LV-2019-049

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Noise monitoring at Geothermal power plants

Summary of noise level measurements 2014-2018

Key Page

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LV report no:	LV-2019-049		**Date:**	August 2019
Number of pages:	12	**Copies:** 1	**Distribution:**	☒ On www.lv.is ☒ Open ☐ Limited until

Title: Noise monitoring at Georthermal power plants. Summary of noise level measurements 2014-2018

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Abstract: In 2014 a new five-year plan for noise monitoring around the Krafla, Þeistareykir and Bjarnarflag was initiated. Automatic fixed logging sound level meters were installed in each area and the frequency of manual spot measurements with a handheld sound level meter was increased. 570 manual measurements have been made at 26 locations. At the same time fixed sound level meters have logged about 95.000 hours of measurements, or about 32.000 hours at each location. Four times the manual measurements recorded noise levels exceeding 70 dB(A). In all other cases the measured noise levels were below the 70 dB(A) limit, according to regulations. Usually the measured noise was well below the limit. The equivalent sound pressure level for each year, as well as the whole five-year period, as measured by the fixed logging sound level meters is also below the 70 dB(A) limit.

Keywords: Krafla, Þeistareykir, Bjarnarflag, sound measurements, sound level, acoustics, monitoring.

ISBN no:

Approved by Landsvirkjun's project manager

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Ágúst 2019

NOISE MONITORING AT GEOTHERMAL POWER PLANTS

SUMMARY OF NOISE LEVEL MEASUREMENTS 2014 - 2018

DOCUMENT NUMBER: 5690211-000-HRP-0006 CURRENT REVISION: 1.0						
1.0	2019.07.02	IFR	GBJ	AA	GBJ	LV
REVISION	**DATE**	**ISSUE**	**PREPARED BY**	**REVIEWED BY**	**APPROVED BY**	**CLIENT**

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1. Introduction

This report discusses results from noise level measurements conducted around the geothermal power stations at Krafla, Þeistareykir and Bjarnarflag between 2014 and 2018.

In 2014 the procedures for noise monitoring at Landsvirkjun's geothermal power plants in Northeast Iceland, i.e. Krafla, Þeistareykir and Bjarnarflag, was reviewed and subsequently changed. Noise measurements had previously been made manually once a year with a handheld sound level meter at a few predetermined locations. In 2014 a new five-year plan for noise monitoring was devised that involved expanding the scope of the measurements and more detailed reporting of their results.

An automatic fixed logging sound level meter was installed at each of the three geothermal sites, which had not been done previously. Manual measurements made with a handheld sound level meter were continued but measurement locations were reviewed, and the frequency of measurements was increased.

The results of these noise measurements have been reported annually (in Icelandic) since the new arrangement has been in place. What follows is a brief summary of their findings.

Figure 1: At the northern edge of the crater Víti in Krafla, facing south.

2. Requirements or prerequisites

The environmental operating licenses for Landsvirkjun's geothermal plants stipulate requirements for noise levels that need to be fulfilled.

They state that noise levels should be limited as possible and that care should be taken to prevent noise disturbance in surrounding areas. Noise levels at site boundaries should be within limits as stated in regulation for noise nr. 724/2008 and should not exceed 70 dB(A). Exceptions can be acceptable during temporary operations such as drilling and well production testing.

Table 1: Limits for noise from commercial activities as stipulated by regulation 724/2008.

	L_{Aeq} (07-19)		L_{Aeq} (19-23)		L_{Aeq} (23-07)		L_{AFmax} night
	At facade	Indoors	At facade	Indoors	At facade	Indoors	Indoors
Homes in residential areas	50	30	45	30	40	25	40
Industrial and commercial areas	70		70		70		
Recreational dwellings	35		35		35		35

Noise limits in residential areas and recreational dwellings are relevant for areas neighbouring the Bjarnarflag power plant. No such areas are close to either Krafla or Þeistareykir.

3. Implementation

Noise level measurements have been carried out both manually with a handheld sound level meter as well as automatically with fixed logging sound level meters in each of the years in question. The measurements have been performed in accordance with Landsvirkjun's protocol for noise level measurements (Landsvirkjun, 2014). That protocol is based on, and in accordance with, the directions given by The Environmental Agency of Iceland for noise monitoring measurements.

Sound level meters of type Nor140 from Norsonic were used for all measurements.

Figure 2: Nor140 sound level meter.

Early in 2014 the locations for manual measurements with a handheld sound level meter were revised and for each of the three geothermal sites 7-10 locations were selected. The locations were chosen so that their distribution would be fairly even at the sites, that there were measurements made in the vicinity of operational wells but also further away, near buildings and popular tourist destinations as well as in more remote areas.

Over the five-year period there were no significant problems involved with carrying out the manual measurements. In very few cases a measurement may not have been possible at a certain location, usually because it was inaccessible at the time, but these are rare exceptions.

As previously mentioned, fixed logging sound level meters were installed in each geothermal site. They were initially put in place in the first half of 2014, but it took some time and effort to get them to run properly and return data consistently. As a result, it was not until end of year 2014 that the first noise levels are logged. Measurements continued in the year 2015 but problems with keeping the instruments running and maintaining a stable connection to them persisted. As a result, the logged data has considerable gaps in it, the data from Krafla for example only covering about 2/3 of the year. The reliability of the logging data slowly improved as time went by, but the noise data logged in 2016 was still disappointingly sporadic.

At this point some experience had been gained with regards to operating and downloading data from the instruments. In 2017 certain changes were made to how measured data was stored and accessed as well as how the instruments were monitored. These changes appear to have solved more or less all remaining problems with the setup. Since then the logged data has been almost completely continuous, with measurements recorded for 97% of that period. There have been no appreciable problems with running these instruments in well over two years.

Figure 3: Drilling at Þeistareykir.

4. Results

4.1 Measurements with a handheld sound level meter

All in all, there have been 570 measurements made manually with a handheld sound level meter in 26 locations in and around the geothermal areas during the five-year period 2014 – 2018.

In four instances the measured sound pressure level exceeded 70 dB(A), once due to excavation work and twice due to blowing geothermal wells being tested in the vicinity. Only once can it not be fully explained why the noise levels measured so high, but even then it is likely due to tourist traffic or similar since the measurement was made at the edge of Víti, a popular tourist attraction.

In all other cases the measured noise levels were below the 70 dB(A) limit, stipulated in the operating licenses and Icelandic regulations.

Results of all manual measurements with a handheld sound level meter can be seen in tables 2 -4.

Table 2: All manual measurements at Krafla, results are in dB(A).

Krafla	Location												
Date	1	2	3	4	5	6	7	8	9	Time	Temp	Wind direction	Wind speed
28.5.2014	35	47		38	45	61	43	53			9°C	S	5-6m/s
25.6.2014	48	44	30	41	46	61	43	53		10:15-14:30	16°C	S	3-4m/s
28.8.2014	54	43	50	33	48	54	43	56		10:50-14:10	16°C	SE	2-6m/s
11.11.2014	41	43	35	47	44	45	42	56		10:10-13:30	3°C	E	5-6m/s
18.5.2015	46	40	35	45	44	41	42	55		13:05-16:30	5°C	NW	3-5m/s
10.7.2015	53	47	22	37	46	31	43	47	49	16:35-18:45	7°C	NW	4-6m/s
17.9.2015	49	45	19	40	59	27	35	51	44	10:10-14:00	6°C	NW	1-4m/s
4.12.2015	45	36	25	33	45	36	39	54	38	08:10-13:00	-8°C	ESE	3-5m/s
21-22.03.2016	41	37	37	42	43	42	43	55	40	14:29-09:10	3°C	NW	1-3m/s
17.5.2016	46	37	28	33	43	33	29	47	28	14:30-18:10	2°C	E	2-4m/s
4.7.2016	56	55	52	44	48	34	37	47	51	15:00	10°C	NNW	2-7m/s
10.8.2016	51	46	34	44	53	32	43	52	47	10:40-15:00	10°C	E	2-4m/s
27.9.2016	53	49	30	45	46	35	31	53	40	14:15-17:30	7,5°C	NE	3-6m/s
10.11.2016	33	49	26	42	58	42	42	55	51	08:25-13:10	0°C	SSE	1-5m/s
28.2.2017	43	34	26	41	42	25	31	49	26	13:00-16:04	0°C	-	0-1m/s
9.5.2017	41	47	25	34	45	27	24	73	35	09:45-13:10	4,5°C	SE	2-5 m/s
27.7.2017	48	49	30	46	50	45			48	08:05-11:00	8,5°C	NNE	3-8m/s
3.10.2017	46	47	25	45	48	34	32	54	36	08:30	4°C	NW	1-2 m/s
11.12.2017	44	43		38	42	40	37	52	35	11:15-15:00	-8°C	E	1-2 m/s
28.2.2018	41	35	22	41	42	32	32	50	37	08:05-11:15	2°C	-	0 m/s
25.7.2018	56	52	41	45	53	30	27	61	43	08:40-11:45	10,5°C	S	1-3 m/s
8.10.2018	40	43	37	43	42	31		46	28	08:00-12:00	0°C	SW	1-4 m/s
19.11.2018	45	49	27	39	42	33	28	52	35	10:00-12:10	-1°C	SE	1-2 m/s

Table 3: All manual measurements at Þeistareykir, results are in dB(A).

Þeistareykir	Location										
Date	1	2	3	4	5	6	7	Time	Temp	Wind direction	Wind speed
22.5.2014	28	31	30	50	43	42				-	0 m/s
26.6.2014	28	38	29	55	34	29		13:30-16:00	16°C	ENE	3-5m/s
9.10.2014	37	40	38	43	53	57		13:00	6°C	NE	5-6m/s
24.11.2014	48	60	34	65	42	51		16:26-18:27	5°C	WSW	3-5m/s
26.2.2015	33	53	47	65	41	33		13:45-16:00	-3°C	ENE	0-8m/s
13.5.2015	40	41	39	57	50	40		10:26-12:10	1°C	S	4-6m/s
14.7.2015	39	48	33	49	52	39	49	9:00-12:10	5°C	NE	5-7m/s
2.9.2015	27	29	25	29	53	25	30	8:47-11:55	8°C	W	1-3m/s
12.1.2016	42	33	40	35	29	47	49	07:30-11:00	-6°C	N	6-8m/s
17.3.2016	39	48	45	55	44	48	51,6	07:55-11:10	0°C	S	9-10m/s
18.5.2016	24	29	19	32	50	30	25,2	08:50-11:50	3°C	-	0-1m/s
29.6.2016	48	50	43	51	43	48	36,9	09:00-13:20	14°C	SSW	0-6m/s
9.8.2016	24	34	26	37	41	38	29	09:05-12:00	6°C	S	3-5m/s
27.9.2016	36	44	35	34	46	54	33	09:10-13:30	3°C	N	2-4m/s
9.11.2016	26	41	50	52	52	47	52	08:30-12:50	-1°C	SSE	1-5m/s
13.2.2017	37	59	56	78	64	53	75	11:30-15:00	3°C	-	0-4,5m/s
13.3.2017	65	44	51	63	55	47	63,4	11:35-14:20	1°C	SSW	2-9m/s
23.5.2017	40	54	41	44	35	26	38	13:40-16:20	14°C	SE	3-5 m/s
26.7.2017	39	45	36	50	40	45	52,9	09:10-12:10	18°C	S and SE	3-4 m/s
10.10.2017	46	52	43		46	46	51	08:30-15:30	4°C	SE	3-9 m/s
5.12.2017	35	41	36		44		47	08:30-12:50	-1°C	SSE	1-5m/s
13.3.2018	30	35	40	46	46	40	42	10:10-13:10	-5°C	E	0-2,5 m/s
26.7.2018	39	36	39	49	63	47	42	08:50-11:30	14°C	S-SE	2-6 m/s
7.11.2018	33	30	34		56	38	41	-	3°C	-	0 m/s
20.11.2018	23	29	27	46	36	34	44	09:00	-2°C	SE	1-8,5 m/s

Table 4: All manual measurements at Bjarnarflag, results are in dB(A).

Bjarnarflag	Location													
Date	1	2	3	4	5	6	7	8	9	10	Time	Temp	Wind direction	Wind speed
24.6.2014	50	44	48	46	50	40	29	40	35	47		17°C	S	3-4m/s
11.11.2014	42	43	46	40	36	35	25	39	49	49	13:40-16:35	4°C	E	3-5m/s
27.5.2015	41	53	46	53	39	38	45	52	50	45	10:15-14:13	4°C	NE	3-5m/s
10.7.2015	56	50	53	51	30	51	35	34	30	46	13:40-16:30	6°C	NW	3-4m/s
2.9.2015	46	52	46	47	37	42	33	36	29	46	13:23-17:05	12°C	NE	2-4m/s
11.1.2016	37	47	41	40	36	42	37	40	35	50	12:50-16:30	-9°C	ESE	0-3m/s
21.3.2016	44	41	41	38	37	41	27	33	33	42	08:55-14:21	0°C	SE	3-5m/s
17.5.2016	46	43	42	41	32	45	30	41	34	42	10:28-14:25	0°C	SE	4-6m/s
4.7.2016	50	52	52	50	40	44	76	38	37	41	10:50	10°C	NNW	2-5m/s
8.8.2016	51	51	49	49	40	47	45	45	42	44	10:55-15:30	8°C	NW	2-6m/s
28.9.2016	61	48	45	42	39	36	32	37	37	48	10:55-14:55	5°C	ESE	2-4m/s
9.11.2016	50	49	50	51	47	38	36	41	50	52	13:20-17:20	-2°C	NE	1-4m/s
28.2.2017	44	30	35	32		31	30	29	27	43	09:00-12:00	-2°C	N	0-3m/s
16.5.2017	46	54	44	41	41	42	29	35	32	44	12:00-16:55	11°C	WSW	3-4 m/s
27.5.2017	41	53	46	53	39	38	45	52	50	45	10:15-14:13	4,2°C	NE	3-10m/s
3.10.2017	52	47	47	45	27	41	35	41	30	54	13:28-16:30	5°C	NW	2-5 m/s
14.12.2017	48	49	43	38	25	31	28	37	28	40	10:00-15:00	-2°C	N	1-6 m/s
28.2.2018	45	43	46	43	26	38	30	39	31	44	12:45-16:00	3°C	-	0 m/s
25.7.2018	44	47	50	44	27	43	35	46	34	45	12:25-15:25	14°C	S	1-3 m/s
8.10.2018	45	44	50	40	24	48		38		45	13:14-16:25	-	SW	0-6 m/s
19.11.2018	47	46	44	38	31	42	29	43	36	48	13:40-16:30	-1°C	SW - SE	0-2 m/s

4.2 Measurements with a fixed logging sound level meter

Almost 32.000 hours of sound level measurements have been made automatically in each of the geothermal areas at Krafla, Bjarnarflag and Þeistareykir since the fixed logging sound level meters were first installed in 2014.

The equivalent sound pressure level for each year, as well as the whole five-year period, as measured by these sound level meters is below the 70 dB(A) limit, stipulated in the operating licenses and Icelandic regulations.

When taking only into account measurements made where windspeed is below 5 m/s, as required by measurement protocols for accurate outdoor sound pressure level measurements, the resulting equivalent sound pressure level is even lower. Using this as criteria the highest equivalent sound pressure level for any one year is 60,4 dB(A) for 2017 at Þeistareykir, at Krafla it is 56,7 dB(A) and at Bjarnarflag 46,8 dB(A), both for the year 2016.

The following graphs in figures 4 to 9 show the equivalent sound pressure levels and average maximum sound levels for each month at each location, since the sound level meters have been in operation. Only measurement data acquired in appropriate weather conditions is used, months where measurement data is incomplete are marked.

Periods where geothermal wells are blowing in the power plant area are also indicated, being by far the noisiest events encountered. This is particularly revealing for the Þeistareykir area since, it being in development, quite a few wells were put into operation during the period in question.

During most of the five-year period the Þeistareykir area was under development. This includes construction of power station, pipelines and service installations, road construction, various earthworks, drilling of wells and putting them into operation, etc. Any and all of these activities can be noisy, but usually higher levels of noise are confined to short periods at a time, associated with some specific operation. On average the noise from these activities is relatively moderate.

The noise generated by blowing geothermal wells being production tested is different. They are consistently very loud over a long period. Just how much noise they generate varies from one well to another but they all generate sound pressure levels far exceeding anything else on site. The sound generated, generally has a stable frequency spectrum and amplitude resulting in a very steady source of background noise over a relatively large area. It has invariably been the case that measured noise levels are higher when there is a well blowing in the geothermal area and can easily account for a 10 – 15 dB(A) increase from what would otherwise be expected, depending on distance to the well and other factors.

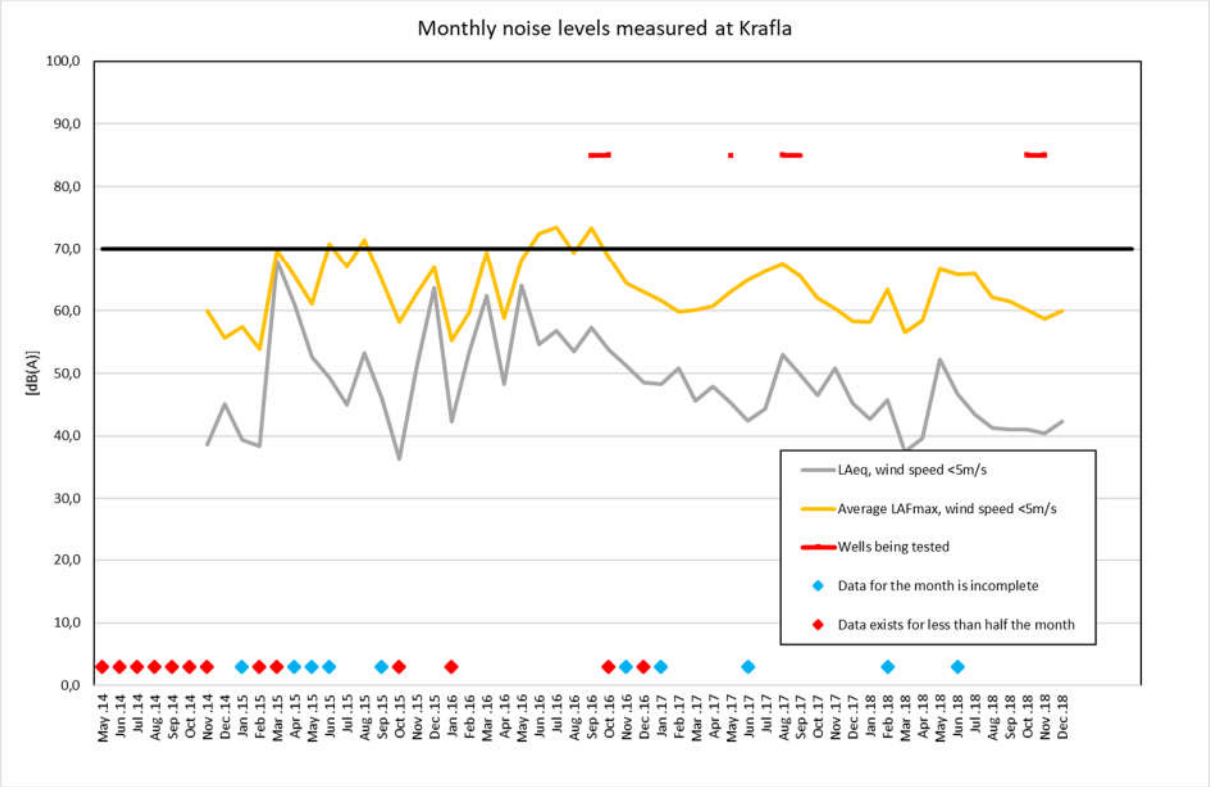

Figure 4: Measured noise levels for each month at Krafla, arranged in series.

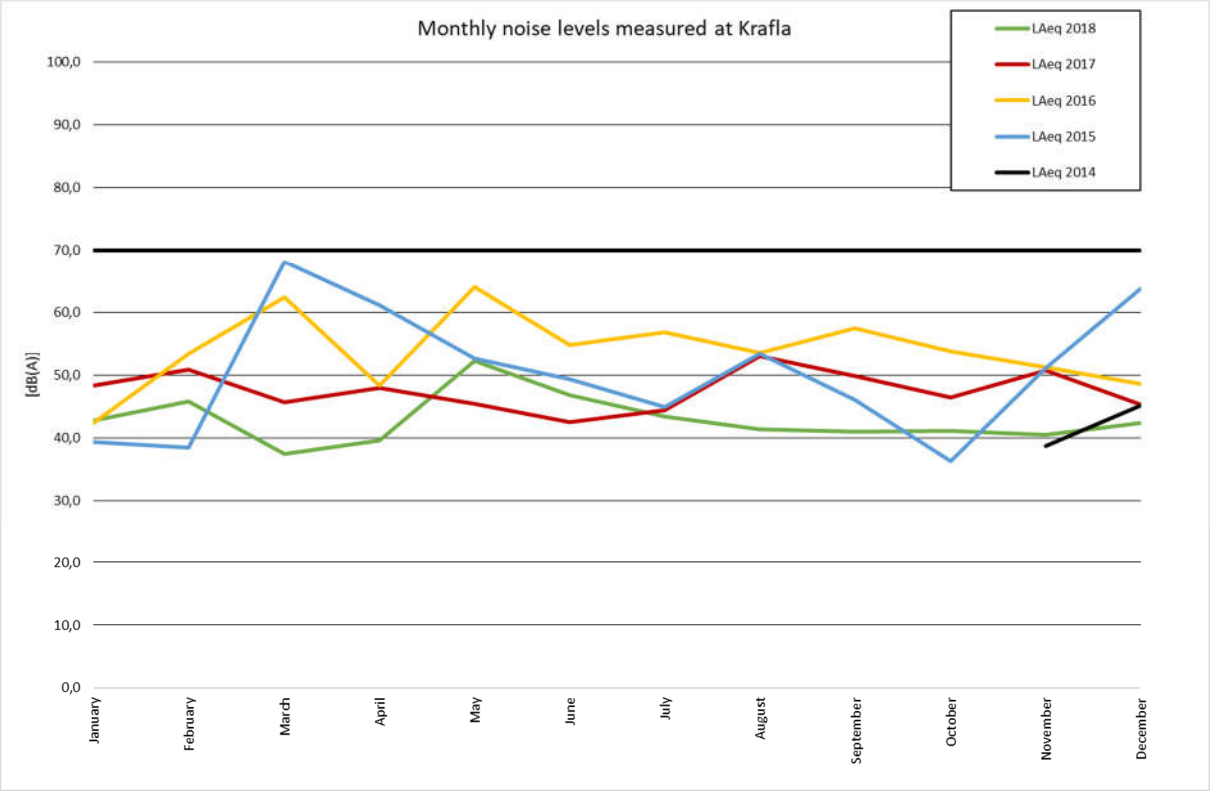

Figure 5: Measured noise levels for each month at Krafla, arranged by year.

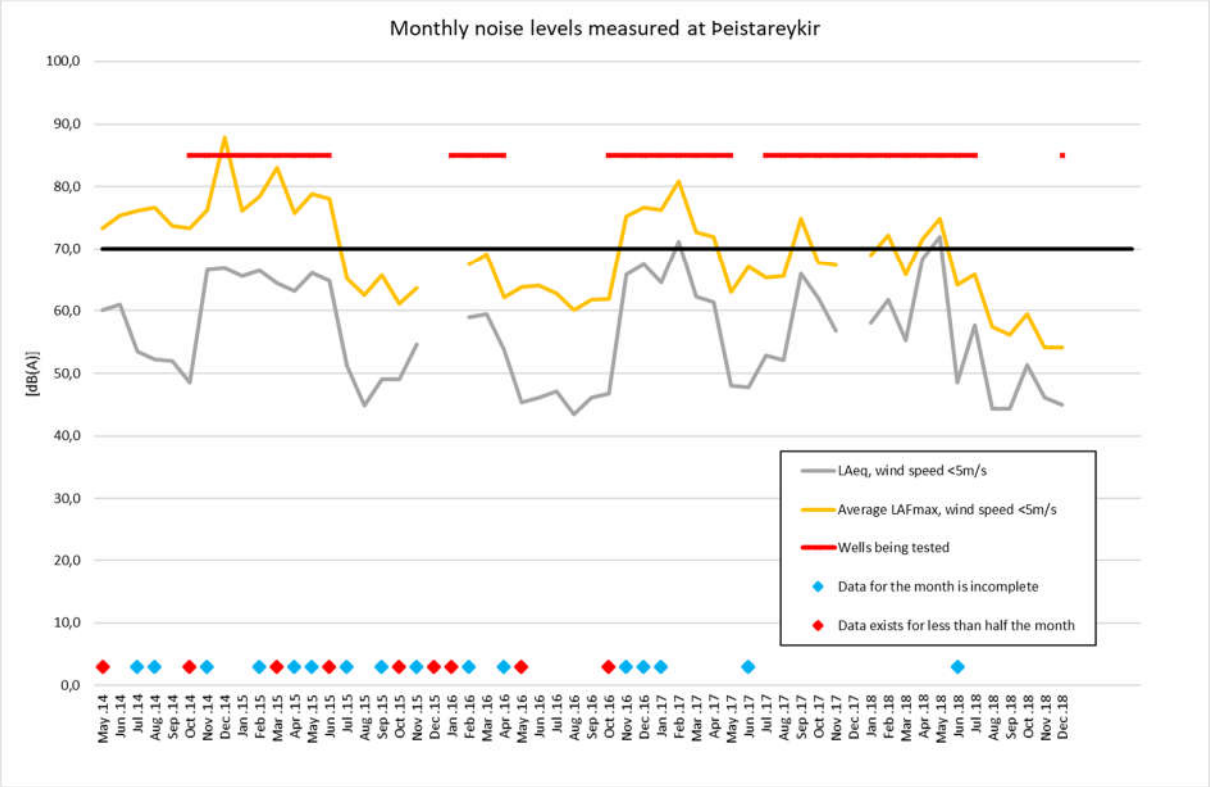

Figure 6: Measured noise levels for each month at Þeistareykir, arranged in series.

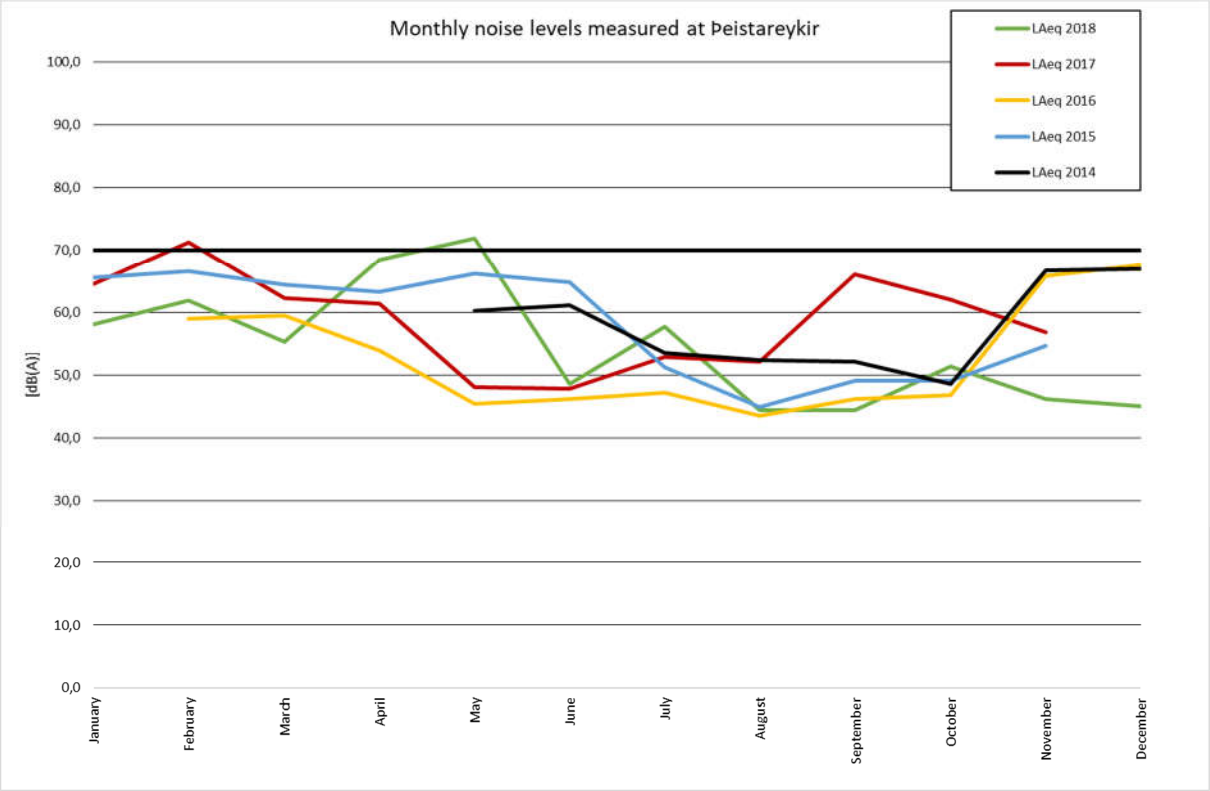

Figure 7: Measured noise levels for each month at Þeistareykir, arranged by year.

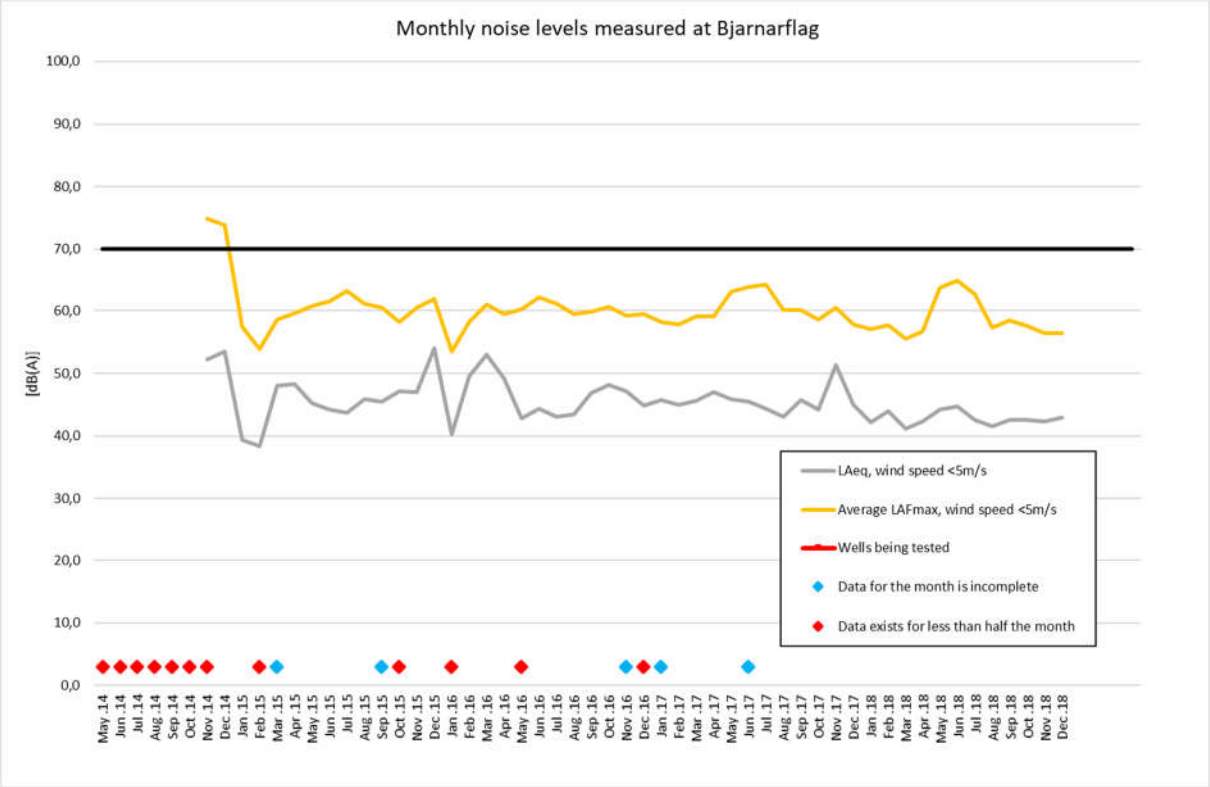

Figure 8: Measured noise levels for each month at Bjarnarflag, arranged in series

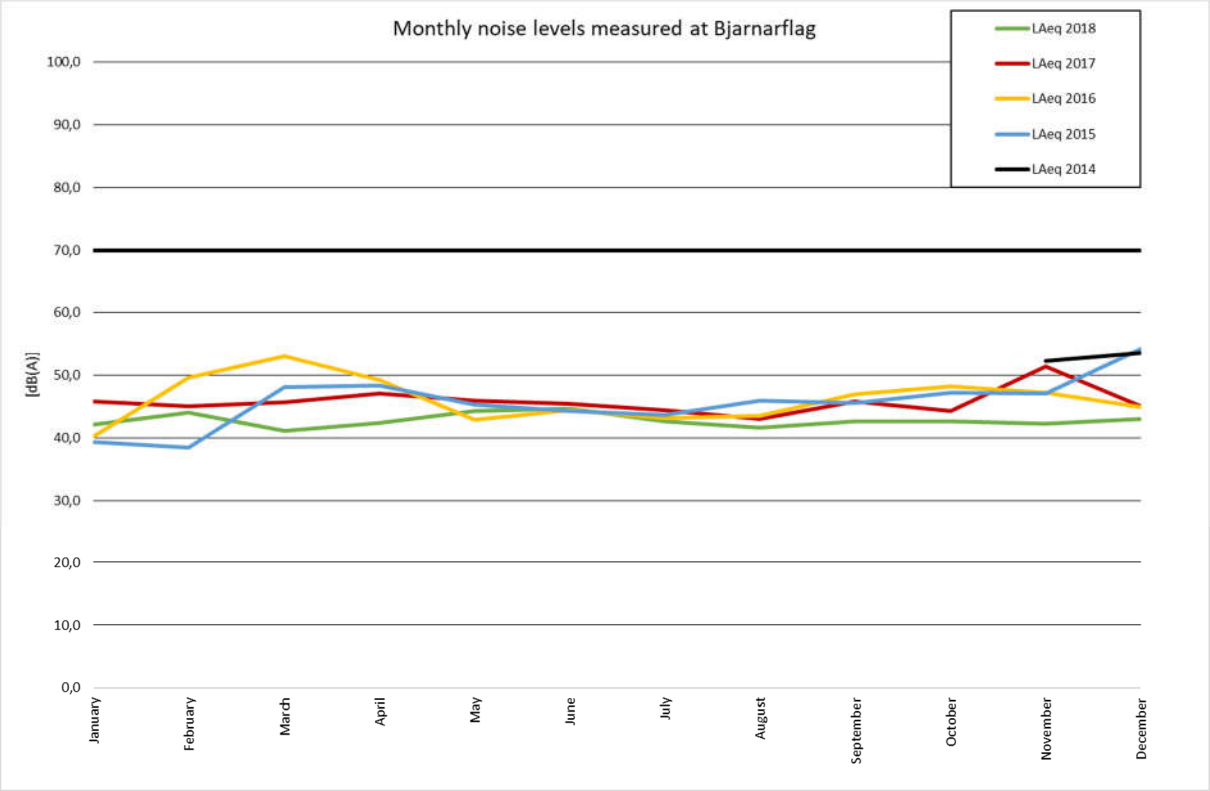

Figure 9: Measured noise levels for each month at Bjarnarflag, arranged by year.

5. Summary

In 2014 a new five-year plan for noise monitoring around the geothermal plants at Krafla, Þeistareykir and Bjarnarflag was initiated. Automatic fixed logging sound level meters were installed in each area and the frequency of manual spot measurements with a handheld sound level meter was increased.

Some issues were encountered regarding running the automatic sound level meters consistently, but these were eventually resolved and there have been no considerable problems for well over two years. There have been no significant problems involved with carrying out the manual measurements.

During the five-year monitoring period 570 manual measurements have been made at 26 locations. At the same time fixed sound level meters have logged about 95.000 hours of measurements, or about 32.000 hours at each location.

Four times the manual measurements recorded noise levels exceeding 70 dB(A). In all other cases the measured noise levels were below the 70 dB(A) limit, stipulated in the operating licenses and Icelandic regulations. Usually the measured noise was well below the limit.

The equivalent sound pressure level for each year, as well as the whole five-year period, as measured by the fixed logging sound level meters is also below the 70 dB(A) limit, stipulated in the operating licenses and Icelandic regulations.

Figure 10: A geothermal well with silencer, during testing.

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