

Low Frequency Noise Proposed Wind Farm in Maastricht, The Netherlands

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Summary

In Maastricht, The Netherlands, a new wind farm was proposed adjacent to an existing wind farm in Belgium. As part of the environmental impact assessment in the planning phase, ARCADIS undertook a noise modelling study to evaluate cumulative noise levels produced by the new and existing wind sites. These calculations were conducted in accordance with both Dutch and Belgian regulations and compared against both national noise regulation limits. Low frequency noise levels were also assessed according to Dutch guidelines. On January 1st, 2012, legislation on low frequency wind turbine noise was approved and enforced in Denmark. Concerned citizens stated the noise levels of the proposed wind farm should be compared against the new, state-of-the-art Danish noise limits for low frequency noise. Calculations showed these noise limits were in compliance at the Dutch dwellings, but opponents asked the City Council of Maastricht for a second opinion from the Danish Aalborg University. The City Council decided to please the opponents and requested a review by the Danish university. The results of this review report showed ARCADIS had understood and applied the new Danish legislation correctly. However, it was further stated that in their opinion the prescribed Danish assessment method was not correct and new calculations were made. This interesting case describes the assessment by Dutch, Belgian, and Danish methods and gives insight into the Danish discussion on their new low frequency noise legislation.

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1. Introduction

On the outskirts of the City of Maastricht, The Netherlands (NL), a new wind farm was proposed adjacent to an existing wind farm and industrial site in Belgium (B). The proposed wind farm is part of the renewable energy plant Limburg. This energy plant consists of a wind farm, a biomass plant and a solar plant in Maastricht, and a wind farm, a biomass plant and a solar plant in Venlo.

As part of the environmental impact assessment in the planning phase, ARCADIS undertook a noise analysis study to evaluate the combined noise levels produced by the new and existing wind farms. The calculations were conducted in accordance with both Dutch and Belgian (Flemish) regulations and were compared against both national noise limits. Low frequency noise levels were assessed according to Dutch guidelines. Later in the process they were also

assessed according to new Danish legislation on low frequency wind turbine noise.

2. Situation

On the outskirts of the City of Maastricht in the south of The Netherlands a small wind farm of four wind turbines was proposed. These wind turbines were planned on a future industrial site just adjacent to the international border shared with Belgium. Just across the border in Belgium, there are already four existing wind turbines. These are located on an existing industrial site on the outskirts of the City of Lanaken. Figure 1 gives a view of the proposed and existing wind turbines.

The existing Belgian wind farm consists of four 2 megawatt turbines type Vestas V80-2.0 MW with a 100 meter hub height. The proposed new wind farm consists of four 3 megawatt turbines type Vestas V112-3.0 MW with a 119 meter hub height.

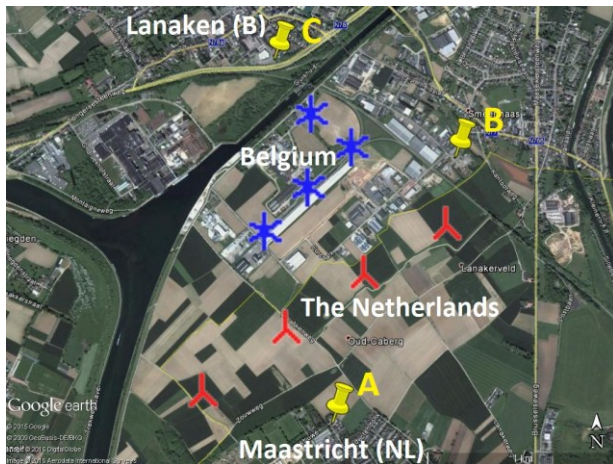


Figure 1. View of the four proposed wind turbines in The Netherlands (red symbols) and the four existing wind turbines (blue symbols) in Belgium.

The nearest noise sensitive locations are a residential area (A) in Maastricht south of the proposed wind farm, a few dwellings on the Belgian industrial site (B), a residential area (C) in Lanaken north of the existing wind farm, and some dwellings around the wind farms on the outskirts of Maastricht and Lanaken. The residential area in Maastricht is partially being redeveloped and the zoning plan allows additional dwellings at the northern edge of the residential area. This means that new dwellings might be situated a bit closer to the wind farm than the existing dwellings.

3. Wind Turbine Noise Legislation in The Netherlands and Belgium

3.1. Dutch Legislation

The Netherlands has specific legislation on noise from wind turbines [1]. The current legislation has been implemented on January 1st, 2011, together with a special regulation for measuring and calculating wind turbine noise [2]. The Dutch code requires a calculation based on the actual wind distribution in order to determine annual average noise levels L_{den} and L_{night} .

L_{den} is the day-evening-night level in dB as defined by the following formula:

$$L_{den} = 10 \log \left(\frac{12 \cdot 10^{\frac{L_{day}}{10}} + 4 \cdot 10^{\frac{L_{evening+5}}{10}} + 8 \cdot 10^{\frac{L_{night+10}}{10}}}{24} \right) \quad (1)$$

L_{day} , $L_{evening}$ and L_{night} are the A-weighted long-term average sound pressure levels determined over respectively all the daytime, evening time

and night time periods of a year. This is calculated using the local wind distribution at hub height as prescribed and made available by the authorities. The daytime period is from 7 a.m. to 7 p.m., the evening period is from 7 p.m. to 11 p.m. and the night time period is from 11 p.m. to 7 a.m.

The calculations require to determine the year average sound power level per day, evening and night in octave bands from 31.5 to 8000 Hz. A meteorological correction is taken into account if the distance from a turbine is larger than 10 times the hub height plus the receiver height. This correction is calculated on the basis of the hub height, the receiver height, and the direction and distance from the receiver position relative to the turbine positions.

The noise limits at dwellings and other noise sensitive buildings are:

- L_{den} : 47 dB;
- L_{night} : 41 dB.

The authorities can chose to take cumulative effects with neighbouring wind farms into account, but this is not obliged. The limit values do not depend on the land use or the background noise. However, the authorities can decide to set different noise limits taking special local circumstances into account.

3.2. Belgian Legislation

The Belgian Municipality of Lanaken is situated in the Flanders region of Belgium. Flanders also has specific legislation on wind turbine noise [3]. The current legislation entered into force on January 1st, 2012.

For noise calculations, the ISO 9613-2 method is used. The noise levels are calculated in 1/3 octave bands beginning at 50 Hz, or can be calculated in octave bands beginning at 63 Hz. The sound power level used is to be determined at 95% of the nominal power from the wind turbine. The calculations assume downwind conditions. A meteorological correction is not allowed.

The target values for wind turbine noise in Flanders are summarized in Table I. If the background noise level is higher than the values as stated in this table, then the noise limit is equal to the background noise level. In this situation a setback distance of a minimum of 3 times the rotor diameter has to be respected.

Table I. Target values for wind turbines in Flanders, Belgium.

Area	Target value in dB(A) open area		
	Day	Evening	Night
residential areas	44	39	39
rural areas, residential areas < 500 m from industrial areas	48	43	43
industrial areas	60	55	55
other areas	44-55	39-50	39-50

4. Wind Turbine Noise Assessment

As part of the environmental impact assessment the noise levels of the proposed wind farm were determined for three possible wind turbine layouts [4]. The calculations took into account the cumulating effect of the proposed wind farm along with the existing Belgian wind farm.

The noise levels were assessed for the existing and future residential areas in Maastricht (NL), the residential area in Lanaken (B), the dwellings on the industrial site and the nearest dwellings around the wind farms on the outskirts of Maastricht and Lanaken.

For the Dutch dwellings the noise levels were evaluated according to the Dutch regulations. For the Belgian dwellings the noise levels were evaluated according to both the Dutch as well as the Belgian (Flemish) regulations. Table II shows for the preferred alternative the results at three representative receptor positions at the existing residential areas (A and C) and the nearest dwelling on the industrial site (B). These positions are shown in Figure 1.

Table II. Cumulative noise levels from existing Belgian and proposed Dutch wind farm according to the Dutch [1] and Belgian [3] legislations for wind turbine noise for the preferred alternative.

Position at Dwellings	The Netherlands*		Belgium*
	L_{den} [dB]	L_{night} [dB]	$L_{Aeq, night}$ [dB(A)]
A (res. area)	45 (47)	39 (41)	--
B (ind. area)	48 (47)	42 (41)	46 (55)
C (res. area)	46 (47)	40 (41)	44 (43)

*The limit values are stated between brackets

The results show the noise levels meet the Dutch limit value at the Dutch residential area. At the nearest dwelling on the Belgian industrial area the Dutch limit value is exceeded by 1 dB, but the noise levels do meet the Flemish target value. At the edge of the residential area in Belgium the noise levels meet the Dutch noise limit, but do exceed the Flemish target value by 1 dB(A). However, since at this location the background noise level already exceeds the target value a higher noise level can be permitted.

Table II shows that assessment according to Dutch and Flemish legislation leads to different conclusions. The main reason is that in Flanders the limit values depend on the type of land use, such as rural, residential or industrial. In The Netherlands the legal limit values do not depend on the land use or the background noise.

It must be noted that we compared the cumulative noise levels of the Dutch and Belgian wind farm against the Dutch limit values and Flemish target values. However, legally the Dutch limit values only apply to the Dutch wind farm and the Flemish target values only apply to the Belgian wind farm and not to the cumulative noise levels.

5. Low Frequency Noise Assessment

The Netherlands and Belgium have no legislation on low frequency noise. However, in The Netherlands it is quite common to assess low frequency noise by comparing the noise levels against the NSG-curve and Vercammen-curve.

The NSG-curve is defined in the low frequency noise guideline of the Dutch Foundation against Noise Pollution (Nederlandse Stichting Geluidshinder, NSG) [5]. The main goal of this guideline is to objectively assess complaints on low frequency noise. The NSG-curve is based on the 90% hearing threshold of a representative group of elderly persons (aged 50 to 60 years). This criterion was chosen by the NSG because research showed complaints on low frequency noise mainly come from elderly people. Therefore, the NSG-curve is mainly used to assess the audibility of low frequency noise. It does not rate annoyance.

To assess annoyance by low frequency noise, in The Netherlands the Vercammen-curve is most commonly used. This curve is based on 3 to 10% range of persons annoyed by low frequency noise [6]. Since a ruling of the Administrative

Jurisdiction Division of the Council of State [7] in 2006 stating the Vercammen-curve is a suitable method to assess annoyance by low frequency noise, this curve has gained importance.

The NSG-curve and Vercammen-curve are shown in Figure 2.

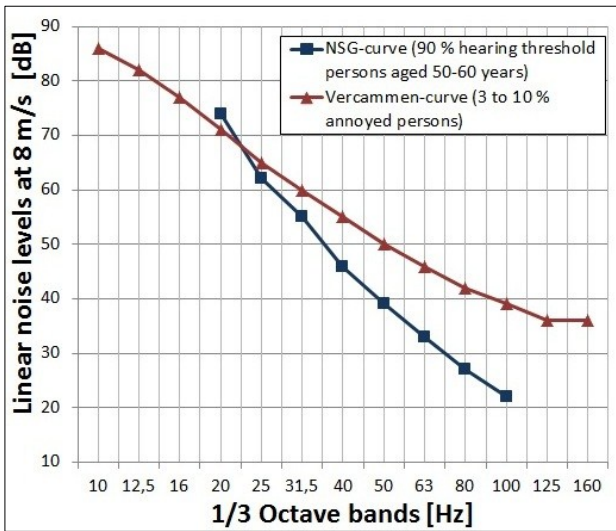


Figure 2. NSG-curve and Vercammen-curve limit values for assessment of low frequency noise.

The initial low frequency noise assessment [8][9] showed the NSG-curve will at the nearest dwellings most likely be exceeded for frequencies above 40 Hz and especially above 63 Hz. The Vercammen-curve will most likely not be exceeded, though the 50 Hz one-third octave band might be critical. This means that at the most critical dwellings the low frequency noise levels will probably be audible indoors. However, since the Vercammen-curve limit values are expected to be met, the possible annoyance by this audible noise is considered acceptable.

6. Danish Legislation Low Frequency Wind Turbine Noise

On January 1st, 2012, a revised statutory order on wind turbine noise entered into force in Denmark [10]. This new legislation includes a calculation method and limit values for impacts of low frequency noise.

The low frequency noise level L_{pALF} is defined as the total A-weighted sound pressure level in dB in one-third octave bands from 10 up to and including 160 Hz. The limit value for dwellings is 20 dB at a wind speed of 6 and 8 m/s. In contrary to regular noise limits, the limit value for low frequency noise applies to the indoor noise levels.

The sound insulation (level difference) to be used in calculating the indoor noise levels in dwellings is defined in the statutory order.

The same month the Danish legislation entered into force, concerned citizens in Maastricht supported by a well-timed article in a regional newspaper brought attention to the Dutch wind farm and that it should also be compared against the new, state-of-the-art Danish low frequency noise limit. Although the formal public participation procedure was finished, the City Council of Maastricht proved to be susceptible to their requests.

Calculations by ARCADIS showed the cumulative noise levels of the proposed and existing wind turbines also met the Danish limit values for low frequency noise, with the exception of the nearest dwelling on the industrial area [11]. The results are stated in Table III. At the dwelling on the industrial area (position B) the noise level L_{pALF} at a wind speed of 8 m/s is 1 dB over the Danish noise limit. This was deemed acceptable, because it is quite common to allow higher noise levels at dwellings on industrial sites.

Table III. Cumulative low frequency noise levels from existing Belgian and proposed Dutch wind farm according to the Danish legislation [8] for the preferred alternative.

Position at Dwellings	Denmark*	
	L_{pALF} [dB] @ 6 m/s	L_{pALF} [dB] @ 8 m/s
A (residential area)	16 (20)	19 (20)
B (industrial area)	18 (20)	21 (20)
C (residential area)	17 (20)	20 (20)
*The limit values are stated between brackets		

7. Second Opinion Aalborg University

After ARCADIS delivered the noise analysis report on the assessment according to the Danish regulations, opponents of the proposed wind farm asked the City Council of Maastricht for a second opinion by professor Møller of the Danish Aalborg University. The City Council decided to please the opponents and requested this second opinion. Møller et al. [12] concluded ARCADIS had understood and used the new Danish regulation for low frequency noise correctly.

However, next Møller et al. stated that the calculation according to the new Danish regulation underestimates the indoor low frequency noise levels. They stated where the 20 dB limit is just met, real measurements would give values that exceed the limit by several decibels in many houses.

Their main criticism on the Danish regulation is:

- The measurements to determine the low frequency sound insulation were not taken correctly. At low frequencies the sound varies within a room. To determine the sound insulation the indoor noise level should be measured where the annoyed person finds it loudest. They state the indoor measurements were taken at arbitrary positions that were not selected for a high level. In their opinion this means the determined sound insulation values are too high. Møller et al. estimate this error at about 5 dB.
- The Danish regulation defines sound insulation values which will be met in 67% of the dwellings. This means that in 33% of the dwellings higher noise levels than 20 dB might be observed. Møller et al. are of the opinion this noise level should be exceeded in not more than 10 to 20% of the dwellings. If the corresponding lower sound insulation is used, about 3 dB higher indoor noise levels will be calculated.

Next, Møller et al. made their own calculations for the proposed wind farm in Maastricht adding 5 dB respectively 8 dB ($= 5 \text{ dB} + 3 \text{ dB}$) to the noise levels as previously calculated by ARCADIS. Of course, these calculations resulted in considerably higher noise levels. Møller et al. concluded the 20 dB limit value would be exceeded in a very large area with many dwellings. They also stated they do not consider noise limits such as the Dutch based on yearly averages as suitable for wind turbine noise.

The second opinion report by Møller et al. was presented to the City Council of Maastricht by one of the opponents of the proposed wind farm. This report and the way it was presented caused a lot of confusion and unrest. The same citizens who appealed to the City Council to apply the Danish legislation to the proposed Dutch wind farm now argued against this legislation.

Note:

Already in 2010 and 2011 Möller et al. discussed their criticism on the new Danish regulation with Mr. J. Jakobsen of the Danish Environmental Protection Agency in the Journal of Low Frequency Noise, Vibration and Active Control [13][14]. Also, they brought their criticism forward in the public consultation procedure for the new Danish legislation. According to the Danish Ministry of Environment the underlying studies were done according to the recommended Danish measurement procedure for low frequency noise [15]. Also, the measurements were undertaken by experienced noise experts. The sound insulation as defined in the statutory order is exceeded by about 67% of the Danish dwellings. This means about 33% of the dwellings have a poorer sound insulation. The Danish Ministry of Environment indicates this choice has to be seen in relation to worst-case assumptions in the noise propagation calculations, like the fact that the calculations assume a wind direction from the turbines towards the dwellings and a wind speed of 8 m/s. However, these weather conditions only occur a limited part of the time. For the Danish Ministry of Environment the criticism by Aalborg University was no reason to adapt the legislation. As described before this legislation entered into force in January 2012.

The Netherlands Commission for Environmental Assessment concluded the second opinion report by Møller et al. was no reason to revise their positive advisory report on the environmental impact assessment for the proposed wind farm [16]. The Commission was of the opinion the chance of annoyance by low frequency noise had been adequately described.

8. Conclusion

The calculations showed the proposed wind farm in Maastricht met the Dutch limit values. It also met the Flemish target values. Taking the cumulative effects with the Belgian wind farm into account, the Dutch noise limit was exceeded by 1 dB at a dwelling located on an industrial area in Belgium. The Belgian target value was exceeded by 1 dB(A) at the edge of a residential area in Belgium. This was deemed acceptable because:

- Legally the Dutch noise limit values only apply to the Dutch wind farm and the Flemish target values only apply to the Belgian wind farm.

- It is quite common to allow higher noise levels at dwellings on industrial sites.
- Due to the vicinity of the residential area to the Belgian industrial area and wind farm, the background noise levels at the edge of the residential area in Belgium exceed the target value, which means a higher noise limit is applicable.

The assessment according to Dutch guidelines showed low frequency noise of the proposed Dutch wind farm and existing Belgian wind farm would probably be audible indoors within the nearest dwellings. However, since the Vercammen-curve limit values were expected to be met, the possible annoyance by this audible noise was considered acceptable. This was confirmed by the fact that the cumulative noise levels also met the Danish limit values for low frequency noise. The only exception was a dwelling on the industrial area. This was deemed acceptable, because it is quite common to offer less protection to dwellings on industrial sites.

A second opinion by Møller et al. of the Danish Aalborg University showed ARCADIS had understood and used the new Danish regulation for low frequency noise correctly. However, Møller et al. criticized the new Danish legislation on low frequency noise and was of the opinion the new regulation underestimates the actual indoor low frequency noise levels. They reported the 20 dB limit value would in Maastricht be exceeded in a very large area with many dwellings.

The second opinion report by Møller et al. was presented to the City Council of Maastricht by one of the opponents of the proposed wind farm. This report and the way it was presented caused a lot of confusion and unrest. The same citizens who appealed to the City Council to apply the Danish legislation to the proposed wind farm now argued against this legislation.

On April 24th, 2012 the City Council of Maastricht accepted a motion not to continue the procedure for the zoning plan which would allow the proposed wind turbines. The main reason was lack of support for the wind farm in the City Council and the need to clear up this issue for the concerned citizens of Maastricht.

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