UPPSALA UNIVERSITET

Noise analysis Vosnæs

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July 8, 2025

On behalf of the association *Foreningen mod vindmøller ved Vosnæs*, we have conducted a comprehensive noise dispersion analysis of the area surrounding the proposed wind farm at *Vosnæs*. Drawing on detailed measurements from several wind farms–such as Målarberget and Lervik–we have calibrated a high-precision computational tool, **SoundSim360**, capable of simulating sound propagation over complex terrain and across the full frequency spectrum, including infrasound (frequencies below 20 Hz).

The way sound propagates over large areas is influenced by a variety of physical factors, including atmospheric conditions, topography, ground characteristics, the spatial distribution of noise sources, and the spectral content of the sound. Accurate modeling must incorporate critical physical phenomena such as diffraction, refraction, geometric scattering, absorption, transmission, reflection, and interference. If these are not represented correctly, noise dispersion cannot be reliably simulated. SoundSim360 addresses this by solving the full 3D wave equation, incorporating real atmospheric profiles and topography, with no user-adjustable "free parameters." This ensures that the accuracy of the simulation depends solely on the correctness of the input source data.

Over the past two decades, my research group has developed a suite of advanced numerical methods specifically for high-fidelity sound propagation modeling (see, e.g., [27, 26, 28, 24, 25, 23, 29, 5, 22, 30, 41, 31, 33, 19, 4, 47, 46, 32, 39]). These methods form the foundation of SoundSim360, which is implemented to run efficiently on high-performance graphics cards.

By contrast, the most widely used model for wind turbine noise prediction today is Nord2000 [3], employed in software such as SoundPlan and windPRO. Nord2000 is fundamentally a ray-tracing model designed under the assumption of high-frequency sound. As a 2D model, it cannot accurately account for low-frequency sound propagation, nor does it model interference between multiple sources. Its handling of diffraction is also limited, which is particularly problematic in hilly terrain or near buildings and noise barriers. We have previously demonstrated that Nord2000 yields unreliable results in complex terrain [5]. To address its limitations, Nord2000 introduces numerous free parameters that users may adjust, making the results highly dependent on the user's input and assumptions. Multiple examples illustrate the inconsistencies that arise from this user–dependence. According to several studies, including work by Conny Larsson [16], Nord2000 tends to underestimate noise levels by 5–7 dBA at distances around 1 km compared to actual measurements. In some cases, even more simplified models are used–such as: 1) The model developed by the Swedish Environmental Protection Agency [1], or 2) The "Danish 2019" model. These models typically produce similar results to Nord2000 but are generally considered even less accurate. All of these simplified models face difficulties in simulating low-frequency noise, especially over large distances and in uneven terrain. Like Nord2000, they rely heavily on adjustable free parameters, leading to user-dependent results. Uncertainty in these models increases with the number of turbines, terrain complexity, and distance from the noise source. Low-frequency noise, particularly infrasound, is less attenuated by air and ground and can therefore propagate over vast areas.

Numerous studies have demonstrated that atmospheric conditions and ground properties cause significant variations in noise levels–up to 20 dBA at 1 km from a wind farm [16, 38, 15]. Long-term measurements by Conny Larsson in 2014 [16, 38] confirmed that these variations are greatest during evenings and nights, especially when snow is present. A particularly disturbing "swishing" noise–amplitude-modulated (AM) sound–occurs mainly during evenings, nights, and mornings. During a year-long measurement campaign, AM noise was observed 19% of the time at a 1 km distance from the wind farm. The occurrence of AM noise depends strongly on propagation path conditions and interference between turbines. AM noise can propagate over 10 km [36] and is significantly more disturbing than continuous sound at the same dBA level. It is typically strongest during winter evenings under atmospheric inversion conditions.

EMD International A/S has performed noise simulations using the *Danish 2019* model within windPRO 4.0.528. The results for normal sound in dBA at wind speeds of 6 and 8 m/s are shown in Figure 5, and results for low-frequency noise are shown in Figure 6. These simulations follow the guidelines in **BEK nr 135 af 07/02/2019**, later revised in **BEK nr 995 af 26/08/2024**. The reported sound power levels are 103.9 dBA (overall) and 91.8 dBA for low-frequency noise. According to **BEK nr 995 af 26/08/2024**, low-frequency noise includes all third-octave bands between 10–160 Hz. In order to simulate low-frequency noise reliably, it is essential to have access to the complete sound power spectrum across these third-octave bands.

However, this data has not been made publicly available. Despite repeated requests to both EMD and the turbine manufacturer (Vestas), we have not received the necessary frequency-specific SPL data. This lack of transparency raises serious concerns, as it prevents any independent verification of the low-frequency noise levels calculated using windPRO. Moreover, relying solely on windPRO's calculated levels at building façades–and then subtracting tabulated façade attenuation values [13], which have been heavily criticized by acousticians [35]–is a questionable and potentially unreliable methodology.

When considering measurements of sound pressure levels (dB) from wind turbines the broad band sound spectra is often divided into octave bands (OB). More accurate measurements present this in third octave bands for all bands between 0.1 Hz and 20000 Hz. The measured A-weighted SPL values for each OB between 4-8000 Hz,

$$[4,\ 8,\ 16,\ 31.5,\ 63,\ 125,\ 250,\ 500,\ 1000,\ 2000,\ 4000,\ 8000]\ Hz\ , \tag{1}$$

for a large set of older (smaller, between 75 kW–3.6 MW) wind turbines is found in [34]. The approximated SPL values (taken from Fig. 2 in [34]) are given by,

$$SPL^{(f)} = [23,\ 37,\ 54,\ 72,\ 85,\ 90,\ 97,\ 99,\ 98,\ 93,\ 88,\ 76]\ dBA\ . \tag{2}$$

To get the correct dB (or dBA) value for a broad band source simply add together each frequency-part according to

$$SPL_{tot} = 10 \cdot log10\left(\sum_f \frac{P_f^2}{P_{ref}^2}\right) = 10 \cdot log10\left(\sum_f 10^{\frac{SPL^{(f)}}{10}}\right)$$

Here $SPL^{(f)}$ are the SPL values for each separate OB. P_f is the pressure Amplitude (in Pa) for frequency f and $P_{ref} = 20\mu\ Pa$, the reference pressure. The resulting $SPL_{tot} = 103.7$ dBA, using the values in (2).

The corresponding non-weighted SPL levels (simply subtract A from the A-wighted SPL) for a typical wind-turbine is given by

$$[124,\ 115,\ 110,\ 112,\ 111,\ 106,\ 106,\ 102,\ 98,\ 91,\ 87,\ 77]\ dB\ . \tag{3}$$

This leads to a combined value of $SPL_{tot} = 125.2$ dB, using the values in (3). In [34, 45] it is shown that the relative amount of low-frequency noise is higher for large turbines, as compared to smaller turbines. The difference can also be expressed as a downward shift of the spectrum for larger turbines. This means that larger turbines have higher dB levels of low-frequency sound and infrasound in particular.

Nord2000 was developed to calculate traffic noise at shorter distances in flat terrain (a few hundred meters). Traffic noise is very different from wind turbine noise. Noise from wind turbines is by nature mostly low-frequency, with the highest levels below 5 Hz. The absolute highest levels are below 1 Hz, and the levels are expected to increase with increasing size of the turbines. Trying to measure infrasound with A-weighting (dBA) is absurd, according to me and many other experts. Some advocate C-weighting, which is an improvement, but this also takes very little account of infrasound. In Figure 1 we show the effect of A- and C-weighting, i.e. how much to deduct for each frequency band. At the Målarberget wind farm, we carried out a measurement of infrasound on October 23, 2024 when the turbines were on, and shortly after when all the turbines were turned off due to negative electricity prices, see Figure 1.

This proves that the wind turbines are the cause of the high infrasound around the wind farm, as the background is about 18 dB below the level with the turbines turned on. We have seen the same result (i.e. 18 dB higher infrasound with the turbines turned on) at the Lervik wind farm on May 21, 2024. If you sum up all frequency bands in the infrasound range (from the measurement in Figure 1) when the turbines are active, you get the value 102.7 dB, which corresponds to 25.6 dBA and 73.9 dBC. When the turbines are switched off, you get the corresponding values 85.9 dB, 7.7 dBA and 56.8 dBC. These are therefore the effective infrasound levels in dB, dBA and dBC (below 20 Hz). At the same time, we would like to emphasize that we do not include frequencies below 1 Hz here, as these cannot be measured accurately with current measurement equipment. We expect the levels to peak around 0.2 or 0.4 Hz. There are also several measurements that show higher levels (about 5 dB) of infrasound indoors [14, 6, 7, 10]. The values we report are from measurements outdoors.

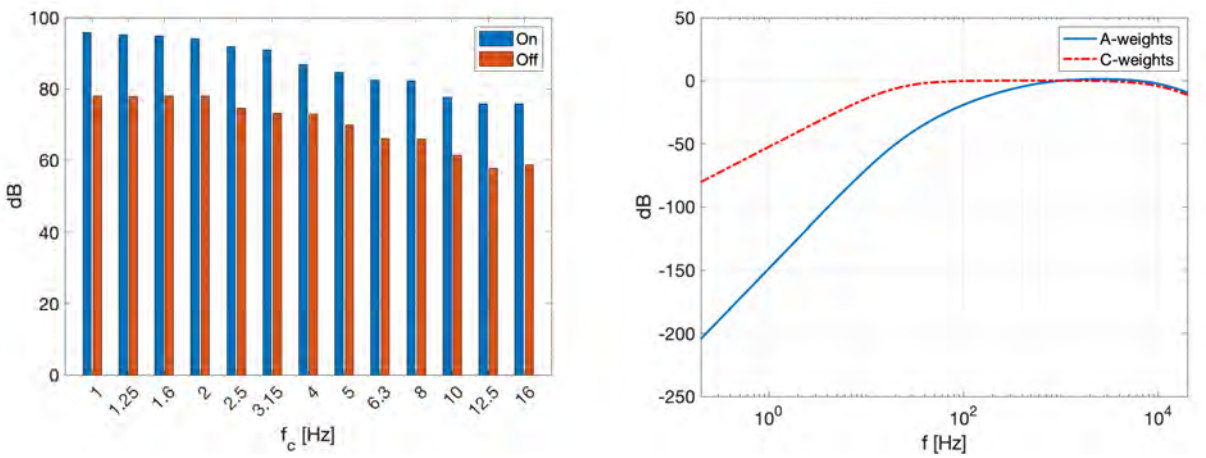


Figure 1: Accurate measurement of infrasound with and without the turbines (left). A- and C-weighting (right).

The impact of infrasound on humans

There are studies that some people highlight as *proof* that infrasound from wind turbines does not cause negative effects on humans, where these two reports [21, 20] are the ones that are often cited recently. What I can say after reading through these and countless previous reports (which allegedly show that infrasound from wind turbines has no negative effects, e.g. [9]) is that none of these have studied the doses that we measure near wind turbines. Neither have any of these studies involved a neurophysiologist. There are studies that link infrasound exposure (when the strength is between 80-90 dB) to brain activity [51, 12]. According to specialists in otoneurology, such as Håkan Enbom and Professor Alec N. Salt [42, 43, 44], there are strong indications that inaudible infrasound can trigger migraines in 30% of the population, which is the proportion of people who have proven to have a highly sensitive nervous system [17, 40]. According to experts in the field, the impact is highly individual. I can confirm that myself and another member of the team that measures infrasound have experienced sleep problems (up to a week) and migraines the day after each measurement around wind turbines (when we have proven to measure at least 95 dB at 1 Hz). In these cases, we have been exposed to infrasound levels of just over 95 dB around the 1 Hz frequency band for at least 4 hours (which corresponds to about 103 dB if you include all frequencies between 1-20 Hz, see Figure 1 as an example). Similar symptoms during infrasound measurements have been reported by others who have previously measured infrasound from wind farms [6], when the dose was significantly lower than 95 dB at 1 Hz. As early as 1985, Danielsson and Landström [11] showed that infrasound at levels of 95 dB during 1 hour of exposure causes an increase in diastolic blood pressure and decreases in systolic blood pressure and pulse rate. More recent studies also show that many animals move more than 5 km from wind turbines, especially deer and birds [48]. Those who live near wind farms also testify that wildlife is relatively sparse.

In the measurements we have carried out during the period 26 October 2023 to 16 December 2024, we have measured levels between 92-115 dB at 1 Hz, around wind farms at a distance of between 500-1000 m from the nearest turbine. For comparison, in the Finnish study [20] a smaller number of subjects were exposed to 73 dB infrasound at 1 Hz (which corresponded to a total of 89 dB infrasound) for 10 minutes. In the Australian study [21] a smaller number of subjects were exposed to 87 dB infrasound for 3 days. **We suggest that the impact of infrasound on health should be investigated as soon as possible by voluntarily exposing a statistical sample of the population (approximately 1000 people) to at least 95 dB at selected frequencies in the infrasound range for a few hours. Ideally pulsating infrasound. The sample should ideally include subjects with proven sensitivity to migraine. For this experiment, an expert in otoneurology should be hired. Until such a study is conducted, my recommendation is to pause the expansion of wind farms.**

Infrasound measurements

Measuring infrasound down to 1 Hz accurately requires measuring instruments that are demonstrably calibrated. A calibration around 1 Hz can be carried out at NORSAR against their Hyperion at their measuring station in Elverum. The station is a CTBTO certified infrasound station. We have used four Lidström infrasound microphones that are described in [18]. We have calibrated the Lidström microphones at NORSAR. The Lidström microphones were developed in the early 1980s in Sweden for helicopter detection. They are extremely sensitive but at the same time well adapted to harsh weather conditions. The Lidström microphones have

previously been used by the Swedish Defence Research Agency (FOI) and KTH (Prof. Thomas Lindblad), and are currently used by a research group at the Institute for Space Physics (IRF) in Kiruna under the leadership of Johan Kero [49], who has been kind enough to lend us three of these microphones.

During our measurements, we have also tested the Nor140 and Nor145 meters (which are popular with acoustic consultants). According to the specification, the Nor145 should be able to measure down to 0.4 Hz, but in reality it is not calibrated for such low frequencies and we clearly saw that it measures about 20 dB too low for infrasound below 3 Hz. To summarize. If the infrasound meter is not calibrated for 1 Hz, it cannot be used to measure infrasound from wind turbines. If you want to measure infrasound accurately, you should use calibrated professional equipment. A couple of the leading manufacturers of professional equipment for infrasound are Hyperion and Chaparall, which can measure accurately between 0.01 and 200 Hz. We have just received 2 Hyperion microphones to measure the infrasound level below 1 Hz accurately. Here it is also important to measure the infrasound level indoors, as it often turns out to be higher compared to outdoors.

The measurements that we have carried out and used to calibrate our calculation code, and to simultaneously inversely model the source strength of the wind turbines in the infrasound regime, took place on May 21, 2024 and September 10, 2024 at the Lervik wind farm, and on October 26, 2023, October 23, 2024 and December 16, 2024 at the Målarberget wind farm. We measured at both farms at several (3-4) measurement points and at different times of the day to collect good statistics. At each measurement, we read in current atmospheric data that we used in the inverse modeling. Here it is also important that we receive data (e.g. which turbines are stationary) from the operator during the measurement period. At Lervik and Målarberget, this has never been a problem. On February 14 we submitted a scientific article that describes the measurements, measurement data and calibration in more detail. Measurement data can be shared upon request. The turbines at Målarberget are of the Vestas V150-4.3 MW model. At Lervik, the turbines are larger, at 6.6 MW (model SG170-6.6). Using careful measurements and inverse modeling in SoundSim360, we can calculate the source strength (SPL) at 1 Hz to 154, 158 and 177 dB for the three measurements around Målarberget. At Lervik, we obtained source strengths (SPL) of 159 and 168 dB for the two measurements that were carried out. This means that there is a large variation in the source strength, which is largely correlated to the prevailing atmosphere. An average value from the five different measurement days gives 163 dB source strength (SPL) at 1 Hz, and is what we calculate in Figure 4. The planned turbines at Vosnæs are of the VESTAS V136-4.5 type with a hub height of 82 meters and a power of 4.5 MW. They are similar to those we measured at Målarberget, which have a hub height of 125 meters and a size of 4.3 MW.

Calculations of infrasound at Vosnæs

In the calculations, we have used a representative atmosphere from March 31, 2023 (weather data downloaded from THREDDS Data Server), and performed calculations for the night (at 4:00 AM) with both 6 and 8 m/s tailwind. The ground type is set as ordinary ground (Impedance class E) according to [3]. The atmospheric attenuation is taken from [2]. We used the source strength (SPL) of 163 dB to calculate the spread of the infrasound (in this case 1 Hz) around Vosnæs. The results can be found in Figure 4. The location of the turbines is taken from the windPRO noise calculation for Vosnæs carried out by EMD International A/S (see Figure 6).

When we present the infrasound maps in Figure 4 we present domains with certain dB levels, including uncertainty. Red domain for example is an area where the sound level is 95 dB ± 1.5 dB (hence within the range 93.5-96.5 dB). This is due to uncertainties in the model parameters, such as grund damping, atmospheric damping, and interference pattern. I consider everything within the red to be 95 dB, and everything inside the inner rim of the red to be higher than 95 dB. Everything outside of the outer rim of red is less than 95 dB.

In Table 3 the dB values at sensitive points (houses) for 1 Hz infrasound is presented. We estimate that the infrasound level at 1 Hz will fluctuate between the calculated values ± 15 dB, depending on weather and ground conditions. These are high levels and I consider it highly inappropriate (health-threatening) to locate this wind farm so close to Vosnæs in view of the research available, which clearly demonstrates an impact on blood pressure and the brain at infrasound levels around 90-95 dB [11, 51, 12]. It is important to note that 95 dB infrasound around 1 Hz corresponds to a total infrasound level (1-20 Hz) of about 103 dB.

Calculations of low frequency noise at Vosnæs

Low-frequency noise is one of the biggest environmental health problems we have today and those exposed to noise for a longer period of time are at increased risk of developing cardiovascular disease [8, 50], which is the most common cause of death in western Europe. There is clear evidence that low-frequency noise from wind power negatively affects sleep and increases with proximity to wind turbines [37]. Relying on a windPRO calculation of the low-frequency sound level at a building facade and then subtracting a tabulated facade attenuation [13] which is also heavily criticized by acousticians [35] is a highly questionable and unreliable method. According to **BEK nr 995 af 26/08/2024** low-frequency noise refer to all the noise in the third

octave bands between 10 -160 Hz. I have myself spoken to leading consultants in acoustics who admit that no current calculation program is able to estimate the transmission (and thus the facade attenuation) of low-frequency noise below 50 Hz.

We have calculated the low-frequency sound dispersion around Vosnæs in dBA using SoundSim360. In order to simulate low-frequency noise it is necessary to have the SPL between 10 -160 Hz. These data are apparently not publicly available. We have asked both EMD and the manufacturer Vestas for these data, but they have not shared this. This is very serious! Instead we have used the data in (2) taken from older turbines presented in [34] and used the highly criticized tabulated facade attenuation presented in [13], resulting in the effective SPL of 75.45 dBA. We assume the location (of the 3 turbines) according to the document *231215 Vosnæs - 3 x V136 - lavfrekvent støj* by EMD International A/S, where they use windPRO to compute low-frequency dBA noise emission maps. In the calculations, we have used a representative atmosphere from March 31, 2023 (downloaded weather data from THREDDS Data Server), and performed calculations for the night (at 4:00 AM) with both 6 and 8 m/s tailwind. The ground type is set as ordinary ground (Impedance class E) according to [3]. The atmospheric attenuation is taken from [2]. The results can be found in Figure 3. The corresponding results from windPRO are shown in Figure 6. In Table 7 the dBA values at sensitive points (houses) for low-frequency noise is presented for the windPRO simulation by EMD, and the corresponding values using SoundSim360 is presented in Table 2.

According to our calculations, the requirement of 20 dBA at 6 m/s and at 8 m/s is never violated here. This also holds for the windPRO calculations by EMD. These low-frequency dBA simulations rely on accurate SPL for each third octave band between 10-160 Hz, that should be available from Vestas, but they have refused to shared this data. My experience is that those values (if present) are not reliable. Especially in the evenings, amplitude modulated (AM) low-frequency noise [16] may occur, which is an extremely disturbing audible (swishing) noise that can spread more than 10 km. When AM noise occurs, the noise level in dBA becomes significantly higher (it can increase by more than 10 dBA compared to the dBA levels in the reported noise maps).

Calculations of dBA levels at Vosnæs

We also calculated the sound dispersion for all third octave bands (normal noise) around Vosnæs in dBA using SoundSim360. We assume a location and source strength (SPL) of 103.9 dBA according to the document *231215 Vosnæs - 3 x V136 - normal støj* by EMD International A/S, where they use windPRO to compute dBA noise emission maps. In the calculations, we have used a representative atmosphere from March 31, 2023 (downloaded weather data from THREDDS Data Server), and performed calculations for the night (at 4:00 AM) with both 6 and 8 m/s tailwind. The ground type is set as ordinary ground (Impedance class E) according to [3]. The atmospheric attenuation is taken from [2]. The results can be found in Figure 2. The corresponding results from windPRO are shown in Figure 5. In Table 7 the dBA values at sensitive points (houses) for normal noise is presented for the windPRO simulation by EMD, and the corresponding values using SoundSim360 is presented in Table 1.

Our simulations show that the standard noise level limits–42 dBA and 44 dBA outdoors are not exceeded for residents near the planned wind farm, except for the sensitive points J and K that have sharper regulation 37/39 dBA (at 6/8 m/s) and are here inside the red 37 dBA domain in Figure 2 for 6 m/s, taking into account the uncertainty of $\pm$ 1.5 dBA in the SoundSim360 computations. In the windPRO calculations by EMD the sensitive point J is exactly on 37 dBA at 6 m/s, presented in Figure 5. These dBA simulations rely on the specified SPL from Vestas (here 103.9 dBA). My experience is that those values are not reliable. Especially in the evenings, amplitude modulated (AM) noise [16] may occur, which is an extremely disturbing audible (swishing) noise that can spread more than 10 km. When AM noise occurs, the noise level in dBA becomes significantly higher (it can increase by more than 10 dBA compared to the dBA levels in the reported noise maps).

Sensitive point	Coordinates	dBA (6 m/s)	dBA (8 m/s)	Uncertainty
A	[583856.910000,6238238.730000]	38.634250	39.844840	± 1.5
B	[583891.560000,6238448.360000]	35.743610	37.086556	± 1.5
C	[584367.330000,6239083.550000]	36.448231	37.794223	± 1.5
D	[584957.950000,6239085.110000]	36.476940	37.947696	± 1.5
E	[585088.900000,6239075.280000]	36.399594	37.737591	± 1.5
F	[585578.820000,6238435.590000]	38.017217	39.213410	± 1.5
G	[585663.320000,6238318.890000]	36.268320	37.520514	± 1.5
H	[585689.080000,6238280.800000]	35.556102	36.832934	± 1.5
I	[585766.800000,6238186.880000]	34.204152	35.538025	± 1.5
J (37/39 dBA)	[585235.870000,6238738.640000]	35.718198	36.706569	± 1.5
K (37/39 dBA)	[585485.620000,6238707.970000]	36.039322	37.452698	± 1.5
L	[584095.400000,6238289.610000]	39.689883	40.816181	± 1.5

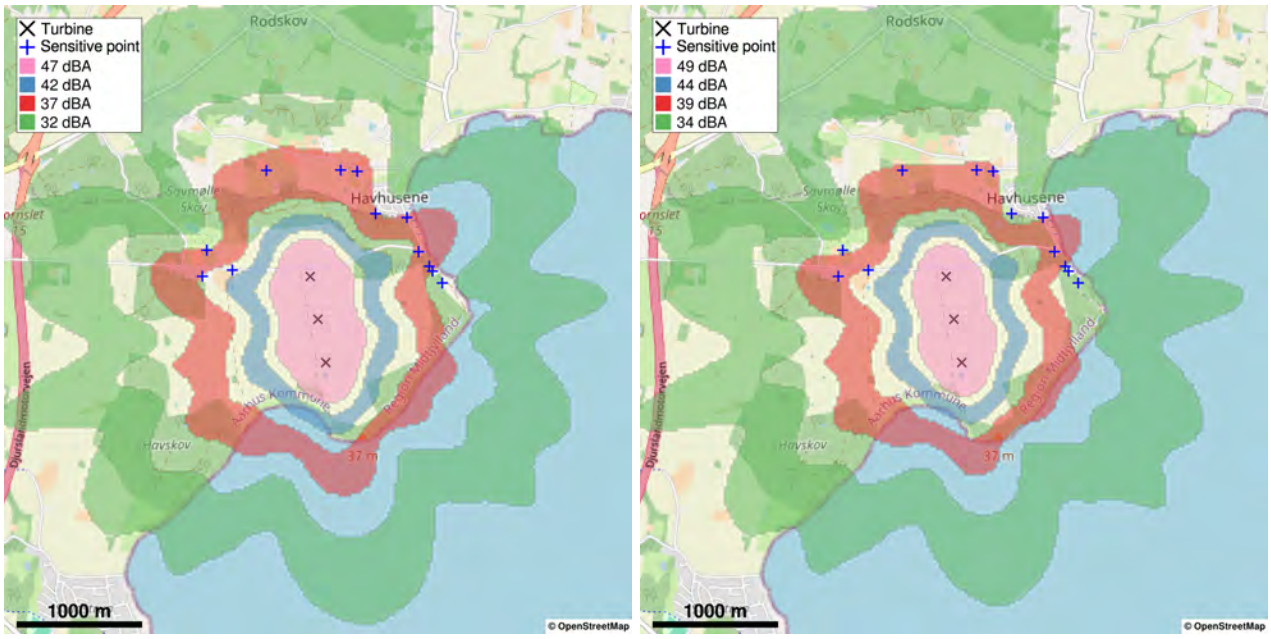
Table 1: dBA levels (normal noise) at the sensitive points (same locations and notation as in the document from EMD) calculated with SoundSim360. Sensitive points J and K have sharper regulation 37/39 dBA (at 6/8 m/s) and are here inside the red 37 dBA domain in Figure 2 for 6 m/s, taking into account the uncertainty of ± 1.5 dBA in the SoundSim360 computations.

Sensitive point	Coordinates	dBA (6 m/s)	dBA (8 m/s)	Uncertainty
A	[583856.910000,6238238.730000]	11.946788	12.754814	± 1.5
B	[583891.560000,6238448.360000]	9.114861	10.060259	± 1.5
C	[584367.330000,6239083.550000]	10.412270	11.373231	± 1.5
D	[584957.950000,6239085.110000]	10.308596	11.350012	± 1.5
E	[585088.900000,6239075.280000]	10.147211	11.072420	± 1.5
F	[585578.820000,6238435.590000]	11.318331	12.130738	± 1.5
G	[585663.320000,6238318.890000]	9.612023	10.481575	± 1.5
H	[585689.080000,6238280.800000]	8.927604	9.824990	± 1.5
I	[585766.800000,6238186.880000]	7.650446	8.586140	± 1.5
J	[585235.870000,6238738.640000]	8.967858	9.514941	± 1.5
K	[585485.620000,6238707.970000]	9.482195	10.490413	± 1.5
L	[584095.400000,6238289.610000]	12.719103	13.446536	± 1.5

Table 2: dBA levels for the low-frequency noise inside nearby buildings (same locations and notation as in the document from EMD) calculated with SoundSim360. Limit is 20 dBA.

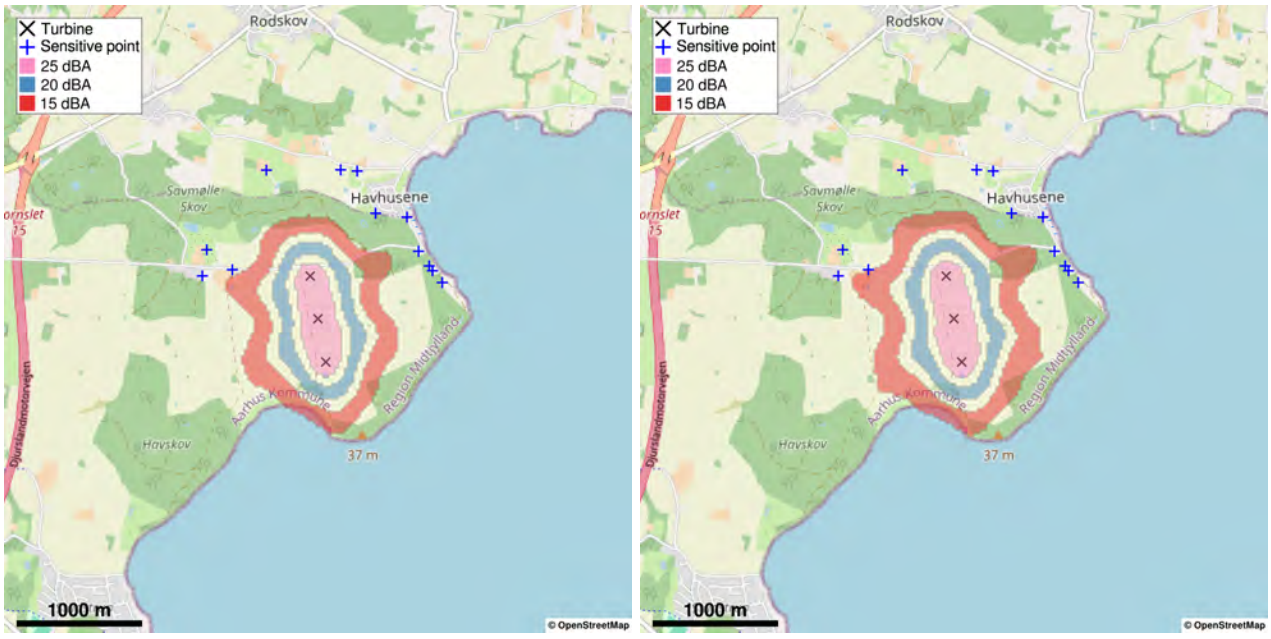
Sensitive point	Coordinates	dB (6 m/s)	dB (8 m/s)	Uncertainty
A	[583856.910000,6238238.730000]	101.9421	102.4148	± 1.5
B	[583891.560000,6238448.360000]	99.8871	100.4848	± 1.5
C	[584367.330000,6239083.550000]	101.4994	102.0417	± 1.5
D	[584957.950000,6239085.110000]	101.1150	101.7071	± 1.5
E	[585088.900000,6239075.280000]	100.8276	101.3249	± 1.5
F	[585578.820000,6238435.590000]	101.5243	102.0602	± 1.5
G	[585663.320000,6238318.890000]	100.0973	100.5998	± 1.5
H	[585689.080000,6238280.800000]	99.5888	100.0812	± 1.5
I	[585766.800000,6238186.880000]	98.8295	99.3220	± 1.5
J	[585235.870000,6238738.640000]	100.1435	100.4484	± 1.5
K	[585485.620000,6238707.970000]	100.0118	100.6212	± 1.5
L	[584095.400000,6238289.610000]	102.7264	103.1049	± 1.5

Table 3: dB levels for the infrasound (1 Hz) at the sensitive points (same locations and notation as in the document from EMD) calculated with SoundSim360. 95 dB and above is most likely harmful for up to 30% of the population. All points here are clearly above this critical limit.



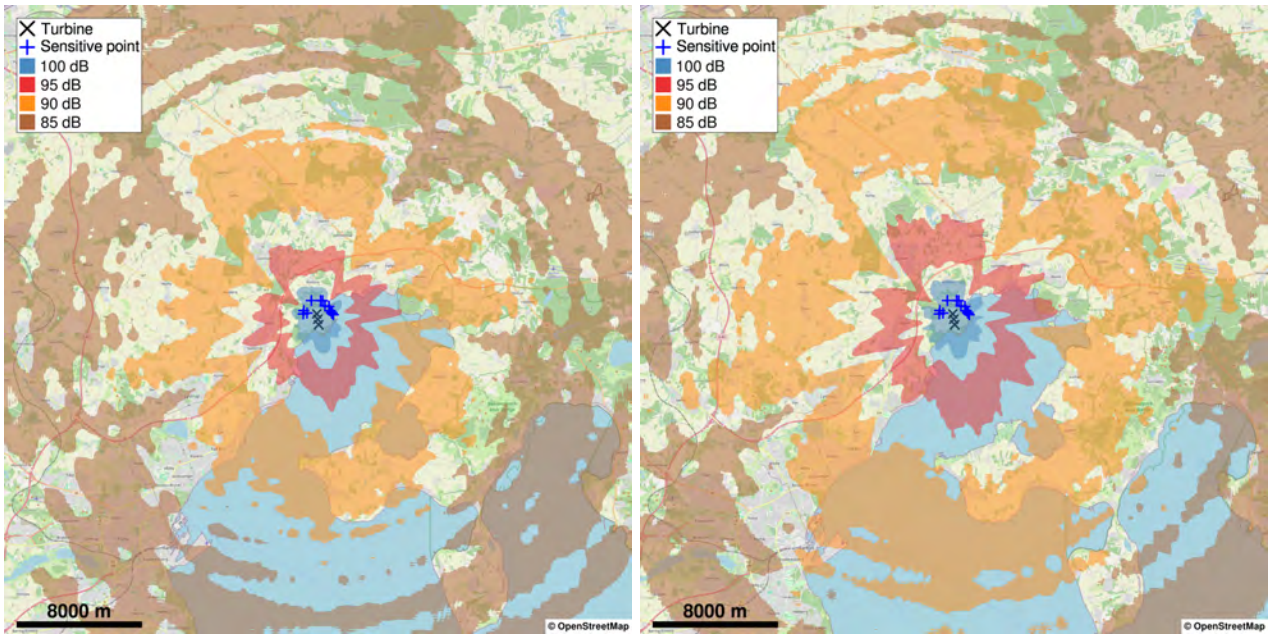
(a) 6 m/s (b) 8 m/s

Figure 2: Calculation of the noise level (dBA) with soundSim360 for Vosnæs. Left with 6 m/s and right with 8 m/s. Area with red show 37 dBA ± 1.5 dBA (with 6 m/s) and 39 dBA ± 1.5 dBA (with 8 m/s). Points J and K are within the 37 dBA domain at 6 m/s.



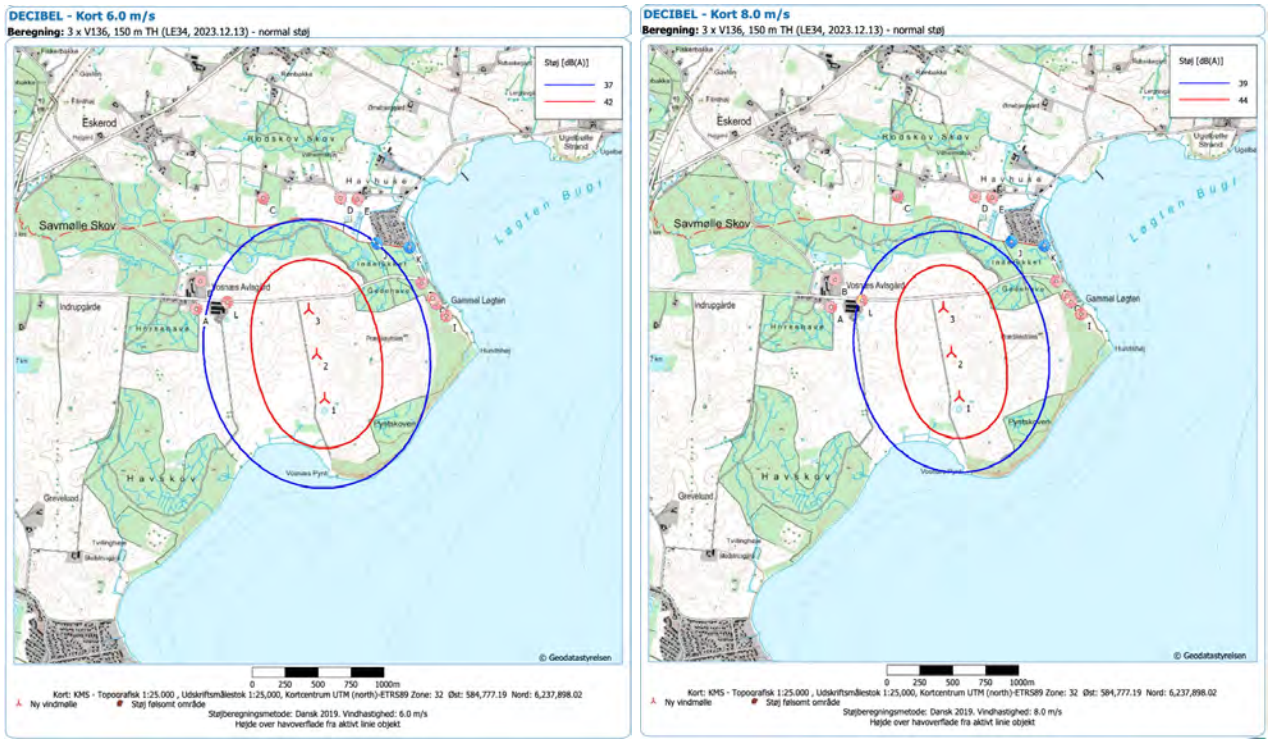
(a) 6 m/s (b) 8 m/s

Figure 3: Calculation of the low-frequency noise level (dBA) with soundSim360 for Vosnæs. Left with 6 m/s and right with 8 m/s.



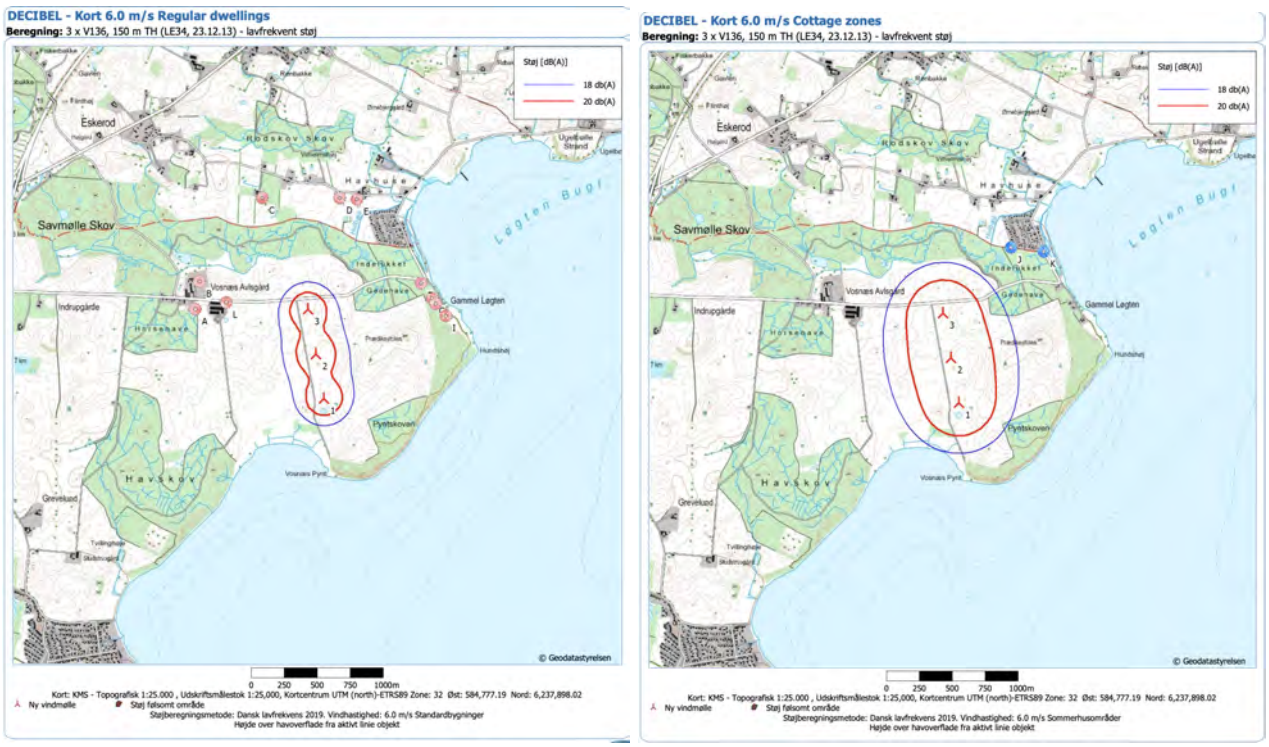
(a) 6 m/s (b) 8 m/s

Figure 4: Calculation of the infrasound (at 1 Hz) noise level (dB) with soundSim360 for Vosnæs. Left with 6 m/s and right with 8 m/s. All within outer edge of red is higher or equal to 95 dB at 1 Hz.



(a) 6 m/s (b) 8 m/s

Figure 5: Calculation of the normal noise levels (dBA) with windPRO for Vosnæs carried out by EMD International A/S. Left with 6 m/s and right with 8 m/s.



(a) 6 m/s (b) 8 m/s

Figure 6: Calculation of the low-frequency noise levels (dBA) with windPRO for Vosnæs carried out by EMD International A/S. Left with 6 m/s and right with 8 m/s.

(a) Normal sound (b) Low frequency sound

Figure 7: Calculation of the low-frequency noise level (dBA) with windPRO for Vosnæs carried out by EMD International A/S. Left with normal sound and right low-frequency noise, at the sensitive points (houses).

Conclusions

Our calculations using SoundSim360 indicate that the infrasound levels for residents located at the outer edge of the red-marked area in Figure 4 exceed 95 dB at 1 Hz. When accounting for all sub-bands between 1–20 Hz, this corresponds to approximately 103 dB infrasound. The area with at least 95 dB at 1 Hz spans several kilometers, potentially affecting a large number of residents. Based on findings in peer-reviewed literature [11, 42, 43, 44, 51, 12, 17, 40], such infrasound exposure is likely to be harmful to up to 30% of the population.

Our simulations further show that the standard noise level limits–42 dBA and 44 dBA outdoors, and 20 dBA for indoor low-frequency noise–are not exceeded for residents near the planned wind farm, except for the sensitive points J and K that have sharper regulation 37/39 dBA (at 6/8 m/s) and are here inside the red 37 dBA domain in Figure 2 for 6 m/s, taking into account the uncertainty of $\pm$ 1.5 dBA in the SoundSim360 computations. However, these results rely entirely on the sound power spectrum data provided by the manufacturer (Vestas), which are not publicly available. Of particular concern is the occurrence of amplitude-modulated (AM) noise [16], especially during the evening hours. This audible swishing noise is highly disturbing and can propagate over distances greater than 10 km. When AM noise occurs, it can raise the dBA level by more than 10 dBA compared to the levels shown in standard noise maps.

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I argue that the sound power level of 103.9 dBA reported by the manufacturer is not reliable. Long-term measurements from previous studies [38, 15] have shown that noise levels can fluctuate by up to 20 dBA at a distance of around 1 km from the nearest turbine, due to varying weather and ground conditions. Many sensitive receptor locations (see Table 1) are within 3 dBA of the legal limits when the manufacturer's reported SPL of 103.9 dBA is used. These locations are therefore at considerable risk of being adversely affected by elevated levels of AM noise, particularly in the evenings.

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