BEFORE THE SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

DOCKET NO. EL- 18-026

IN THE MATTER OF THE APPLICATION BY PREVAILING WIND PARK, LLC FOR A PERMIT OF A WIND ENERGY FACILITY IN BON HOMME COUNTY, CHARLES MIX COUNTY AND HUTCHINSON COUNTY, SOUTH DAKOTA FOR THE PREVAILING WIND PARK PROJECT

RESPONSE OF SHERMAN FUERNISS TO DIRECT TESTIMONIES

26 September, 2018

I would like to submit the following as response/rebuttal to a number of filed testimonies and statements concerning Docket EL 18-026.

1) In response to Dr. Mark Roberts' supplemental direct testimony, especially exhibits 2, 2a, 2b and 2c, I would like to submit the peer-review of the Australian National Health and Medical Research Council Draft Information Paper "Evidence on Wind Farms and Human Health" conducted, at the request of the NHMRC, by Dr. Colin Hansen (see attachment). Dr. Hansen is also currently involved in a 5-year project funded by the NHMRC titled "Establishing the physiological and sleep disruptive characteristics of wind farm versus traffic noise disturbances in sleep".

On page 45 of the book 'Wind Farm Noise: Measurement, Analysis and Control' Hansen, C., Doolan, C. and Hansen, K.(2017) John Wiley and Sons, Ltd. the authors quote Hanning, C. 2015 Submission to the Australian Senate Select Committee on Wind Turbines, Technical report, University Hospitals of Leicester as follows:

> "… in considering the evidence, NHMRC adopted inappropriately strict evidential criteria. This is the reactionary approach to public health risks and is clearly not in the public interest. Action in the defense of the public health does not require certainty. In addition, they have turned the burden of proof on its head. It is the wind industry's duty to prove the safety of its activities not that of the public."

2) In response to Mr. David Hessler's answer to the Staff Question: Can you please summarize your overall opinion of the sound study submitted on behalf of the project? Answer: "In general, the noise modeling methodology and assumptions are satisfactory …", I would submit that pages 230-231 of 'Wind Farm Noise: Measurement, Analysis and Control' Hansen et al.(2017) list nine "uncertainties and issues associated" with the ISO9613-2 model used for the Applicant's sound study as follows:

- "It has only been validated for distances between source and receiver of less than 1 km.
- The model is only valid for octave band analysis for octave band centre frequencies ranging from 63-4000 Hz. Of course, it is also valid for calculating overall A-weighted sound pressure levels over the frequency range covered by the 63-4000 Hz octave bands.
- Downwind propagation is assumed by the ISO model, but only wind speeds between 1 and 5 m/s (measured between 3 and 11 m above the ground) are valid.
- Significant deviations from the ISO model may be expected for wind speeds above the 5 m/s limit (Kalapinski and Pellerin 2009).
- The ISO model has only been validated for source heights of less than 30m above the ground.

- No allowance is made for the attenuation effects of scattering due to atmospheric turbulence.

- The ISO standard states that the expected accuracy of sound level predictions are plus/minus 3dB for source heights less than 30 m and for distances between the source and receiver that are less than 1000 m. It is expected that the errors will increase as the source-receiver distance increases. Also as the source height increases above 30 m the calculation of the excess attenuation due to the ground becomes less accurate.

- The ISO model assumes that sound propagation is from point sources, which makes the calculated sound levels within about 200 m of the closest turbine subject to greater errors than those estimated above.

- As for all models, the ISO model assumes that the turbine sound power levels as a function of wind speed at rotor height are accurate. In most cases, turbine sound power levels are derived from measurements made on flat ground with a smooth horizontal air flow into the turbine rotor. These conditions deviate considerably from those generally found in practice. In many cases, turbines are mounted on hilltops in hilly terrain, so the inflowing air can deviate considerably from horizontal. In addition, local turbulence due to the uneven terrain and uneven heating of the air near the ground results in an air flow into the turbines that is often far from smooth. Inflow turbulence and non-horizontal inflow can both add to the rated turbine sound power levels."

Moller, H. & Pedersen, C. S. (2011). Low-frequency noise from large wind turbines. The Journal of the Acoustical Society of America, 129(6), 3727-3744. DOI:10.1121/1.3543957 also have this to say regarding ISO 9613-2 and ground reflection:

> "On this background, it is reasonable to suspect that the addition of 1.5 dB for the ground reflection is too low at low frequencies, and that higher values up to a theoretical maximum of 6 dB would be more appropriate. Thus, the procedure used to calculate out-door sound pressure levels at the neighbors is likely to underestimate the low-frequency sound."

3) In response to Mr. Hessler's answer to Staff Question:"What about Ms. Jenkins' proposed conditions of 35 dBA?", I would submit that page 33 of 'Wind Farm Noise: Measurement, Analysis and Control' Hansen et al. (2017) gives examples of "Maximum Allowed Calculated External Noise Levels" which include:

> "An allowed A-weighted (see section 2.2.11) nighttime limit of 35 dBA or La90+5 dBA, whichever is lower, when La90 is determined using several 10-min measurements during the quiet night hours between 10pm and 4am when the wind is blowing slightly (<2 m/s at 1.5 m above the ground) from the wind farm to the residence and the wind farm is not operating. Daytime levels can be 5 dBA higher."

Page 33 also contains Table 1.7 ISO 1996-1971 recommendations for allowable community Laeq noise limits. Limits for a rural district are: Day 7am-7pm, 35dBA; Evening 7pm-11pm, 30 dBA; and Night 11pm-7am, 25 dBA.

In their conclusions Moller and Pedersen (2011) write:

"Indoor levels of low-frequency noise in neighbor distances vary with turbine, sound insulation of the room, and position in the room. If the noise from the investigated large turbines has an outdoor A-weighted sound pressure level of 44 dB (the maximum of the Danish regulation for wind turbines), there is a risk that a substantial part of the residents will be annoyed by low-frequency noise even indoors. The Danish evening/night limit of 20 dB for the A-weighted noise in the 10-160 Hz range, which applies to industrial noise (but not to wind turbine noise), will be exceeded somewhere in many living rooms at the neighbors that are near the 44 dB limit. Problems are much reduced with an outdoor limit of 35 dB."

Also concerning noise limits, Hansen et al.(2017) state on pages 32-33 of 'Wind Farm Noise: Measurements, Analysis and Control':

"However, noise measurements by the authors of this book indicate that for modern wind farms with turbine powers of 3 MW and greater, the setback distance should be much larger than 2 km if intrusive noise at noise-sensitive locations is to be at acceptable levels at night when people are trying to sleep. In addition there should be a minimum setback distance of 4 to 5 times the total turbine height (nacelle height plus blade length) to the nearest neighbour's property line."

4) In response to Staff's question to Mr. Hessler concerning C-weighted sound levels and low frequency sound Question: Would you agree with this recommendation?, which Mr. Hessler answers in part with "The low frequency sound emissions … are below the ability of normal instrumentation to measure.", I would submit that section 6.2.7 on page 317 of 'Wind Farm Noise: Measurement, Analysis and Control', Hansen et al.(2017) describes the use of infrasound sensors, also referred to as microbarometers, by Woolworth et al.(2017) and in addition states:

"The infrasound monitoring system described by Annan et al., (2015) consists of infrasound sensors, a wind-filtering apparatus, data-logging equipment and signal processing capabilities. It was demonstrated that this system performed well in isolating wind turbine noise from other sources of infrasound such as marine storms, aeroplanes, urban noise and wind noise. Through use of four infrasound sensors arranged in a square topology with 50-m spacing, the direction of arrival of infrasound signals could be monitored and it was found that this correlated well with the direction of the wind farm.

A range of infrasound sensors (such as Infiltec) are commercially available and in cases where the infrasonic and low-frequency range is of prime importance (such as at large distances from a wind farm), they can prove to be more cost effective than a microphone.

Other advantages of these sensors are their low power consumption and ruggedness, as discussed above. The main disadvantage is that they can only be used to measure noise at low and infrasonic frequencies."

5) In response to Mr. Hessler's answer to Staff's question about larger turbines producing more or worse low frequency noise Question: Would you agree with this assertion?, I would submit the following from the conclusions of Moller, H., & Pedersen, C. S. (2011). Low-frequency noise from large wind turbines. The Journal of the Acoustical Society of America, 129(6), 3727-3744. DOI: 10.1121/1.3543957 :

"The results confirm the hypothesis that the spectrum of wind turbine noise moves down in frequency with increasing turbine size. The relative amount of emitted low-frequency noise is higher for large turbines (2.3-3.6 MW) than for small turbines (< 2MW). The difference is statistically significant for one-third-octave bands in the frequency range 63-250 Hz. The difference can also be expressed as a downward shift of the spectrum of approximately one third of an octave. A further shift of similar size is suggested for turbines in the 10-MW range.

When outdoor sound pressure levels in relevant neighbor distances are considered, the higher low-frequency content becomes even more pronounced. This is due to the air absorption, which reduces the higher frequencies a lot more than the lower frequencies. Even when A-weighted levels are considered, a substantial part of the noise is at low frequencies, and for several of the investigated large turbines, the one-third-octave band with the highest level is at or below 250 Hz. It is thus beyond any doubt that the low-frequency part of the spectrum plays an important role in the noise at the neighbors."

6) In response to references to studies concerning population of upland game species after establishment of wind farms, I would submit that this is a straw man argument. Out of state hunters from urban and suburban areas have visited our farm to hunt pheasants for the last 15 years. The number of birds to hunt and the number birds taken is of secondary importance to the ambience and experience of the hunt. These visitors enjoy the quiet, the scenery, the serenity, the sunrises, the sunsets and the comaraderie and fellowship. They no longer hunt very near our property but go 10 to 40 miles away for the majority of their hunting.

7) In response to Staff's consideration of the thoroughness and completeness of the permit application, I would submit that there are still misidentifications of land use and participating/nonparticipating residences, as well as lack of consideration for rural cemeteries

8) In response to the South Dakota Department of Health's comments on health impacts and studies, I am submitting as an attachment a copy of an open letter to the members of the panel developing the revised WHO Environmental Noise Guidelines for the European Region.

This concludes my responses at this time.
Sherman Fuerniss

Expert Review of the NHMRC Draft Information Paper, "Evidence on Wind farms and Human Health"

Emeritus Professor Colin H Hansen
University of Adelaide

April 10, 2014

Summary

The NHMRC Draft Information Paper: "Evidence on Wind Farms and Human Health", is a document that seems to be predisposed to the notion that noise from wind farms has no direct or indirect effects on the health of people living in their vicinity. This conclusion is reached on the basis that no evidence in the numerous studies published on the subject is of sufficient scientific merit to be considered reliable and thus taken into account. Based on the evidence or supposed lack thereof, it would be equally valid to conclude that there is **no evidence that wind farms do not have** a substantial impact on the health of some people who live in their vicinity. However, this notion is never mentioned in the paper, which could lead to the unfortunate conclusion that the paper is biased towards the interests of the wind farm industry.

Another unfortunate conclusion that one may reach on reading the Draft Information paper is that suggestions of associations between environmental noise and adverse health effects "*are based on limited evidence*." This is in direct contravention of what is stated in the 2009 WHO report titled, "Night Noise Guidelines for Europe", which states, "*While noise-induced sleep disturbance is viewed as a health problem in itself (environmental insomnia), it also leads to further consequences for health and wellbeing*" and "*For the primary prevention of subclinical adverse health effects related to night noise in the population, it is recommended that the population should not be exposed to night noise levels greater than 40 dB of* $L_{night,outside}$ *during the part of the night when most people are in bed*".

The Draft Information Paper contains a few errors of fact and also seems to not appreciate the current state of the art in noise surveys. This results in incorrect conclusions being made and these are outlined in some detail in the following discussion. The Draft Information Paper is based on the document, "Final Report: *Systematic review of the human health effects of wind farms*", which has excluded, on questionable grounds, many important studies that show a link between wind farms and health effects.

The discussion of the need for further research to properly evaluate the effect of wind farm noise on the health and well-being of people in surrounding communities is relegated to Appendix C. This is perhaps the most important outcome of the review and should occupy a more prominent place in the Draft Information Paper.

Introduction

In undertaking this review I note that the systematic review of the literature, Final Report: *Systematic review of the human health effects of wind farms*, which has been finalised, also underpins the Draft Information Paper. Therefore I begin my review with some brief comments on the systematic review document in so far as they are relevant to my "*evaluation of the appropriateness of the conclusions made in the Information Paper regarding the potential health effects of wind turbines*".

There seems to be a misunderstanding in the systematic review document regarding the current state of the art in noise surveys. The state of the art for community surveys of noise from sources other than wind farms has been well established by extensive peer review (see Schomer and Parmidighantam, 2013) and such studies do not necessarily meet the general criteria specified for inclusion in the systematic review. For example it is not generally possible to hide the purpose of a noise study; aircraft noise studies are invariably done in the vicinity of airports, traffic noise studies are invariably done where there is a significant amount of traffic and military noise studies are done near military bases, with little chance of hiding the purpose of the survey. In addition almost all noise studies are necessarily cross sectional studies as it is generally not possible to predict sufficiently far in advance when and where a particular noise source may arrive. Nevertheless, this is the state of the art of noise surveys and as such should be applied to selecting appropriate studies for the systematic review of wind farm noise.

It is also unfortunate that studies by medical researchers such a Pierpont (2009) were excluded on the basis that they were case reports and case series studies. It is difficult to justify such exclusions, especially in the case of Pierpont whose work involved comparison studies (before and after turbines were operating as well as before and after relocation of residents).

An important study by Moller and Pedersen (2011) clearly establishes that as wind turbine power generating capacity increases so too do the LFN emissions and therefore it is predicted that so too will their effects be increased on residents in their near vicinity. This study was not mentioned in the systematic review. However, it has great importance to the conclusions drawn in the Draft Information Paper, as many current wind farms contain turbines of much greater generating capacity than turbines that were the basis of many previous studies, and it is generally expected that future wind farms will include turbines of even higher generating capacity than is the current case, leading to even more serious health effects on surrounding communities.

The 7 studies that met the criteria listed in the systematic review were all rated by the document as "*D, The body of evidence is weak and findings cannot be trusted.*" This effectively implies that no studies that have ever been done on the health effects of wind farm noise provide any useful information. This is an extraordinary result considering the extensive peer review undergone by numerous articles not included in the above mentioned seven, which were rejected on the basis of not satisfying some very strict criteria, but which have been published in reputable international journals. Rejection of all of these peer reviewed papers is the main limitation of the systematic review and this has led to the Draft Information Paper reaching incorrect conclusions.

The following paragraphs document specific comments in response to the review request from NHMRC in which I was asked whether:

- the rationale applied in examining the evidence on the potential health effects of wind turbine noise is understandable and clearly explained;
- the evidence has been accurately translated into the messages in the draft Information Paper; and
- the conclusions in the documents align with my understanding of the latest evidence in my area of expertise (i.e. acoustics).

Rationale applied in examining the evidence on the potential health effects of wind turbine noise is understandable and clearly explained

Although the rationale applied to examine the evidence is understandable and has been explained reasonably clearly, this does not mean that the rationale is logical or acceptable. As explained above, the rejection of peer reviewed papers in reputable international journals, which clearly show a link between wind turbine noise and adverse health effects has not been sufficiently well justified. Also the rejection of case series studies has not been sufficiently well justified. In addition, the argument that any health effect claimed to be due to noise has to have a direct physiological link with noise in order to be considered, is also flawed, as there is no logical reason to exclude indirect effects such as adverse health effects due to stress and disturbed sleep, which in turn have been shown in many studies to be directly linked to excessive wind turbine noise.

The evidence has been accurately translated into the messages in the draft Information Paper

In **Sections 3.2 and 3.3**, of Draft Information Paper the selection of evidence and included studies are discussed. As mentioned above, the main limitation of the systematic review procedure is that it rejected peer reviewed papers in reputable international journals, which clearly demonstrated a link between wind turbine noise and health effects (e.g. Phillips, 2011) and this has led to the Draft Information Paper reaching some incorrect conclusions.

In **section 3.4**, under the heading, **study design**, the Draft Information Paper states, "*All seven studies that met the inclusion criteria for the systematic component of the independent review used a cross-sectional design. Cross-sectional studies examine the relationship between an exposure (in this case wind turbines) and specific health outcomes in a defined population at a single point in time. Because the health outcomes were assessed at a single point in time, none of the included studies were able to provide any indication of the order of events — that is, whether a health outcome first occurred before or after the exposure began. This might mean that a person's self-reported health outcomes were present prior to the person's exposure to wind turbines*."

The above statement shows a lack of appreciation of the current state of the art in noise surveys. As discussed in Schomer and Parmidighantam (2013), where the lead author is an expert in such surveys, almost all noise surveys are cross-sectional studies, as it has not been possible to predict in advance where and when an annoying noise source would be located. Schomer and Parmidighantam (2013) write, "cross-sectional is the state-of-the-art in acoustics. There are hundreds of refereed papers on cross-sectional surveys in acoustics." They go on to point out that of the 43 international surveys undertaken for aircraft noise, 42 were cross-sectional studies, of the 37 international surveys for road traffic noise, 37 were cross-sectional studies and of the 11 international surveys of railroad noise, 11 were cross-sectional studies. If we use the same logic as the Draft Information Paper is applying to wind farm noise, then we would conclude that there is no valid scientific evidence that aircraft noise, traffic noise and railroad noise adversely affect the health of communities and that for all we know, any reported adverse health effects may have been there before the noise was. We could further conclude that all the militant communities around airports are making it up and further, that the curfew for many airports around the world should be lifted, as airport noise studies are not "scientifically sound". Of course these conclusions would be in direct contravention with the conclusions reached by international experts responsible for the 2009 WHO document, which states categorically that transportation noise is responsible for a range of serious adverse health effects.

Under the heading, **selection bias**, in **Section 3.4**, the Draft Information Paper states, "*There is a high risk of selection bias in a study with a low participation rate, as those who chose to participate in the study may have different exposure and health outcomes to those who did not participate*." One would have thought that the whole purpose of the review was to determine if wind farms caused adverse health effects so one would expect that those most exposed or affected would be those most likely to participate in studies. The logic for excluding such studies is flawed, as they provide excellent evidence that there are adverse health effects from wind farm noise.

Under the heading, **selection bias**, the Draft Information Paper states, "*In many of the studies, the purpose of the research was not masked (i.e. hidden) from participants. Where the studies did attempt to hide the intent of the study from participants, this may not have been effective. A lack of successful masking of a study's purpose can contribute to selection bias by making it more likely that a person who is concerned about wind farms will take part than a person who is not concerned about wind farms*." As pointed out by Schomer and Parmidighantam (2013), this is an argument that ignores the state-of-the-art in noise surveys for which it is virtually impossible to mask the intent of a survey. One may ask how well an aircraft noise survey is hidden in a survey near an airport for which the answer is invariably "not very well".

Under the heading, **information bias,** in **section 3.4**, there is a very unbalanced discussion attempting to explain why surveys may show that people living near wind farms suffer worse adverse health effects than those living further away, when in fact their health outcomes may be the same. The same argument could be used for any noise survey, including all the transportation noise surveys that have been used to shape government policy. Again this statement is in direct contravention to what is argued by other international experts and the World Health Organisation.

The same argument as above can be applied to the statements made under the heading, **confounding factors** in **Section 3.4**. It would be virtually impossible in practice to take account of every possible confounding factor and again this argument would null the results of almost every noise survey taken to date.

Under the heading, **consistency** in **Section 3.4**, the Draft Information Paper states, "*Among the seven studies reviewed, there was no consistency in finding an association between wind turbine exposure and self-reported physical or mental health outcomes. However there was some consistency in showing associations between wind farm exposure and annoyance, disturbed sleep and poorer quality of life*." Perhaps it would be helpful if the link between disturbed sleep / annoyance and adverse health effects were made at this point in the document, rather than waiting until Section 7. This would also be a good place to reference the 2009 WHO report on night noise levels.

Under the heading, **overall quality rating** in **Section 3.4**, the Draft Information Paper states, "*the body of evidence is weak and cannot be trusted), following NHMRC criteria for assessing the quality of evidence. This grading is largely due to the methodological weakness of the cross-sectional design used by all studies*." For reasons discussed above, cross-sectional studies are the state of the art in noise surveys. Almost all peer reviewed and published papers are cross-sectional as it is generally not possible to predict sufficiently far in advance the location and installation date of a future noise source.

The summary dismissal of all published evidence of sleep deprivation and health effects could indicate bias in favour of finding that wind farms do not adversely affect the health of neighbouring communities.

In **Section 4**, the Draft Information Paper states, "*In addition, it examined whether any health or health-related effects have been observed from these emissions when produced by sources other than wind farms (parallel evidence).*" It is not sufficient to just examine the level of a noise when comparing two different exposures. Also important are the frequency content, variability and impulsive nature, as well as the duration and time of day or night that it is experienced. It is unlikely that any studies of noise other than wind farm noise would be suitable for comparison with a wind noise study. Note also that the 2009 WHO document has already reported on the health effects of relatively low-level night-time environmental transportation noise.

In **Section 5**, the Draft Information Paper states, "*Deciding whether an association between wind farm exposure and a particular health outcome is causal — that is, wind farm exposure causes the health outcome — requires more evidence. First, it must be clear that the exposure (to wind turbines) preceded the outcome (the health or health-related effect).*" Although this is a desirable requirement, it may not be a very practical one. In cases where the adverse health effect is due to a wind farm, there will obviously be no evidence of such an effect prior to the wind farm being constructed. However, obtaining this evidence through medical records of participants may be problematic and so the proposed requirement in itself may not be achievable.

In **Section 5**, the Draft Information Paper states, "*Second, it must be possible to rule out alternative explanations for the association, including both: bias resulting from the design of the study or the way the study was conducted; and causation by one or more confounding factors associated with wind farm exposure.*" When one looks at all the possible confounding factors listed in the systematic review, one could easily conclude that it would not be possible to eliminate all of them simultaneously. It would be more helpful to examine the accepted state of the art for the numerous published surveys of other noise sources such as transportation noise and use those requirements and methods of analysis.

In **Section 5**, the Draft Information Paper states, "*Third, it should be shown: that the association is consistent with other evidence on the effects of the exposure (e.g. noise from some other source); and ideally, that there is a biological mechanism by which the exposure could cause the health outcome with which it is associated.*" It would be clearer if it was pointed out that "exposure" refers to the character of the noise (impulsiveness, frequency content etc.), and its duration in addition to its level. It is unlikely that one would find groups exposed to such noise, except in the vicinity of wind farms, so this requirement may be impractical to satisfy. Likely biological mechanisms have been suggested in the scientific literature (e.g. see Salt and Lichtenhan, 2014), even though the Draft Information Paper implies that no such mechanisms exist. More importantly, if a noise source leads to sleep disturbance on a prolonged basis, it is well known that adverse health effects are likely to result. This effect is discussed in some detail in the 2009 WHO report.

In **Section 5**, the Draft Information Paper states, "*NHMRC found no consistent direct evidence that exposure to wind farms was associated with any health outcome. The few associations reported by individual studies could have been due to chance. Therefore NHMRC concluded there is no reliable or consistent evidence that wind farms directly cause adverse health effects in humans*." This is written in a way that could indicate bias. A more balanced version would be "NHMRC found no consistent direct evidence that exposure to wind farms was **or was not** associated with any health outcome. The few associations reported by individual studies **may or may not** have been due to chance. Therefore NHMRC concluded there is no reliable or consistent evidence that wind farms directly **cause or do not cause** adverse health effects in humans."

In **Section 5**, the Draft Information Paper states, "*Therefore even though there was support for some of these associations in studies of effects of noise from other sources, NHMRC could not conclude that exposure to wind farm noise causes annoyance, sleep disturbance or poorer quality of life*." This statement is written in a way that could indicate bias. To make it more balanced, the following statement should be added. "On the other hand, NHMRC could not conclude that exposure to wind farm noise **does not cause** annoyance, sleep disturbance or poorer quality of life." Of course a result such as this only occurred because all of the evidence pointing to health effects was rejected during the systematic review.

The conclusions in the documents align with my understanding of the latest evidence in my area of expertise (i.e. acoustics)

Regarding Section 7.1, in the Draft Information Paper, it seems that the statements are written with a clear bias towards the belief that wind farm noise does not cause adverse health effects. The first dot point states that "*there is no reliable or consistent evidence that proximity to wind farms or wind farm noise directly causes health effects*." This statement could also be written as "there is no reliable or consistent evidence that proximity to wind farms or wind farm noise **does not cause** health effects." The two statements effectively state the same thing but with a different bias. To eliminate any unintended bias, the word "**cause**" in the original statement should be replaced with "**causes or does not cause**".

To remove bias in the second dot point which states, "*Finding an association between wind farms and these health-related effects does not mean that wind farms cause these effects*" the following words should be added at the end, "nor does it mean that wind farms do not cause these effects". The statement "*These associations could be due to selection or information bias or to confounding factors.*" Should be replaced with "These associations **may or may not** be due to selection or information bias or to confounding factors."

The fourth dot point which states, "*It is unlikely that substantial wind farm noise would be heard at distances of more than 500–1500 m from wind farms*" is incorrect. I have many measurements showing that wind farm noise can be heard at distances up to 8 km from a wind farm. There are many factors that contribute to how far away a wind farm can be heard, including wind farm layout and size (number of turbines), individual turbine size, terrain and atmospheric conditions. Regarding wind farm layout, it is well documented that some wind farms produce a low-frequency thumping noise that can disturb people several kilometres away and this is likely to be worse if turbines are located too close together so that some turbines are in the wake of upstream turbines in some wind directions.

The fifth dot point states, "*Noise from wind turbines, including its content of low-frequency noise and infrasound, is similar to noise from many other natural and human-made sources. There is no evidence that health or health-related effects from wind turbine noise would be any different to those from other noise sources at similar levels*." The first part of the statement may be true of some mining noise sources but is certainly not true of surface transportation noise which has been the subject of most of the health impact studies. The second sentence in the above statement ignores the completely different character of wind farm noise when compared with surface transportation noise and should be removed from the document. This is discussed in more detail earlier in this review.

The sixth dot point which states, "*People exposed to infrasound and low-frequency noise in a laboratory (at much higher levels than those to which people living near wind farms are exposed)*

experience few, if any, effects on body functioning" is misleading. First, there is no quantitative definition of how much higher the words "much higher" mean. Second there is no distinction between acute and chronic exposure. As shown by Swinbanks (2012), the **length** of exposure to infrasound is important, with effects becoming more pronounced as the exposure duration increases. Typical laboratory exposures are of very short duration (less than 1 hour), whereas wind farm exposures prior to adverse effects can often (but not always) be measured in terms of weeks or months. Also, the above statement does not take into account the differences in character of wind farm infrasound and the character of the sound typically used in laboratory tests. As explained by Salt and Lichtenhan (2014), there are a number of physiological mechanisms whereby infrasound and low-frequency noise from wind farms can adversely affect human health. The fact that all people are not affected does not diminish the importance of recognising these mechanisms in people who are affected and who are physiologically more disposed to being affected.

Under the **Annoyance** heading in Section 7.2.1, the Draft Information Paper states, "*The five studies all reported an association between annoyance and higher estimated levels of wind farm noise or living closer to a wind farm.*" And then goes on to state, "*Factors other than the noise produced by wind farms, such as the participants' demographic, psychological and biological factors, their attitudes and perceived degree of control, and situational factors (including day and time, activity disturbance, type of area and features of the dwelling) may have contributed to the annoyance reported by participants.*" I find it puzzling that consistent results from five different studies can be so easily discarded. All those other factors mentioned should even out when looking at the effect of distance from a wind farm and clearly the **most likely** effect on annoyance is the wind farm, when it is shown that annoyance decreases with distance.

Under the **Sleep** heading in Section 7.2.1, the Draft Information Paper states, "*Six studies reported poorer sleep (mostly disturbed sleep and poor sleep quality) among people exposed to higher estimated levels of wind farm noise or living closer to wind farms.*" And then goes on to state "*The reported associations of wind turbine noise with sleep quality were generally weak*." Again, it is difficult to justify this statement given that six different studies all reported that people living closer to wind farms had poorer sleep. Under the same heading is the statement, "*The studies did not assess whether poorer sleep associated with wind farm noise might have had any effect on health*." One would have thought that the effect of poor sleep on health was well understood and did not need to be further considered in these studies, as this consideration would make the studies more complicated and expensive to undertake. So it would be better if this statement were removed or qualified. Another statement, "*participants who did not economically benefit from wind turbines reported more sleep interruption than others*" is made without any mention of the other differences between the groups which could represent equal or more important confounding factors (see page 61 of the referenced paper).

Under the **Quality of life** heading in Section 7.2.1, the Draft Information Paper points out that all 3 studies that assessed quality of life, found that it decreased following the construction of a nearby wind farm. The last sentence in this section attempts to explain away this association and is not at all helpful. It could be construed as significant bias in favour of the wind farm industry and should be deleted.

Under the **Noise in other environments** heading in Section 7.2.2, the Draft Information Paper states "*The World Health Organization reported a number of effects on sleep when night noise is in the range of 30–40 dBA (measured outside)*". This statement is correct. However, later statements, "*There is no evidence that health or health-related effects from wind turbine noise would be any different to those from other noise sources at similar levels. Based on the studies referred to above,*

wind turbines would be unlikely to cause any direct health effects at distances of more than 500 m. At 500-1500 m from a wind farm, wind turbine noise levels are generally in the range 30–45 dBA. At these distances, effects on sleep are likely to be modest, if any," are incorrect on a number of levels (see below) and again indicate the possibility of bias by the writers of the document.

- If noise levels supposedly vary from 30 to 45 dBA at distances of 500—1500 m from a wind farm, then why is it stated that wind farms "*are unlikely to cause any direct health effects at distances of more than 500 m*" and that the effects on sleep will be modest, if any? One would assume that in the above statement, 30 to 45 dBA corresponds to the distance range of 500 to 1500 m, so one would expect 30 dBA at 1500 m and 45 dBA at 500 m so the statement should read, "*are unlikely to cause any direct health effects at distances of more than 1500 m*".
- I do not agree that wind farm noise will be below 30 dBA at 1500 m. Of course it depends on the size and layout of the wind farm, individual turbine size, terrain and atmospheric conditions as well as distance to the nearest turbine. I have data taken in high wind shear conditions, when background noise levels are low, that show noise levels above 40 dBA at distances over 2000 m. I also have seen noise predictions made by acoustical companies working for wind farm developers that show estimated noise levels of 37 dBA at 1670 m. So the estimated noise levels given in the Draft Information Paper are way too low.
- Wind turbine noise does not have the same character as transportation noise. By the time it reaches residents located more than 1 or 1.5 km away, it has a much higher dominance of low frequency noise and infrasound. The A-weighted noise level underestimates the importance of low-frequency noise and infrasound (Salt and Lichtenhan, 2014) and it is incorrect to state that "*there is no evidence that health or health-related effects from wind turbine noise would be any different to those from other noise sources at similar levels*". This is because the level referred to here is the dBA or A-weighted level and this is not a good measure of the effects of environmental noise on health as it does not adequately take into account the effect of infrasound and low-frequency noise, nor does it account for variability or amplitude modulation associated with the noise.

Under the **Noise in other environments** heading in Section 7.2.2, the Draft Information Paper states, "*the noise in the studies discussed above would have included infrasound, which is considered by some to be an important component of the noise from wind farms. The infrasound from these other noise sources would be at similar levels to that from wind turbines. Therefore the evidence summarised above applies as much to infrasound as it does other sound frequencies from wind farms*." The effect of wind farm infrasound and low-frequency noise on people is a far more complex phenomenon than implied by the Draft Information Paper (see Salt and Lichtenhan, 2014).

The **laboratory studies** referred to in Section 7.2.2 of the Draft Information Paper are not relevant to wind farm noise. The studies involved higher level and much shorter exposure durations and neither the wind farm noise spectrum nor crest factors (ratio of peak to rms levels) were duplicated.

Comments on Section 6 of the Draft Information Paper

I have the following comments regarding section 6 on noise in the Draft Information Paper, which is directly in my area of expertise.

In **Section 6.1**, it is implied that the A-weighting scale adequately takes into account the lower sensitivity of the ear at low frequencies. However, the A-weighting scale is a very inaccurate estimate of the loudness of a noise at low levels and low frequencies. It is an even more inaccurate

estimate of the annoyance of low-frequency sound. It is well known that low-frequency noise is more annoying than noise characterised by a balanced frequency spectrum with the same overall A-weighted level. Although the generation of wind farm noise may be characterised by a relatively well-balanced spectrum, by the time it propagates the 2 kilometres or so to a residence and then passes through walls and windows to reach the inside, it becomes dominated by low frequencies below 200 Hz, which are much less attenuated by ground, atmospheric and building transmission effects. Thus, wind farm noise is more annoying than one may expect from the A-weighted level, especially in quiet rural environments where noise from other sources is very low, and especially late at night and in the early hours of the morning when people are trying to sleep.

In **Section 6.1**, the Draft Information Paper states, "*Wind turbines produce mechanical sound at a frequency of 20–30 Hertz (for a 1500 kilowatt turbine) and a "whooshing" aerodynamic sound in the range of 200–1000 Hertz. Noise from wind farms is mostly aerodynamic*." This is an over-simplification and not quite right. Noise from modern wind turbines (which are now all 3 MW in size or greater for recent and proposed wind farms in Australia) is mainly aerodynamic in nature and covers the frequency range from below 1 Hz to 500 Hz. Although aerodynamic sound is also produced at higher frequencies, these higher frequencies do not propagate sufficiently well for this higher frequency sound to be detectable at residences located 2 or more kilometres away. Low frequency aerodynamic sound is mostly a result of in-flow turbulence and possibly stall (see Laratro et al. 2014). It has been suggested that stall noise becomes more significant when there are high levels of wind shear, such as in the early hours of the morning. It has been further suggested that this type of noise is what appears as a "thumping" noise (Oerlemans, 2013), which can be very annoying when one is trying to sleep. However, more research is needed to properly demonstrate the link between blade stall and thumping noise. Aerodynamic noise generated by in-flow turbulence is worse when turbines are located in hilly terrain and also when they are placed in the wake of other turbines. This latter situation occurs more often in wind farms where turbines are placed closer together than recommended by the manufacturer. In addition, it is not definitively known how much the aerodynamically generated vibration of the tower and blades contribute to the noise levels experienced at residential locations.

In **Section 6.1**, the Draft Information Paper states, "*It is difficult to estimate the level of noise from wind farms in the presence of background noise.*" This is true but it is not impossible if the wind farm operator cooperates by shutting the wind farm down at various times so background noise levels can be established.

In **Section 6.1**, the Draft Information Paper states, "*As the sound level decreases with distance, it is unlikely that substantial noise would be heard at distances of more than 500–1500 m from wind farms*." This is not correct. See the first two dot points on the previous page.

In **Section 6.1** the Draft Information Paper states, "*Infrasound is considered by some to be an important component of the noise from wind farms. Evidence suggests that levels of infrasound are no higher in environments near wind turbines than in a range of other environments. For example, a South Australian study observed similar levels of infrasound at rural locations close to wind turbines, rural locations away from wind turbines, and at a number of urban locations*." Wind turbine infrasound has very specific characteristics. Its frequency content is the blade pass frequency and its harmonics (usually around 0.8 to 1 Hz and multiples thereof, respectively). In addition it varies in intensity over a turbine blade revolution and also over longer time frames. The periodic nature of the noise means that it could possibly have a different effect on people than noise that is random in nature, such as other environmental infrasound. There are experts in this area (e.g. Salt and Lichtenhan, 2014) who have demonstrated that one does not need to be able to "hear" infrasound

or low-frequency sound for it to have a physiological effect on some people, causing them to have similar symptoms to motion sickness. There is still much to be understood about the effects of low-level infrasound and low-level, low-frequency noise on people, as well as the effects of the infrasound frequency content and peak to average levels. There is a well-founded suggestion that increasing the exposure duration can also affect the response of a subject (Salt and Lichtenhan, 2014), as can the presence or absence of noise in the audio frequency range (Swinbanks, 2012). It is also possible that low-frequency sound can have similar effects to those attributed to infrasound (Salt and Lichtenhan, 2014). Much more work needs to be done on the effects of infrasound and low-frequency sound on people before any definitive statement can be made.

Considerations that Appendix B suggests I should have been asked to provide

In Appendix B, the Draft Information Paper states, "*Expert reviewers have been asked to consider a number of factors, including: the comprehensiveness of the literature reviewed; the validity of conclusions drawn from the evidence and any alternative conclusions that could be drawn*". This does not seem to agree with the review request that I received. To be consistent with what I was asked to comment on, the word "validity" in the above statement should be changed to "appropriateness". The request that I received did not ask if I could draw any alternative conclusions as mentioned in the above statement. I was also not asked to comment on the comprehensiveness of the literature reviewed. Assuming that I should have been asked to consider the factors outlined in Appendix B, I have the following comments.

- I do not consider that the literature reviewed was sufficiently comprehensive as it stopped before the end of 2012 and did not include references to many surveys of transportation noise which would have informed the current state of the art for noise surveys. In addition, a number of relevant papers have been published since November 2012 and these should be included in the review prior to it being finalised. The references listed in the papers under the heading "References" below should be reviewed. Also, no reason has been given for omitting series case studies from the review. There are a number of this sort of study that show a definite link between wind farm noise and health effects and if included in the review, may have resulted in the NHMRC arriving at a more balanced conclusion such as, "There is some evidence that wind farms can cause adverse health effects in nearby residents. However, more research is needed to properly quantify these effects."
- I believe that the conclusions drawn are written in a very unbalanced way that could suggest bias in favour of the wind farm industry. The conclusions are written in a way that implies that the NHMRC is already predisposed to believing that wind farms pose no threat of adverse health effects, even though the statements in Appendix C call for more research to be done in order to be able to provide a definitive answer. I have made many suggestions in the preceding paragraphs regarding how the conclusions could be written in a more balanced way.

Other General Comments

I could find no evidence of any effort in the systematic review to determine whether there was any source of bias by the authors of any of the seven studies that were deemed to have met the criteria. In cases where such studies are funded by the wind industry, it would not be surprising to find outcomes that suggest no adverse health effects, in a similar way that many early medical studies on the effects of smoking that were funded by the tobacco industry found no adverse health effects for

smokers. Thus any studies funded by the wind farm industry should have been excluded due to the potential for bias.

In appendix C, there is the statement, "*Given the lack of objective health measurements in these studies, information bias cannot be excluded as an explanation for any apparent association*." This sort of statement in itself is unhelpful and insulting to all of the researchers who have undertaken these studies and found a link (either direct or indirect) between wind farms and health. The statement should be removed or at the very least changed to "*Given the lack of objective health measurements in these studies, information bias,* ***however unlikely it may be****, cannot be excluded as an explanation for any apparent association*."

Much is made of the need for longitudinal studies. Given the difficulty in undertaking such studies, it is surprising that nothing is mentioned about giving people with reported health problems 2 weeks holiday far away from any wind farm and checking their symptoms then. There are many reported cases where this sort of break has resulted in the cessation of symptoms and one would think this would be an acceptable alternative to a longitudinal study and in many cases it would clearly demonstrate the influence of the wind farm on a person's health.

In addition to the research areas discussed in Appendix C, research is needed to develop more accurate noise propagation models so that the expected range of noise levels over the entire frequency range can be accurately predicted at each residence likely to be affected. The single number A-weighted time averaged values provided by current models do not adequately relate to the disturbance of the noise. There are factors other than the noise level, such as crest factor (ratio of peak to average (or rms) noise level), frequency content, variability over the short and medium terms, difference between the intrusive noise level and ordinary background noise levels, especially at night, which determine how disturbing a noise will be. More research is also needed to establish suitable metrics that take into account the low-frequency nature and variability of the noise from wind farms that is experienced at residences (Salt and Lichtenhan, 2014).

In the Glossary, the definition for decibel is given as, "*A unit of measure used to express the loudness of sound, calculated as the logarithmic ratio of sound pressure level against a reference pressure*". This is incorrect. The decibel rating of a sound pressure is not a measure of loudness – the Phon measures loudness. So the words "*A unit of measure used to express the loudness of sound*" should be replaced with "A unit of measure used to express the sound pressure amplitude associated with a sound in the form of a more manageable logarithmic scale, in place of using the linear scale of Pascals. It is calculated……"

In the glossary, the definition of "A-weighting" is missing. It is a weighting applied to a measured sound pressure level that reduces the importance of low-frequencies and high-frequencies when calculating an overall sound pressure level. It is supposed to approximate the response of a normal ear but it does a very poor job of this.

There is no mention anywhere in the document of the effect of wind farm size (ie number of turbines), wind farm layout, terrain in the wind farm vicinity, atmospheric conditions (including wind shear) and the size of the individual turbines within a wind farm. All of these factors influence noise levels that will be experienced by communities in the vicinity of wind farms. Differences in these factors between some recent wind farms in Australia and wind farms studied in Europe mean that conclusions of earlier studies may not necessarily apply to more recently installed and planned wind farms in Australia.

It is unfortunate that the argument for further research and the suggested areas of further research are relegated to Appendix C, where it is unlikely that any policy makers will find it. Surely the conclusion that further evidence is needed "*to explore the relationships between noise at varying distances from wind farms and other health-related effects such as annoyance, sleep and quality of life*" should occupy a prominent place in the Information Paper. This should be included in an executive summary which unfortunately seems to be missing at the moment.

As stated by Nancy Timmerman and repeated by Salt and Lichtenhan (2014), "the time has come to acknowledge the problem and work to eliminate it".

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Open Letter to the members of the panel developing the WHO Environmental Noise Guidelines for the European Region.

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Mark Brink.
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Ladies and Gentlemen,

We understand that you are currently in the process of developing the WHO Environmental Noise Guidelines for the European Region as a regional update to the WHO Community Noise Guidelines. We also understand that:

1. The new Guidelines will be based upon a review of evidence on the health effects of environmental noise in the light of significant research carried out in the last few years.

2. The guidelines will review evidence on the health benefits of noise mitigation and interventions to decrease noise levels.

3. The evidence will be systematically reviewed to assess likely effects such as: sleep disturbance, annoyance, cognitive impairment, mental health and wellbeing, cardiovascular diseases, hearing impairment and tinnitus and adverse birth outcomes.

One of the sources of noise you are investigating is that from wind turbines which was not addressed in previous guidelines.

We welcome your review because, despite mounting anecdotal and academic evidence, for too long mitigation against adverse health effects following the construction of wind turbines has been absent from planning guidelines and **noise pollution regulations** in many European countries, especially **with respect to sound below 200 Hz.**

There is a pressing need for new guidelines to encourage governments better to safeguard the health of their citizens.

You will be aware that these problems are not confined to Europe. Neither are they confined to human beings.

We are hopeful that your deliberations will result in tough new European guidelines which in turn will prompt a serious worldwide examination of all aspects of this problem, including the widely-reported effects on animals.

Yours sincerely,

The undersigned:

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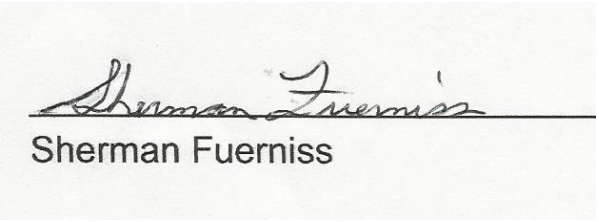
BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY PREVAILING WIND PARK, LLC FOR A PERMIT OF A WIND ENERGY FACILITY IN BON HOMME COUNTY, CHARLES MIX COUNTY AND HUTCHINSON COUNTY, SOUTH DAKOTA, FOR THE PREVAILING WIND	)))))))	**Certificate of Service** **EL18-026**

I hereby certify that on September 26, 2018, true and correct copies of Sherman Fuerniss's Response/Rebuttal to filed testimonies and statements concerning Docket EL 18-026 and Attachments 1 and 2 and certificate of service were served electronically to the all parties on the Service List:


Sherman Fuerniss