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Background noise assessment in Utrecht

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Summary
In 2013 the municipality of Utrecht (The Netherlands) investigated the possibility to operate a wind farm on an industrial area surrounded by residential areas with dwellings as close as 125 meters.
Although there is a single national noise limit for wind farms (47 dB L_{den}), the local Utrecht noise policy allows for a lower limit equal to the level of the background noise L95 in order to reduce noise annoyance.
During a three month measurement survey, background noise was measured on eight locations around the industrial area. At the same time meteorological data was gathered. On three locations low frequency background noise was measured as well.
The noise measurements yielded information about the background noise level as a function of wind speed, wind direction and location. In order to prevent the wind farm to exceed background noise levels in residential areas, the measurement results were then used to help – in addition to visual aspects - design the wind farm (location, type, height and number of turbines). This resulted in a proposal for a wind farm of six turbines on a distance of at least 600 meter to the closest residential area. To fulfill the noise limits, some wind turbines would have to be adjusted (low noise mode, lower rpm) at specific meteorological conditions.
Furthermore, we investigated the influence of the proposed wind farm on the number of annoyed people in relation to noise mitigation measures.
In this paper the results of the background noise measurements are presented and how they influenced the design of the projected wind farm and proposed noise limits and how that would affect the number of annoyed people in the surrounding residential areas.

1. Introduction
The city of Utrecht in The Netherlands wants to reduce the use of fossil fuels by means of saving energy and using sustainable energy. Part of this energy can be produced within the city limits. In 2012-2013 the possibility was investigated to realize a wind farm (15-25 MW) on an industrial area “Lage Weide” within the municipality (see figure 1). The industrial area (red) is surrounded by several

residential areas (blue). A motorway (A2) is situated at the southwest boundary of the industrial area.

Figure 1 – Overview industrial area Lage Weide at Utrecht

In order to make a well-balanced decision an Environmental Impact Assessment has been carried out [1]. Because noise from the wind farm was one of the major concerns of the local residents, this aspect played an important role in the assessment. This paper shows how background noise measurements were used to help design the wind farm in such a way that the increase in the number of highly annoyed people would be limited as much as possible.

2. Noise limits

In The Netherlands the standard limit values for wind farm noise are 47 dB L_{den} and 41 dB L_{night} at the façade of dwellings. Surveys show that noise from wind turbines causes more annoyance than an equal noise level from - for instance - road traffic. At a level of 47 dB L_{den} 8% of the exposed population can be expected to be highly annoyed [2].

There are however possibilities for local governments to set alternative limits. A key element in the local noise policy in Utrecht is the protection of quiet residential areas whereas higher noise levels are accepted along busy roads. The background noise level is used as the preferred limit value in environmental permits for industries. In order to apply this policy rule in designing the wind farm a background noise survey has been carried out. With this information the city of Utrecht wanted to investigate the impact of the planned wind farm on the number of residents highly annoyed by noise.

3. Background noise measurements

During a period of three months noise measurements were carried out on eight different locations around Lage Weide by an acoustic consultancy. The locations were carefully chosen; mainly near the dwellings closest to the planned wind farm but also in the middle of the neighborhoods. Some locations were situated in a relatively quiet residential area (locations 3 and 7), others along a busy road (locations 2 and 8).

Because the noise emission from a wind farm as well as background noise increases with wind speed, both wind speed and wind direction have been monitored as well. A wind sensor was installed at a height of 10 meters in the center of the industrial area. Figure 2 gives an overview of the monitoring stations.

Figure 2 – Locations of all eight noise monitoring stations and wind sensor

The monitoring system measured the equivalent noise levels every second. The average wind speed and direction have been determined in time blocks of 10 minutes. Background noise level is defined as the L_{95} or 95-percentile of the measured $L_{eq,1sec}$ values. L_{95} values were tagged with the simultaneous wind data.

The results of this survey are presented in [3]. Figure 3 shows the L_{95} levels in the evening (19:00-23:00 h) as a function of wind speed and direction at location 5 southwest and location 8 northeast of Lage Weide. It is clearly visible that in a quiet residential area (location 5, Frederik Loewestraat) the background noise level increases with wind speed. This effect is less stronger along a busy road (location 8,

Amsterdamsestraatweg). The influence of the wind direction at position 5 is also recognizable; the noise level is higher at wind directions between northwest and northeast due to the motorway.

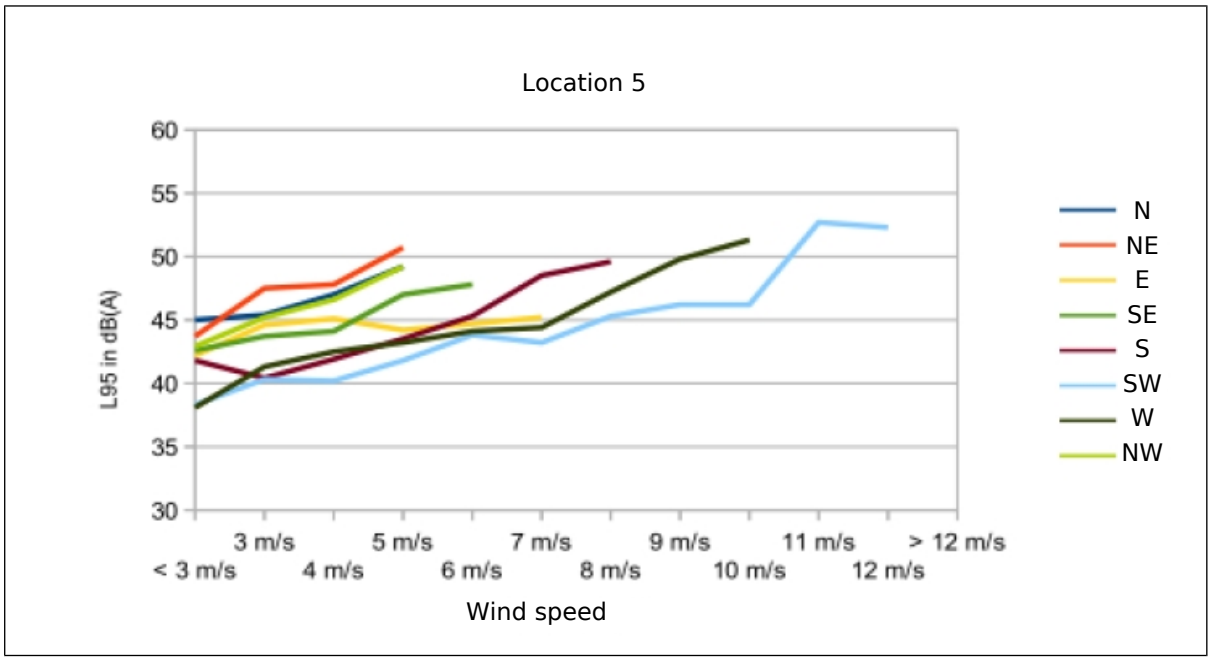

Figure 3a – L_{95} in quiet residential area (location 5) and in evening period as a function of wind speed and direction

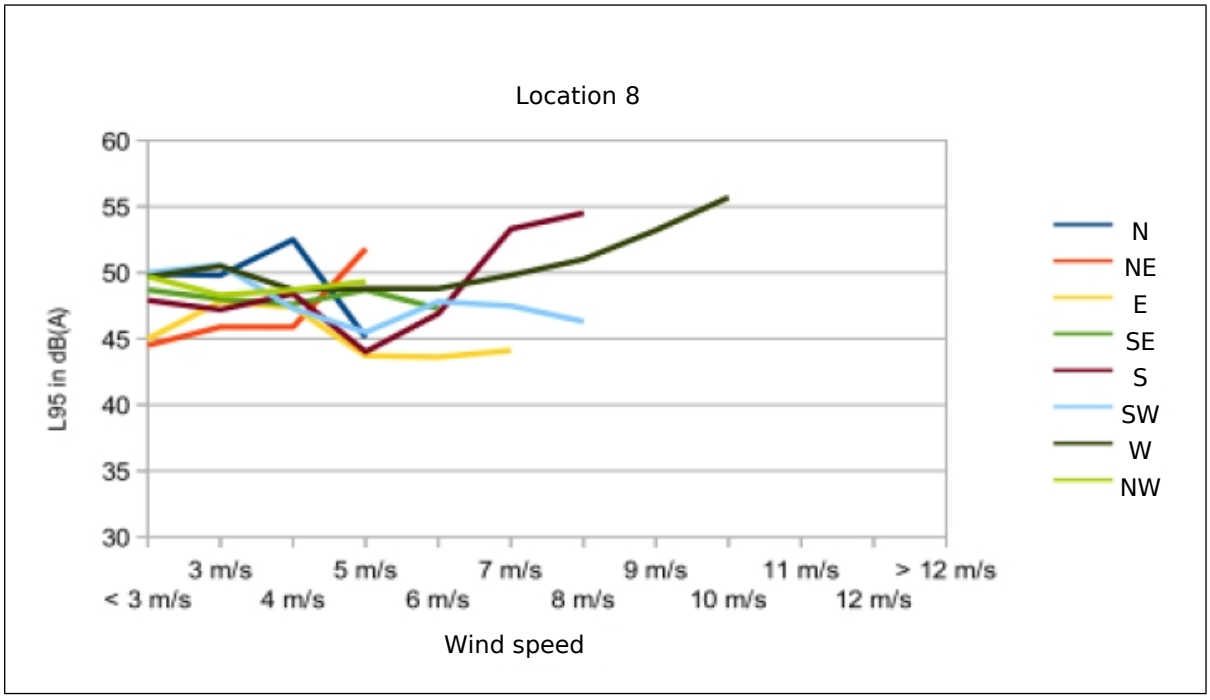

Figure 3b – L_{95} along busy road (location 8) and in evening period as a function of wind speed and direction

4. Restrictions for the wind turbine farm

In the process of designing the wind farm many different variants were investigated. Every variant first had to fulfill the national noise limit of 47 dB L_{den}. The next step was to calculate the measures that had to be taken to stay below the background noise levels. As an example figure 4 shows a configuration with 5 turbines of 4 MW.

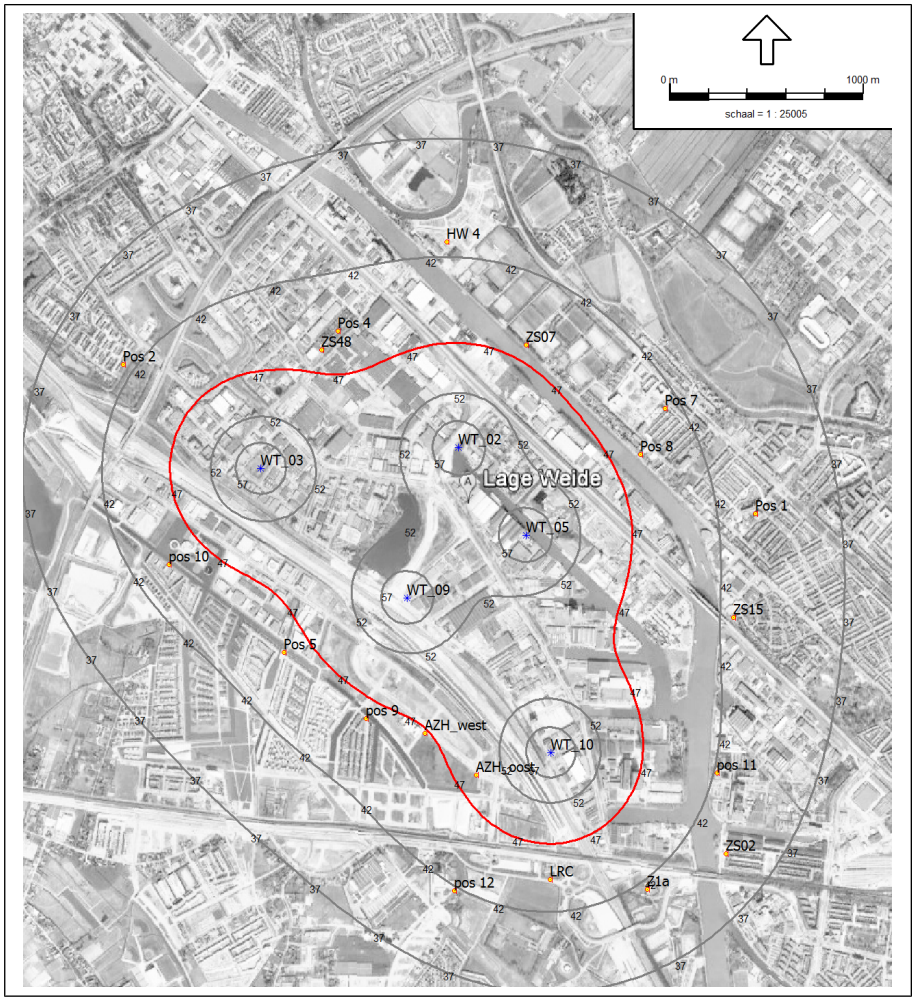

Figure 4 – Wind turbine noise contour lines for five turbines at values of 47 dB (red), 42 and 37 dB (grey) L_{den}

In the next step the resulting calculated wind farm noise levels at different wind speeds were compared with the average background noise levels. As figure 5a shows, the background noise level at position 7 is exceeded at wind speeds of 5 and 6 m/s (at 10 meter height). In order to stay below the level of the background noise, two wind turbines have to be put in low noise mode at these specific wind speeds. The resulting noise levels can be seen in figure 5b.

To do this calculation a fixed relation between the wind speed at 10 meters and at hub height has been used. However, on calm evenings - especially in summertime - the wind speed at ground level can sometimes drop while the wind speed at hub height remains relatively high. During those meteorological conditions the wind farm can be better audible and cause annoyance. To prevent this, the wind farm also has to stay below background noise during those specific conditions and perhaps even has to be brought to a standstill.

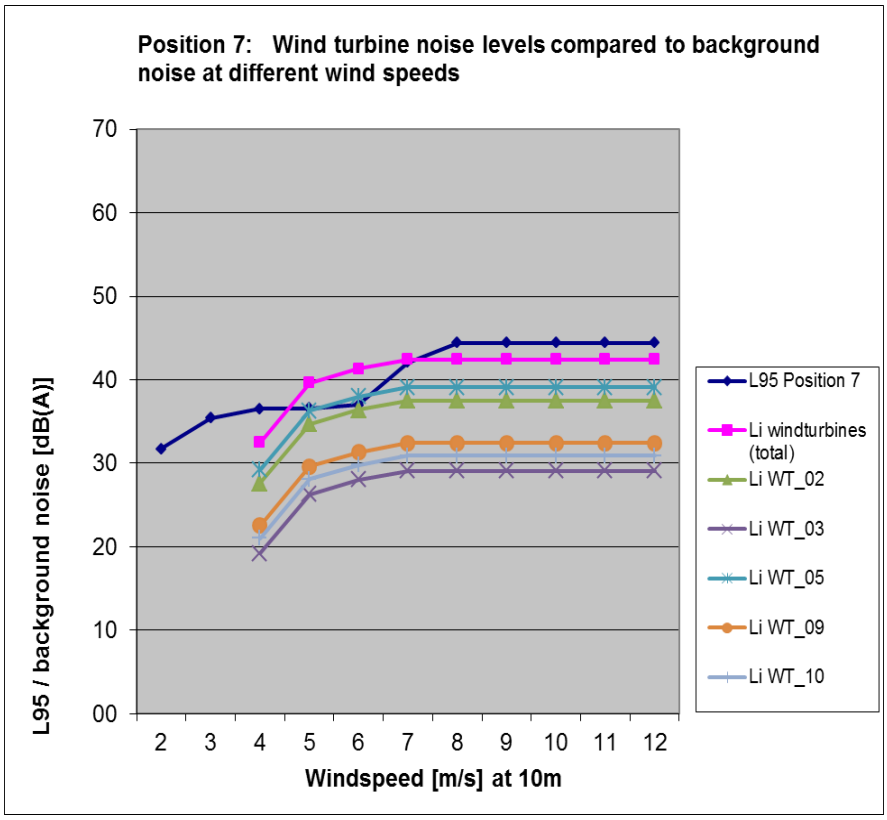

Figure 5a – Individual and total wind turbines noise levels compared with the L_{95} background noise level

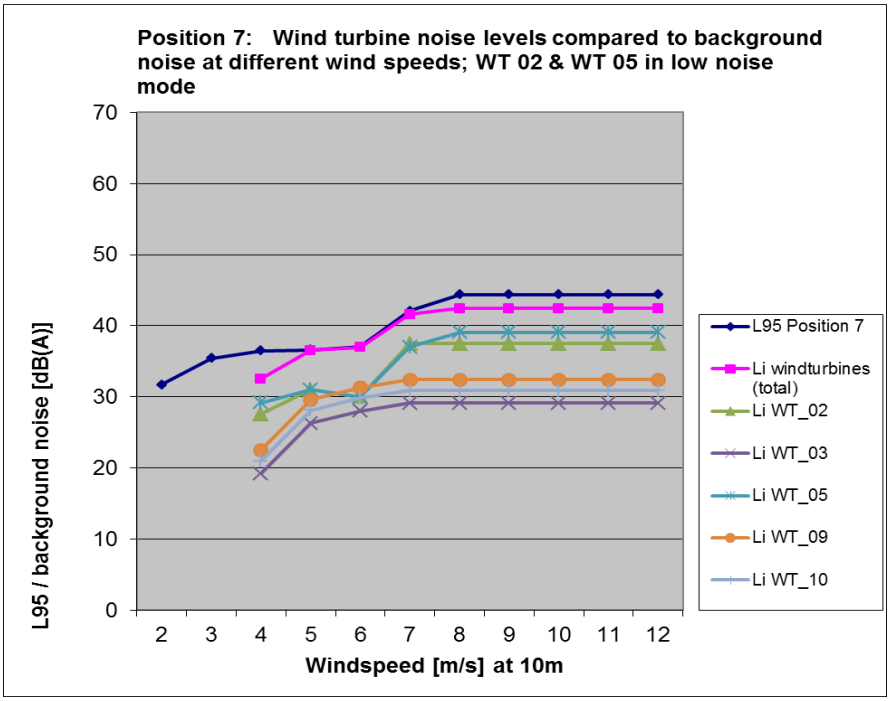

Figure 5b – Individual and total wind turbines noise levels in low noise mode compared with the L_{95} background noise level

5. Number of annoyed people

In the Environmental Impact Assessment of course other aspects than background noise were also taken into account such as visual impact (see figure 6) and safety risks. Low frequency background noise was addressed as a separate factor as well [4]. This resulted in a proposal for six wind turbines of 2.5 MW at a central location on the industrial site.

Figure 6 – One of the views for the visual impact assessment

Even when the noise level of the wind farm is below the background noise level, the wind farm can still be audible and cause annoyance. In order to consider the effect of the wind farm on the number of highly annoyed people, the annoyance due to existing noise sources was determined by using noise maps and dose-response relations, and the increase due to the wind farm was calculated.

In the reference situation the number of highly annoyed people due to (calculated) road traffic, railway and industrial noise in the residential areas around Lage Weide amounted to 610-990 people. The calculations showed that adding a wind farm on Lage Weide would lead to an increase of 30-60 residents being highly annoyed.

6. Conclusion

By using the background noise level as a limit, the increase in annoyance can be reduced when compared to applying the standard noise limit.

However, even though much effort was put into the prevention of annoyance, opposition to the plan was strong and in the end the plan was rejected by the city council.

References

[1] RoyalHaskoningDHV (2013) *MER Windmolenplan Lage Weide,* report 9Y3509/R003/EHA/T

[2] S.A. Janssen, H. Vos, A.R. Eisses, E. Pedersen. *A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources*, J. Acoust. Soc. Am. 130 (6), 3746-53 (2011)

[3] Peutz bv (2013) *Onderzoek naar referentieniveau van het omgevingsgeluid in de omgeving van industrieterrein Lage Weide ten behoeve van mogelijke ontwikkeling windturbinepark,* report F 20267-3-RA

[4] E. de Beer (2013) *Assessment of low-frequency noise due to wind-turbines in relation to low-frequency background noise* Internoise 2013