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Long term low frequency noise measurements near a large wind farm

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Summary

Long term noise measurements have been carried out at a wind farm consisting of 45 turbines with a hub height of 145 m and rotor diameter of 131 m. The measurements were performed at the location of nine dwellings during a period of two years. This period contains several months where the wind farm was not in operation and several months where the wind farm was nearly in full operation. The analysis is made of three consecutive months of data from the same season of different years (with and without wind farm activity). By analysing the difference, the sound levels from the wind turbines can be separated from the ambient sound levels. This is done by comparing the results in the form of a histogram. The aim of the measurements was to evaluate the low frequency noise. The results show that low frequency noise emitted by the turbines can be measured and that an increase in low frequency sound level occurs at dwellings near the wind farm. The levels are below limit values for low frequency noise and are mostly in agreement with expected values. For four of the nine measurement locations a 3 to 7 dB higher than expected noise level was measured at 100 and 125 Hz third octave bands. Also noise emission was measured of a few turbines according to the IEC61400-11 method, to measure the sound power level. These measurements show good agreement with the specifications of the turbines but do not confirm the higher measured levels at 100 and 125 Hz.

1. Introduction

From 2020 to 2022 measurements have been carried out near a large wind farm in the Netherlands. The measurements started in 2020 when the wind farm was not yet built or in operation. The measurements were continued during the construction of the wind farm until the farm was in full operation. The aim of the measurements was to assess the low frequency noise caused by the wind farm at dwellings near the wind farm.

The measurements were carried out by DGMR and LBP|SIGHT by order of the municipalities Aa and Hunze and Borger-Odoorn.

2. The wind farm

Wind farm 'De Drentse Monden en Oostermoer' is located in the northeast of the Netherlands near the town of Stadskanaal and consists of 45 turbines in six lines. The turbines are of the type Nordex N131 with a hub height of 145 m and rotor diameter of 131 m.

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3. Measurement setup

Measurements were carried out at nine dwellings surrounding the wind farm. Most microphones (apart from N227 and Z71 which were mounted on a pole) were mounted close to the facades of the dwellings causing a reflection of 3 to 6 dB. The measurement height was between 3 and 4 m above ground level.

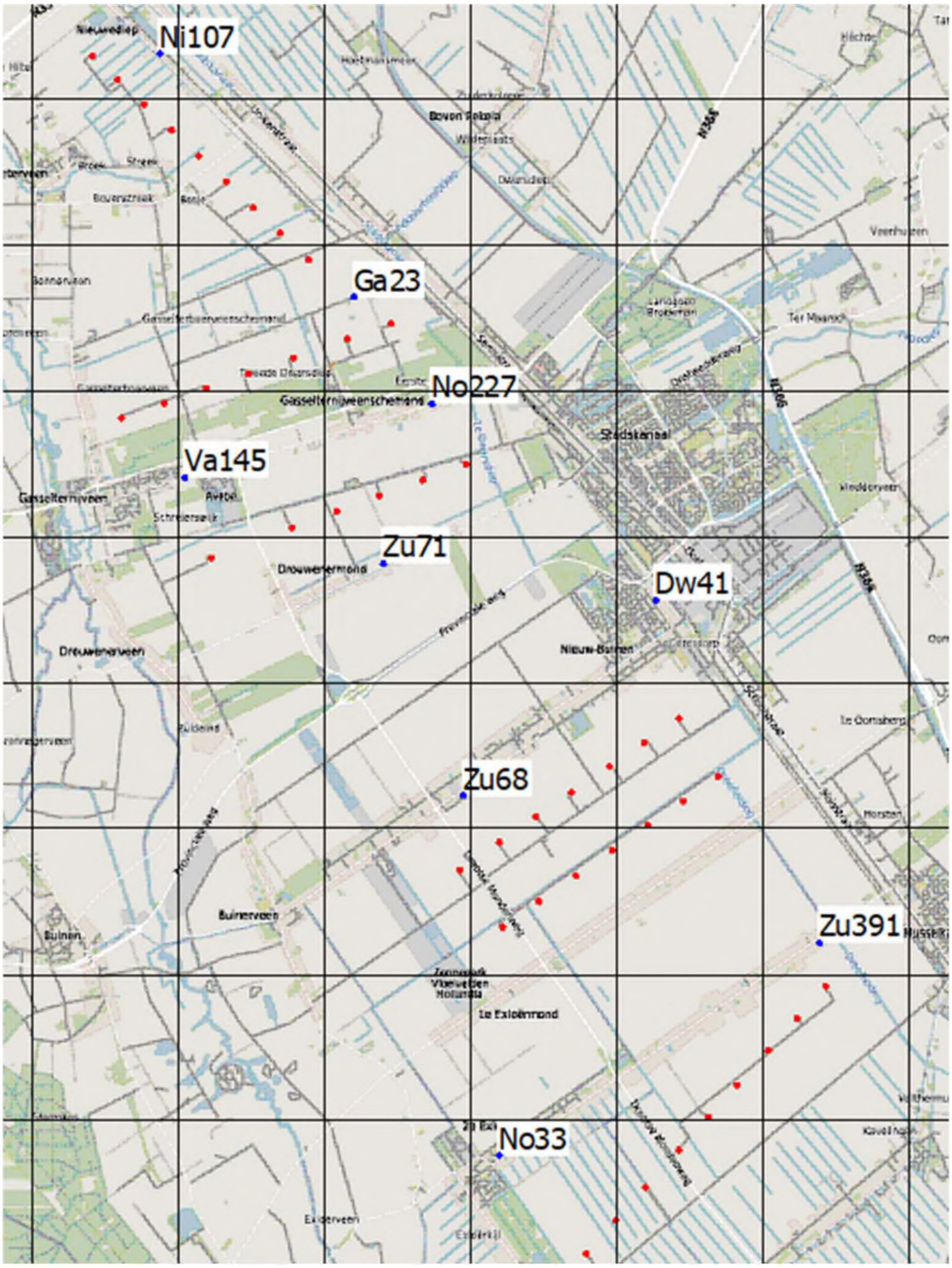

Figure 1 The measurement locations in blue, turbines of the wind farm in red. The grid is 2 km.

At measurement point Z71 and N33 the meteorological conditions were also measured. The shortest distance to a turbine is location Ga23 and Zu391 with a distance of approximately 600 m. The longest distance to the closest turbine is location Dw41 and No33 with a distance of approximately 1700 m.

At each measurement point the average sound pressure level was measured of the overall A-weighted sound level and of the unweighted sound level in the third octave bands of 6,3 to 125 Hz. The sampling and averaging time was 10 minutes. The equipment was measuring the whole period from start to finish and was not removed during construction of the farm.

The data from May, June and July of 2020 and the data from May, June and July of 2022 was used in the analysis. The first dataset is from the period when the wind farm was not yet built, the second dataset is from the period when the wind farm was (almost) in full operation. The same months of the year have been used to minimise the effect of vegetation. A period of three months was used to obtained results at a broad range of meteorological conditions.

Only the data in the evening and night periods (between 7.00 pm and 7.00 am) was used in the analysis. The levels during the day were considerably higher than during the night and were mostly influenced by traffic noise.

4. Results

The effect of the wind farm can be assessed by comparing the time equivalent sound levels of all evening and nights of the data set from 2020 with the data from 2022. If the level in 2022 is substantially higher (i.e. more than 3 dB), then the effect of the wind farm can be calculated by subtracting the levels from each other. In figure 2, the results of point zu68 are given. This is one of three measurement locations where an effect on the average noise level was found. At six locations (see example in figure 3) the effect on the average sound level is minimal.

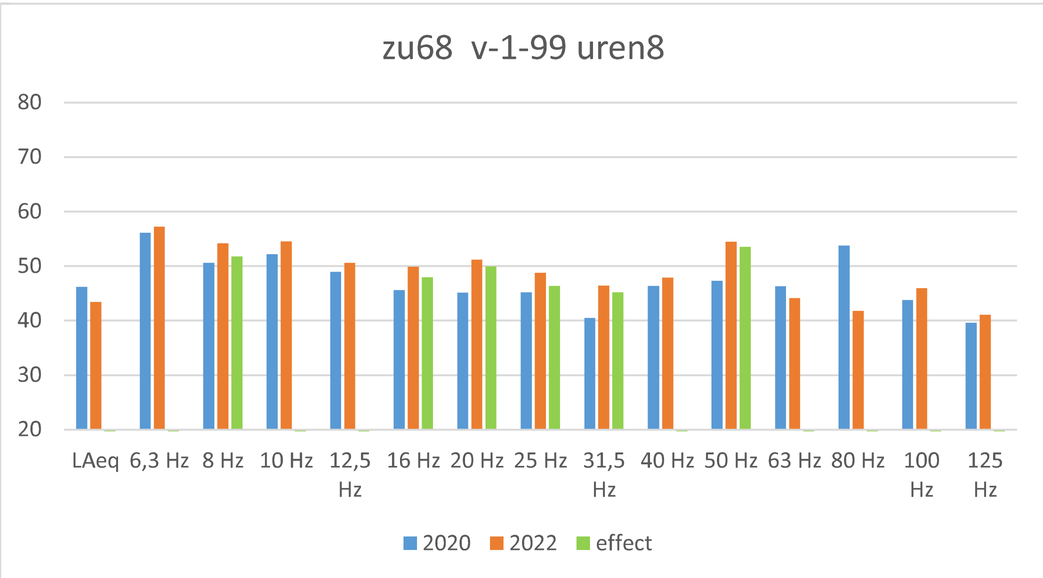

Figure 2 The average sound level at location zu68 of all nights from the data set.

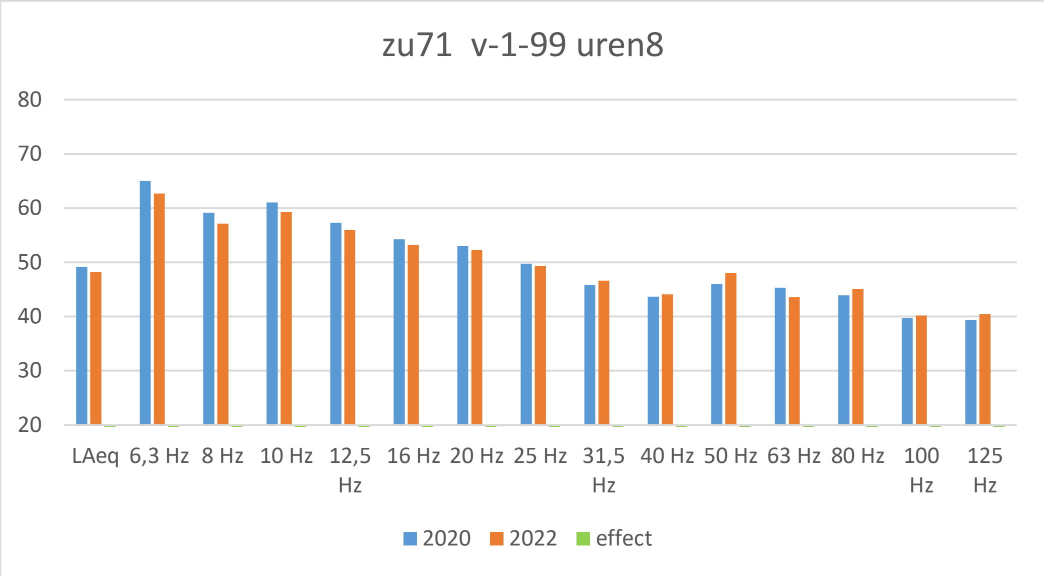

Figure 3 The average sound level at location zu71 of all nights from the data set.

The effect of the wind farm can also be assessed by using a histogram to present the data. By binning the data according to 10 minute sound levels of 1 dB and counting the number of samples in each bin, a histogram is obtained. Figure 4 shows the results for location zu68. The data from 2020 show quite a symmetric distribution of sound levels between 25 and 60 dB(A). The data from 2022 show that including the wind farm, most levels are in the region of 33 to 43 dB(A).

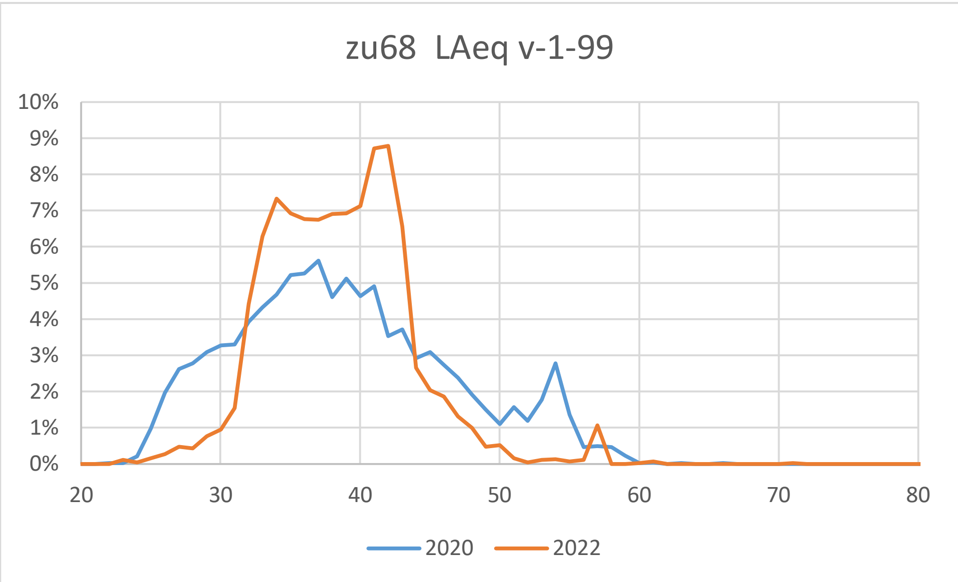

Figure 4 Histogram of location zu68 of all nights from the data set.

For location zu71, the histograms of 2020 and 2022 appear to be almost identical, apart from an increase in the occurrence of sound levels at 41 and 42 dB(A). The increase becomes more distinct when only comparing data at wind speeds higher than 1 m/s (see figure 6).

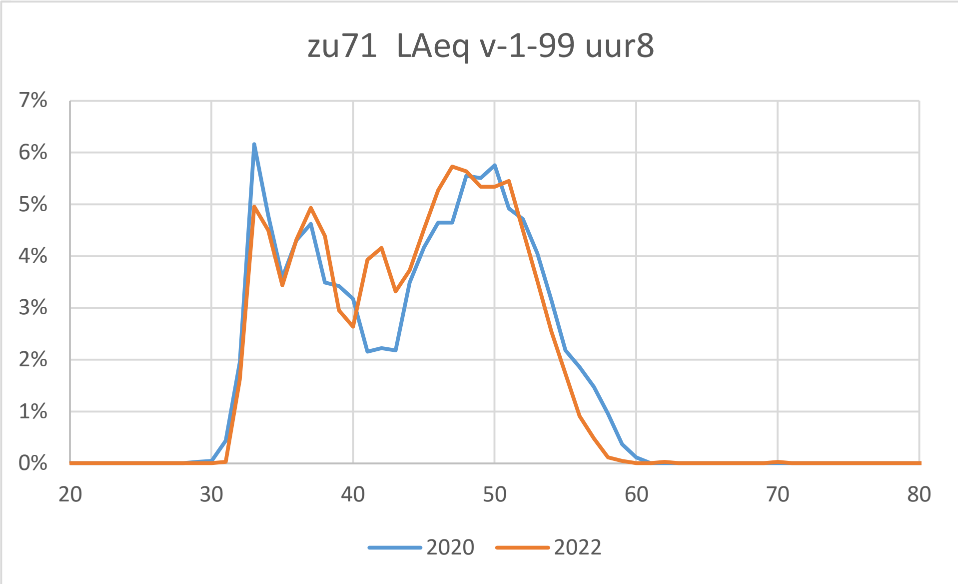

Figure 5 Histogram of location zu71 of all nights from the data set.

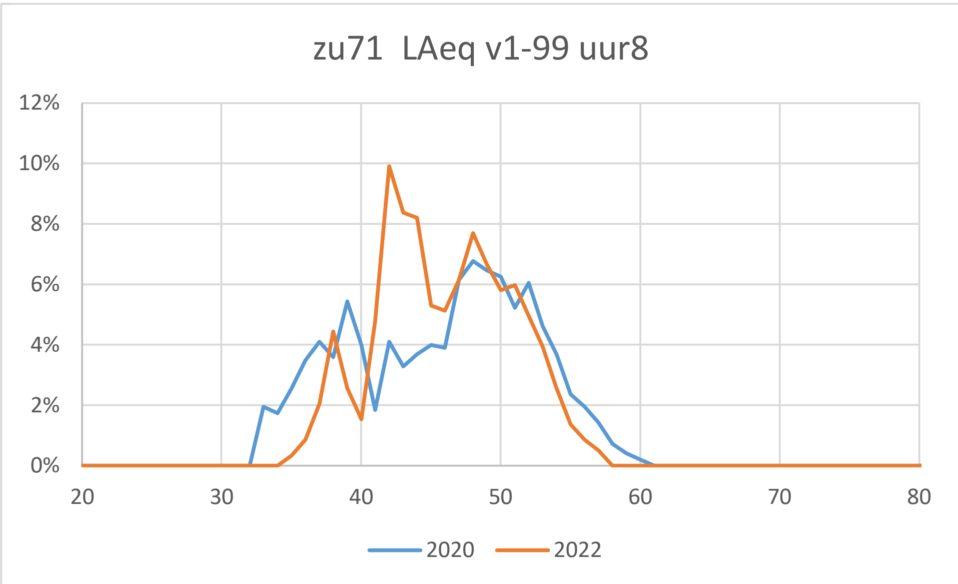

Figure 6 Histogram of location zu71 of all nights from the data set with wind speed > 1 m/s.

A histogram was made of all measured third octave bands. Most low frequencies show a clear increase in noise level when data is used with sufficient wind (> 1 m/s) (see the example in figure 7).

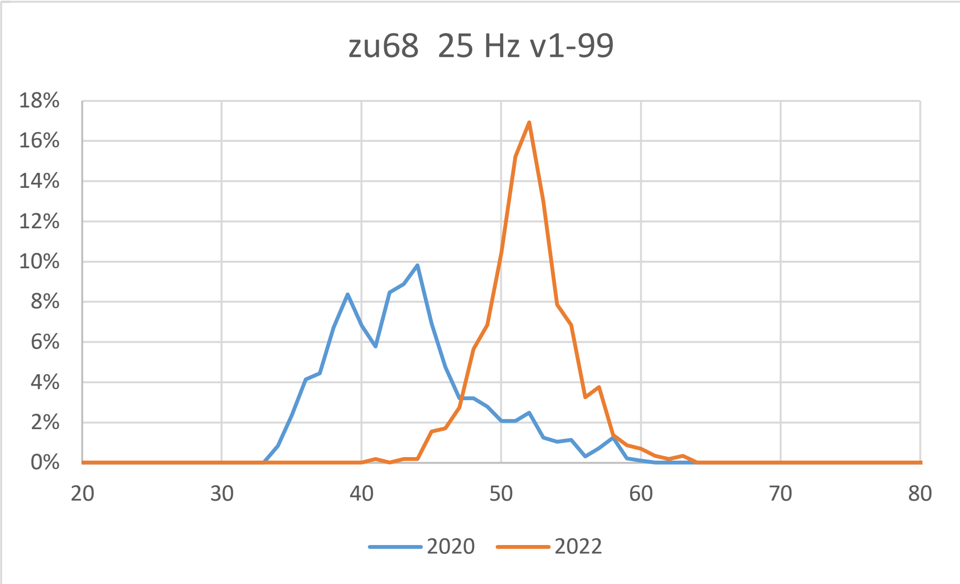

Figure 7 Histogram of third octave band 25 Hz of location zu68 of all nights from the data set with wind speed > 1 m/s.

From all histograms [1] of the third octave bands, the unweighted sound levels of figure 8 are obtained. The levels are from the samples when the wind farm is almost in full operation. The graph in figure 8 also shows two curves to assess the low frequency levels outside dwellings. The NSG-curve [2] can be understood as the level at which low frequency can be heard by humans. The VROM-curve [3] can be assumed as the level when annoyance occurs.

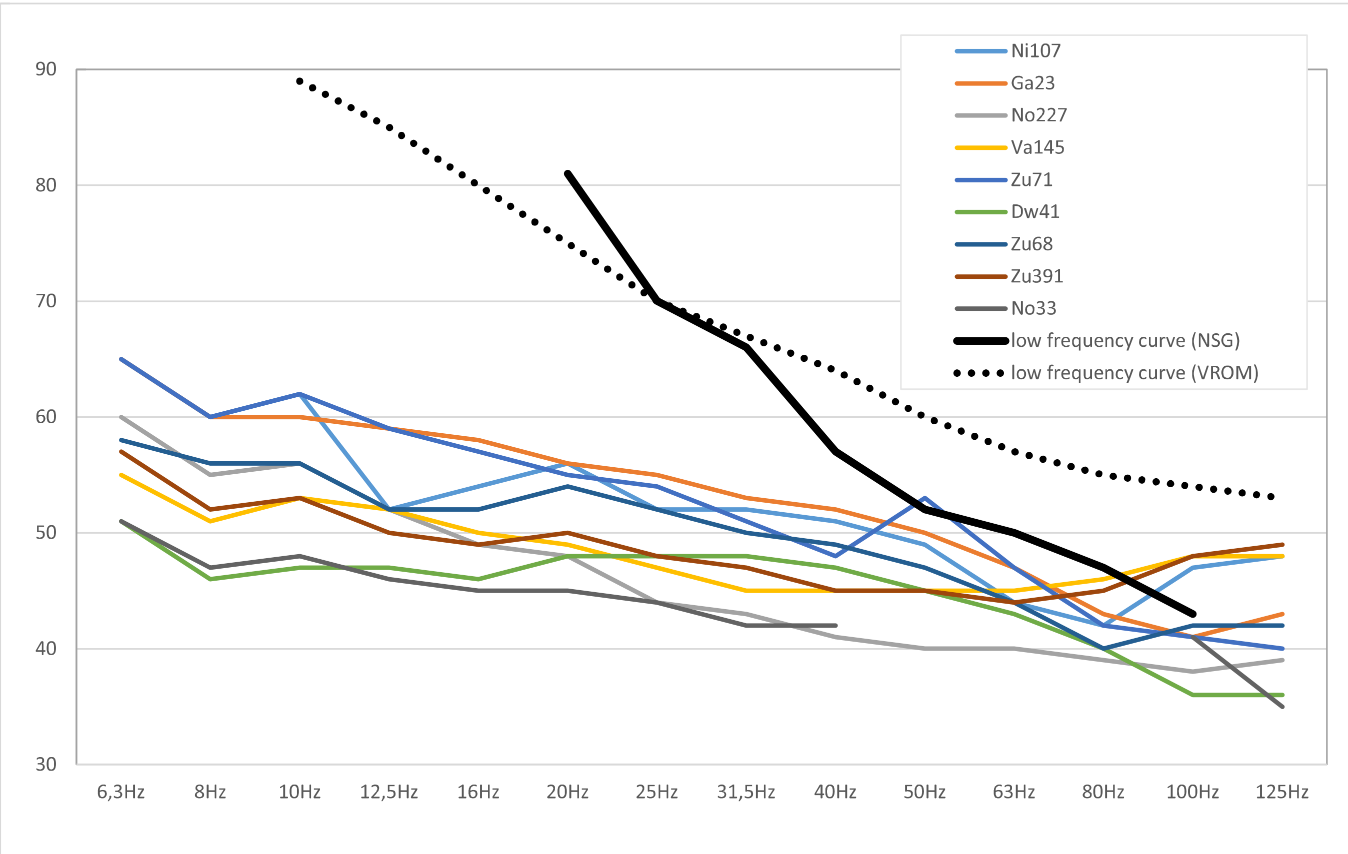

Figure 8 Unweighted low frequency sound level in windy conditions compared to NSG and VROM curves to assess outdoor low frequency sound.

The sound levels at dwellings are also calculated according to the Dutch method (similar to ISO 9613-2) based on the specifications from Nordex. In table 1 the measured levels are compared to the calculated levels.

Table 1 A-weighted levels in octave bands

	Measured					Calculated		
Point	8Hz	16Hz	31,5Hz	63Hz	125Hz	31,5Hz	63Hz	125Hz
Ni107	-8	6	18	24	33	23	32	29
Ga23	-9	7	19	25	28	25	34	31
No227	-14	-1	9	19	24	19	28	24
Va145	-17	0	12	25	34	21	30	27
Zu71	-8	6	17	26	26	18	27	24
Dw41	-23	-2	14	21	22	17	26	23
Zu68	-13	4	16	22	28	22	31	28
Zu391	-17	0	13	24	34	22	31	28
No33	-22	-4	9	--	24	15	25	21

Tabel 1 shows that the measured levels for the 31,5 and 63 Hz octave bands are lower than expected. For the 125 Hz octave band the measured levels are up to 7 dB higher than expected at four of the nine locations (Ni107, Va145, Zu71 and Zu391).

5. IEC61400-11 emission measurement

In addition to the long term measurement of the sound emission at dwellings, short term measurements of the emission of three of the 45 turbines were performed according to the IEC61400-11 method. Additional indicative short term measurements were also performed at 12 other turbines to check if the spectral distribution is the same as the three turbines measured according to the IEC-method.

The results of the three turbines measured according to the IEC-method show that the overall sound power level are similar or lower than the specifications. No relevant tonality was found.

In figure 9 the spectral results in octave bands are given. The results show that the measured spectral distribution is similar to the specifications. The measured levels at high frequencies are notably lower. For one of the measured turbines, the emission at 31,5 and 63 Hz is 1 to 2 dB higher. At the 125 Hz octave band the measured levels are not higher than expected.

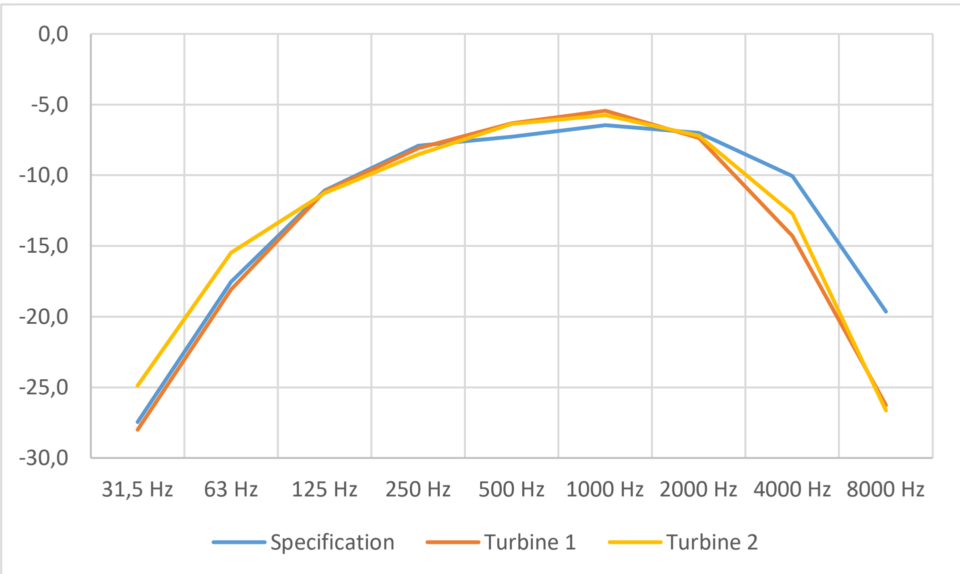

Figure 9 Sound spectrum of measured emission of 2 turbines compared to the specifications

6. Conclusions

Long term sound measurements have been performed before and after the wind farm was built. By analysing a period of several months, a clear difference can be found in the sound emission levels with and without the wind farm. Histograms have been used to analyse the difference in sound levels. The histograms show the number of 10 minute samples for each discrete sound level value. The analysis shows that low frequency sounds were measured at dwellings surrounding the wind farm.

For most measurement locations and most frequencies, a clear effect of the low frequency sound of the wind farm can be seen. Figure 8 shows that for the lowest frequencies (6 to 40 Hz) the sound levels are not relevant and probably will not be perceived.

The higher frequencies (50 to 125 Hz) can be heard but are not significantly higher than expected and annoyance due to low frequency sound is not expected.

The measured levels for the 31,5 and 63 Hz octave bands are lower than expected. For the 125 Hz octave band the measured levels are higher than expected at four of the nine locations (Ni107, Va145, Zu71 and Zu391).The higher levels at the 125 Hz octave band were not found in the measured emission at the turbines. The cause of these higher levels at the dwellings was not found.

Acknowledgements

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