Comments on: The multiple understandings of wind turbine noise: Reviewing scientific attempts at handling uncertainty.

My main comment is that the discussion of the fundamentals of sound and the characteristics of noise from wind turbines is insufficient for what the paper is trying to do. The purpose of the paper seems to be to emphasize the importance of the non-technical aspects of noise while deemphasizing, close to denigrating, the "hard science"/technical aspects of noise. By this point in time it is clear from many studies that the sound pressure level at locations in the vicinity of wind turbines, measured in dB(A), is insufficient to explain resistance to wind turbines. The paper does a good job at summarizing some of the key observations in this regard. What is lacking is describing the nature of wind turbine sound and relating it to that resistance. The paper should begin with a review of what sound (and thus noise) are, how they can be quantified, how wind turbines produce sound and how the sound is propagated.

Fundamentally, sound (in air) is the result of pressure variations in the air, and this can originate in a variety of ways. These vibrations are characterized by their frequency and the amplitude of the various frequencies. The vibrations can span a wide range of frequencies, from below audible (20 Hz, i.e infrasound) to above audible (20 kHz, i.e. infrasound), and the sound pressure amplitudes can also span a wide range, from just barely audible (20 µPa, i.e. 2×10^{-5} Pa) to above the pain threshold (200 Pa). Because of the wide range of amplitudes and for historical reasons values are reported on a log scale, referenced to 20 µPa, which provides a more compact range, for example 0 dB to 140 dB instead of 20 µPa to 200 Pa. It is also the case that human auditory response depends on frequency, so weighting scales, denoted A, B, C, G and Z, have been developed. The most commonly used scale is the A weighting scale; its effect is to attenuate the response for frequencies below 1000 Hz, so the reporting is given in units of dB(A). A summary measure of the total effect of all the vibrations, SPL_av, is given by integrating the amplitudes at all frequencies over all frequencies. When the weighting is included, that apparent total will be reduced below the value that would be obtained without the weighting. It is important to note that a given average sound power level can correspond to different amplitudes at different frequencies, so when frequencies are relevant to the response, the SPL_av is only partially relevant and may even be misleading.

In common usage today, the SPL_av, is measured by an instrument which does the integrating and filtering over all relevant frequencies and reports out one value over some prescribed sampling time. This method of reporting is done for historical reasons since it has heretofore not been convenient, or perhaps necessary, to collect more detailed information. In the case of wind turbines, amplitude as a function of frequency, and also amplitude as a function of time ("amplitude modulation"), may well be interesting and in fact such information may now be readily obtained. The authors should consider this possibility.

The types of wind turbine noise and the ways in which turbines produce sound are also relevant but were not discussed in the paper. There are at least four types of noise: tonal, broadband, low-frequency, and impulsive. The characteristics of the noise at a given location are a function of the turbine itself as well as the environment in which it operates. For example, upwind vs. downwind rotors have different noise characteristics. Higher blade tip speeds result in significantly higher noise production than slower tip speeds. Rotors can be designed to operate with lower tip speeds but then the total blade area (and thus blade mass and so blade costs) will be higher, so there are trade-offs to be considered. As has been widely reported, wind turbines may produce a thumping or whooshing sound; these have particular frequency and temporal features which are not apparent from the SPL_av data. Wind shear and atmospheric stability may also affect the noise produced and how it is perceived. The occurrence and characteristics of the sound may be weather dependent, and variations may occur in an apparently random and hence non-predictable manner.

The frequency characteristics of wind turbines, including low-frequency sound and infrasound, has been discussed by a variety of authors, but were not included in the paper- they should be. Examples include: Leventhall, G. (2009). "Low Frequency Noise. What we know, what we do not know and what we would like to know." Journal of Low Frequency Noise, Vibration and Active Control, 28(2). 79-104 and Leventhall, G. (2006, June). "Infrasound from wind turbines - fact, fiction or deception." Canadian Acoustics, v 34, n 2, p 29-36. Another report that has potentially useful references is the Wind Turbine Health Impact Study (https://www.mass.gov/doc/wind-turbine-health-impact-study-report-of-independent-expert-panel/download).

The use of predicted average sound pressure level may be less than ideal from a number of perspectives. For regulators to use SPL_av as a basis of permitting may compel turbine designers and project developers to focus on reducing that average value. If the frequency characteristics are actually more important, then the standards and regulations should be updated accordingly. Turbine designers would have an additional impetus to fine-tune designs, perhaps to even consider "noise cancelling". In summary, there may well be considerations other than purely technical regarding the wind turbine noise conundrum, but it should not be assumed that the average sound power level is the only relevant technical issue.