical properties	Unit	Maximum value												
Acidity	pH		7.48	6.88	7.66	7.57	6.82	8.04	7.25					
T (pH)	°C		25.0	21.8	21.6	22.2	22.4	22.4	21.9					
CO ₂	mg/kg	*	49.8	62.6	25.0	14.8	38.6	27.5	33.0					
F	mg/kg	1.5	0.05	0.05	0.093	0.039	0.031	0.042	0.04					
Cl	mg/kg	*	8.03	9.10	12.60	5.17	7.10	6.71	9.95					
SO ₄	mg/kg	200	9.92	23.7	6.32	9.92	1.63	6.52	4.94					
B	Mg/kg	1	0.01	0.02	0.03	0.02	0.007	0.02	0.01					
Ca	mg/kg	100	7.55	6.89	4.9	2.76	4.18	4.99	7.97					
Fe	mg/kg	0.2	0.004	0.003	0.003	0.004	0.02	0.007	0.012					
K	mg/kg	12	1.15	1.18	1.20	0.67	0.77	1.00	1.27					
Mg	mg/kg	50	8.43	15.10	2.91	1.71	3.91	2.57	3.20					
Na	mg/kg	200	9.61	9.20	7.46	4.30	6.12	6.00	11.00					
SiO ₂	mg/kg	*	30.62	41.59	25.07	14.69	16.57	20.04	23.51					
Al	µg/kg	200	2.30	3.79	5.41	10.30	1.28	1.51	2.75					
As	µg/kg	10	<0.05	0.10	< 0.05	< 0.05	< 0.05	<0.05	0.08					
Ba	µg/kg	700	0.81	0.79	0.63	0.39	1.64	1.18	0.60					
Cd	µg/kg	5	0.005	0.005	< 0.002	<0.002	0.009	0.0119	0.003					
Co	µg/kg	*	0.02	0.03	0.007	0.0237	0.04	0.024	0.046					
Cr	µg/kg	50	0.64	0.28	0.58	0.39	0.10	0.09	0.54					
Cu	µg/kg	2,000	0.94	1.40	0.28	0.23	1.44	1.44	1.04					
Hg	µg/kg	1	<0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002					
Mn	µg/kg	50	1.57	1.76	0.34	0.75	6.52	1.86	2.12					
Mo	µg/kg	*	0.33	0.09	0.18	0.10	0.06	0.15	0.39					
Ni	µg/kg	20	0.59	0.71	0.14	0.12	1.19	0.78	0.36					
Pb	µg/kg	10	0.03	0.03	<0.01	0.01	0.02	0.02	0.02					
P	µg/kg	5,000	51.7	42.8	50.4	20.2	5.98	1.6	47.5					
Sb	µg/kg	5	0.085	0.123	1.92	0.699	0.012	0.107	0.011					
Se	µg/kg	10	<0.3	< 0.3	1.72	1.14	< 0.3	0.574	< 0.3					
Sr	µg/kg	*	18.5	18.3	11.0	6.1	10.1	12.8	16.9					
Ti	µg/kg	*	0.116	0.120	0.156	0.155	0.034	0.022	0.011					
V	µg/kg	*	16.5	2.8	8.52	5.5	2.3	1.6	17.1					
Zn	µg/kg	3,000	26.7	46.5	2.69	22.7	36.0	36.5	17.2					

* Maximum limits not specified in the potable water regulation