The impact of wind turbine noise on health

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There is a global need to convert the electricity production from fossil fuel dependent processes to renewable energy in order to reduce the carbon dioxide emissions. To capture the energy of the wind with wind turbines is now days a well-known technique that is also, with today's energy prizes, profitable if the wind turbines are placed on land. The installed capacity of wind power in the world is rapidly increasing and hence also the number of wind turbines. The wind turbines are preferable placed close to the electrical grid and where there are roads in order to reduce the costs. This means that they are often placed in areas where people live and that an increasing proportion of the population come in contact with single wind turbines or larger wind farms.

The erection of wind turbines is in Sweden, and many other countries, preceded by an environmental assessment of the impact of wind turbines on people living nearby. One impact to be assessed is sound. It is thus important to have scientifically based knowledge of how wind turbine sound will be perceived in order to ensure that this sound does not adversely affect the health of residents in the area. The relationship between sound levels from wind turbines at dwellings and perception of sound was therefore derived using data from two Swedish epidemiological field studies (Pedersen and Persson Waye, 2004; Pedersen and Persson Waye, 2007).

The percentage of respondents who noticed wind turbine sound and their dwelling increased with increasing sound power level (Figure 1). About 80% of the respondents (n =1095) could hear the wind turbine at 37.5 – 40.0 dB(A) (calculated as equivalent levels over the time when the wind was blowing 8 m/s at 10 meters height at the turbine downwind from the turbine to the receiver).

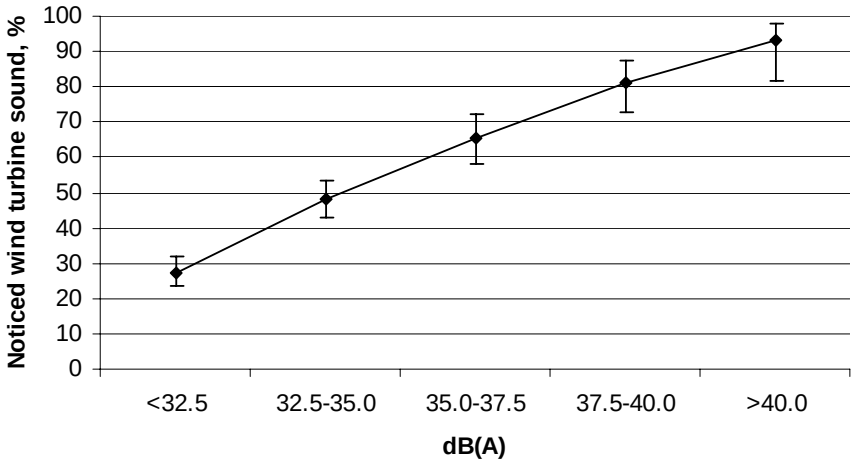

Figure 1. The percentages of respondents who noticed wind turbine sound at their dwelling (with 95% confidence intervals) related to A-weighted sound pressure levels at 8 m/s (n = 1095).

Also the percentages annoyed by wind turbine sound increased with increasing sound levels (Figure 2). The recommended highest sound pressure level for wind turbine noise in this situation is in Sweden 40 dB(A). The results showed an increase in annoyance at somewhat lower levels.

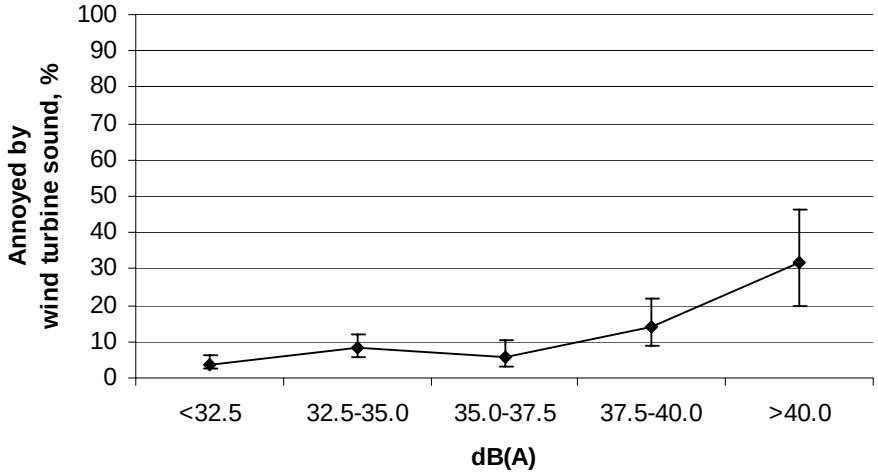

Figure 2. The percentages of respondents who were annoyed (rather or very) by wind turbine sound at their dwelling (with 95% confidence intervals) related to A-weighted sound pressure levels at 8 m/s (n = 1095).

Several situational factors were predicted to moderate the effect of the noise. The probability of being annoyed was found to be greater in rural areas and if the turbines were visible from the dwelling. However, differences in terrain had no statistical effect. Individual factors also had an impact on the response. The attitude to the impact of the wind turbines on the landscape scenery was highly associated with noise annoyance and also the general attitude to wind turbines; respondents who thought that the wind turbines spoiled the landscape were more likely to be annoyed. People who rated themselves as noise sensitive were also more annoyed, a finding well in agreement with those from studies of other environmental noise sources.

The findings were confirmed in an EU-study that took place in the Netherlands and had a similar study design as the two Swedish studies (Pedersen et al., 2009). No direct health effects other than annoyance were detected in any of these three studies. The only relationship between sound levels and health-related variables other than annoyance was disturbed sleep (Pedersen, 2009). There was however an association between noise annoyance and stress related variables such as headache, undue tiredness, feeling tense or stressed, and being irritable. This indicates that wind turbine noise in the home environment could be a hindrance for a needed psycho-physiological restoration (Pedersen and Persson Waye, 2008).

Wind turbine noise has been found to be more annoying than other types of environmental sounds such as that from industry (Jansen et al., 2009) or traffic. This is possibly due to the character of the sound. The sound is amplitude modulated with the pace of the rotor blades caused by the differences in wind speed at different height over the ground. An amplitude modulated sound is easily perceived and also more annoying than a more even sound. The occurrence of the sound is furthermore unpredictable as it depends on the wind speed that is currently changing. It is therefore difficult to get used to wind turbine sound the same way as to a sound with a clear diurnal pattern. Also, wind turbines are often placed in rural areas, and the sound could therefore stand out as technical in an environment with otherwise natural sounds.

It has also been questioned if the sound propagation models used for predicting the sound pressure levels at nearby residents are accurate. A measurement study was therefore carried out. The sound pressure levels at about 500 meters from a 1.5 MW wind turbine were recorded for 10 minutes each hour during one month. Meteorological data were assessed for

the same time period. Recordings that were not polluted, i.e. when there was no noise from tractors, birds or other disturbing noise sources, were used for comparisons with calculated levels for the same meteorological situations. The calculations were based on emissions measurement by the wind turbine were the relationship between the sound power levels and the wind speed was established. The emission level for each wind speed was entered into the sound propagation model so that the immission levels 500 meters from the wind turbine could be derived. The calculated immission levels showed rather good agreement with the measured immission levels (Figure 3). The variation in measured levels was however large. It was hypothesized that meteorological factors (for example temperature and air pressure) that are not taken into account when using the propagation model proposed by the Swedish Environmental Protection Agency could explain the large variation. This was in the study not confirmed and a simplified model is therefore possible to use at distances up to 500 meters. The large variation is instead due to the large variation in wind speed at hub height, constantly changing the emission sound power level. The result indicates that better descriptions of the sound are needed in the Environmental Impact Assessment in order for the public to understand what the sound will be like once the wind turbines are erected.

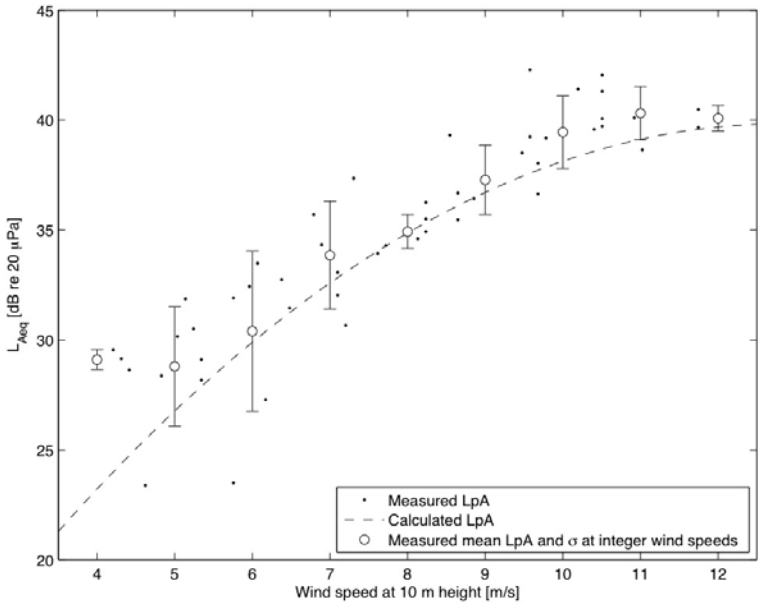

Figure 3. Measured immission levels for downwind cases and calculations according to Swedish standard. Measured levels grouped to integer wind speeds are shown as mean value and standard deviation. From Forssén et al., 2010.

The field studies were supplemented with an interview study analysed in accordance with the method Ground Theory (Pedersen et al., 2007). The study showed that the informants

perceived the wind turbines as intruders in their private environment. The swishing noise, blinking light and always turning rotor blades were difficult to not think about and became a daily hassle. People who thought of their dwelling as a place that should be peaceful and quiet so that it was suitable for restoration expressed strong feelings of being abused in their privacy. Several factors enhanced the feeling, for example being unfairly treated and not believed. It can be concluded that it is of large importance to include the concerns of the public when developing new wind farms and to fairly consider their needs in their home environment. Long-term hindrance of psycho-physiological restoration could have adverse health effects such as metabolic syndromes.

Future studies should include more field surveys so that a more stable dose-response relationship between sound levels and annoyance could be derived and used internationally. The description of the dose needs to be further discussed. The possible influences of wind turbine noise on sleep and the risk for stress-induced illness are also not yet known. I welcome all researchers interested in the issue to join this interesting research field.

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