Noise Assessment

Shell WindEnergy
Hermosa West Wind Farm Project, Albany County, Wyoming

March 2, 2010

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Shell WindEnergy

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Hermosa West Wind Farm Project

March 2, 2010

Project No. 0111210
Albany County, Wyoming

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TABLE OF CONTENTS

1.0 Hermosa West Wind Farm Noise Assessment 1

1.1 INTRODUCTION 1

1.2 PROJECT SETTING 1

1.2.1 Baseline Information 2

1.2.2 Acoustics and Glossary of Terms 3

1.3 NOISE PREDICTION MODEL 5

2.0 Noise Predictions 6

2.1 WIND TURBINE NOISE SOURCE TERMS 6

3.0 Noise From Wind Turbines, Low Frequency Noise, Infrasound and Health Effects 10

3.1 INTRODUCTION 10

3.2 SOURCES OF NOISE 10

3.3 WEATHER EFFECTS AND WIND SHEAR 10

3.4 INFRASOUND, LOW FREQUENCY NOISE AND ANNOYANCE 11

3.5 VIBRATION 13

4.0 Results 14

LIST OF TABLES

1-1 Closest Noise Sensitive Properties to the Project

1-2 Contains Typical Sound Levels for Various Activities

2-1 Octave Band Sound Power Levels (dB) for the Vestas V90 3 MW, Siemens SWT 2.3MW and GE 1.3MW Wind Turbines (hub height 80m/262 feet, corrected to 10m/33 feet) in Accordance with IEC 61400-11

2-2 Wind Turbine Noise Levels (dB) for the Vestas V90 3MW, Siemens SWT 2.3MW and GE 1.3 MW Turbines (hub height 80m/262 feet, corrected to 10m/33 feet) at Increasing Wind Speeds

2-3 Predicted WTG Noise from the Vestas V90 3 MW at the Closest Noise Sensitive Properties

2-4 Predicted WTG Noise from the Siemens SWT 2.3MW at the Closest Noise Sensitive Properties

2-5 Predicted WTG Noise from the GE 1.5MW at the Closest Noise Sensitive Properties
LIST OF FIGURES

1-1 VICINITY MAP
1-2 VESTAS V90 3MW TURBINES AND RECEPTORS
1-3 SIEMENS SWT 2-3MW TURBINES AND RECEPTORS
1-4 GE 1.5MW TURBINES AND RECEPTORS
1.0 HERMOSA WEST WIND FARM NOISE ASSESSMENT

1.1 INTRODUCTION

Shell WindEnergy, Inc. (SWE) proposes to construct, operate and maintain the Hermosa West Wind Farm Project (the Project) in southeast Albany County, Wyoming near Tie Siding (Figure 1-1, Site Vicinity Map). Western Area Power Authority (Western) is evaluating under the National Environmental Policy Act (NEPA) the interconnection of the Project, which consists of transmission system upgrades and construction of a new substation (Proposed Action). The Project would consist of a maximum of 200 wind turbines with a total generating capacity of up to 300 megawatts (MW) of electricity. The wind turbines would be arranged in roughly collinear “strings”; each turbine string would be situated within an approximately 250 foot (ft) or 400ft wide corridor, depending on topography. The Project would interconnect with a Western-operated transmission line traversing the Project area.

The Project would also include a wind energy collection system, on-site operation and maintenance (O&M) building, underground collector lines, an Applicant-built transmission line and substation, associated access roads, and off-site upgrades to facilities owned by Western.

At the request of SWE, Environmental Resources Management (ERM) has prepared this Noise Assessment for the Project. The Noise Assessment is intended to provide information on estimated noise impacts of the three selected turbine models on sensitive noise receptors located near the Project area. Noise prediction (screening) calculations have been undertaken at the closest noise sensitive properties to the three proposed scheme layout and wind turbine options. The following options have been considered:

- 147 Siemens SWT 2.3MW wind turbines (normal operation), hub height 80m and total capacity of 338 MW;
- 224 GE 1.5MW wind turbines (normal operation), hub height 80m and total capacity of 336MW; and
- 113 Vestas V90 3MW wind turbines (mode 0), hub height 80m and total capacity of 339MW.

The layouts of each turbine option (and closest noise sensitive properties) are illustrated in Figures 1-2, 1-3 and 1-4.

1.2 PROJECT SETTING

The Project area is located within Albany County, Wyoming. The City of Laramie is located approximately 18 miles northwest of the Project area, while the town of Tie Siding, Wyoming is located to the north-northeast of the Project area. One residence is located within the Project area, while the area surrounding the Project area is sparsely populated with a majority of these homes being located directly west of the Project area along a ridge line. The elevation of the Project area is 7,100 to 7,900 ft and it is characterized by nearly level floodplains and low terraces. According to the National Renewable Energy the average wind speed at 30m within the Project Area is
approximately 17 miles per hour (mph). The Project area is located approximately three to four miles west of State Highway 287. This is a highly utilized highway which was widened near the Project in 2009 from two to four lanes. There is also a railroad located approximately two miles to the northeast.

1.2.1 **Baseline Information**

Sources of noise within the Project area include trucks and automobiles, aircraft, railroad, power lines, firearms, animal communications, and wind.

Six noise sensitive properties around the Project participating property boundary have been considered for the screening calculations and are listed in Table 1-1 below.

**TABLE 1-1 Closest Noise Sensitive Properties to the Project**

<table>
<thead>
<tr>
<th>Property</th>
<th>Coordinates</th>
<th>Distance to closest turbine (Vestas V90 layout), feet</th>
<th>Distance to closest turbine (Siemens SWT layout), feet</th>
<th>Distance to closest turbine, (GE 1.5 layout), feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Buttes</td>
<td>452226, 4558120</td>
<td>36,410</td>
<td>36,320</td>
<td>36,150</td>
</tr>
<tr>
<td>Home 4 – Fish Creek</td>
<td>451630, 4543490</td>
<td>3,360</td>
<td>3,210</td>
<td>3,180</td>
</tr>
<tr>
<td>Home 3 – Fish Creek</td>
<td>451963, 4543962</td>
<td>2,055</td>
<td>2,045</td>
<td>2,050</td>
</tr>
<tr>
<td>Home 2 – Fish Creek</td>
<td>452353, 4541414</td>
<td>8,090</td>
<td>7,610</td>
<td>7,265</td>
</tr>
<tr>
<td>Tie Siding</td>
<td>457259, 4547829</td>
<td>6,995</td>
<td>7,190</td>
<td>6,945</td>
</tr>
<tr>
<td>Home 1 – Tie Siding</td>
<td>457517, 4546720</td>
<td>5,435</td>
<td>4,790</td>
<td>4,715</td>
</tr>
<tr>
<td>Landowner</td>
<td>450567, 4546067</td>
<td>1,500</td>
<td>1,475</td>
<td>1,400</td>
</tr>
<tr>
<td>Home 5</td>
<td>450112, 4546288</td>
<td>780</td>
<td>1,350</td>
<td>2,875</td>
</tr>
</tbody>
</table>

Measurements of the prevailing monthly wind speed, direction and wind shear exponent are listed in Table 1-2 below.

**TABLE 1-2 Site Wind Measurements**

<table>
<thead>
<tr>
<th>Measurement Period</th>
<th>Mean Wind Speed (m/s) at 57 m height</th>
<th>Mean Wind Shear (57m / 32m)</th>
<th>Prevailing Wind Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 2008</td>
<td>13.21</td>
<td>0.15</td>
<td>West</td>
</tr>
<tr>
<td>February 2008</td>
<td>12.81</td>
<td>0.12</td>
<td>West</td>
</tr>
<tr>
<td>March 2008</td>
<td>11.28</td>
<td>0.10</td>
<td>West</td>
</tr>
<tr>
<td>April 2008</td>
<td>9.98</td>
<td>0.10</td>
<td>West</td>
</tr>
<tr>
<td>May 2008</td>
<td>9.06</td>
<td>0.09</td>
<td>North West</td>
</tr>
<tr>
<td>June 2008</td>
<td>8.34</td>
<td>0.09</td>
<td>West</td>
</tr>
<tr>
<td>July 2008</td>
<td>6.01</td>
<td>0.09</td>
<td>South South East</td>
</tr>
<tr>
<td>August 2008</td>
<td>6.60</td>
<td>0.15</td>
<td>South East</td>
</tr>
<tr>
<td>September 2008</td>
<td>6.41</td>
<td>0.09</td>
<td>South South East</td>
</tr>
<tr>
<td>October 2008</td>
<td>7.43</td>
<td>0.12</td>
<td>West North West</td>
</tr>
<tr>
<td>November 2008</td>
<td>14.13</td>
<td>0.17</td>
<td>West</td>
</tr>
<tr>
<td>December 2008</td>
<td>13.31</td>
<td>0.16</td>
<td>West</td>
</tr>
</tbody>
</table>
The predominant wind direction, based on 2008 measurements is westerly (7 months out of 12), blowing away from the town of Tie Siding. This could also increase ambient noise levels in the area from the highway.

Wind shear is discussed in Section 3-3 below.

### 1.2.2 Acoustics and Glossary of Terms

The terms ‘sound’ and ‘noise’ tend to be used interchangeably, but noise can be defined as unwanted sound. Sound is a normal and desirable part of life. However, when noise is imposed on people it can lead to disturbance, annoyance and other undesirable effects.

Noise is measured and quantified using decibels (dB), and examples of noise levels are shown in Table 1-3.

#### TABLE 1-3 Examples of Noise Levels on a Decibel Scale

<table>
<thead>
<tr>
<th>Noise Level, dB(A)</th>
<th>Typical noise source / example</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>“Threshold of hearing” – lowest sound an average person can hear</td>
</tr>
<tr>
<td>20</td>
<td>Standard required in a broadcasting or recording studio – just audible</td>
</tr>
<tr>
<td>30</td>
<td>Library or soft whisper at 5 feet – this is very quiet</td>
</tr>
<tr>
<td>40</td>
<td>Bedroom or living room</td>
</tr>
<tr>
<td>50</td>
<td>Conversational speech at 3 feet</td>
</tr>
<tr>
<td>60</td>
<td>Busy general office or air conditioning unit at 20 feet</td>
</tr>
<tr>
<td>70</td>
<td>Traffic on freeway at 50 feet</td>
</tr>
<tr>
<td>80</td>
<td>Pneumatic drill at 50 feet</td>
</tr>
<tr>
<td>90</td>
<td>Heavy truck at 50 feet</td>
</tr>
<tr>
<td>140</td>
<td>“Threshold of Pain” – maximum tolerable noise level such as very close to a jet engine or similar</td>
</tr>
</tbody>
</table>

The dB(A) scale is a particular way of measuring the different frequencies in sound, designed to match how the human ear perceives sound, called the ‘A’-weighting.

The decibel scale is logarithmic, which means that noise levels do not add up or change according to simple linear arithmetic. For example, adding two equal noise sources results in a doubling of sound energy, which gives a combined noise level that is 3dB higher than the individual levels. So, 60 dB + 60 dB = 63 dB (not 120 dB).

However, even though the energy levels have doubled, the ear perceives only a slight increase in loudness instead of a doubling because human hearing responds to changes in noise logarithmically. This means that a relatively large change in sound energy is needed before it is perceived to be louder or quieter. For example, it is generally accepted that:

- an increase or decrease of 1dB cannot usually be heard in everyday conditions (although possible in ‘laboratory’ conditions);
- an increase or decrease of 3dB is generally accepted as the smallest change that is noticeable in ordinary conditions;
- an increase or decrease of 5dB is a clearly perceptible change in noise; and
• an increase or decrease of 10dB is perceived to be a doubling (or halving) of perceived loudness.

To place this into context, to change a noise level by around 3dB there would need to be a doubling or halving of the noise energy; and a change of 10dB would need a ten-fold change in noise energy.

Sound can be distinguished by its content, and Hertz (Hz) is the unit used to describe the tonality or frequency content of sound. The lowest frequency that can be identified as sound by a person with good hearing is 20Hz. Frequencies below this (infrasound) can be detected, but are perceived as a feeling in the body as opposed to an actual sound. At the other end of the scale, the highest frequency that can be heard may be up to 20,000Hz, but this depends on factors such as age, health and previous exposure to noise and an upper range between 16 and 18 kilo hertz (KHz) might be more representative. Sound below 20Hz is referred to as ‘infrasound’, and sound between 10Hz and 200Hz is often described as ‘low frequency noise’ (LFN), although there is no a commonly held definition for these terms. Although our hearing can detect sounds throughout this range, it does not ascribe the same importance or weight to sound in each frequency.

For example, if a person was listening to a tone at 1KHz at a fixed level, then a tone at 30Hz would have to be 50dB higher for it to be judged equally as loud, although this varies depending on the reference loudness. To account for our sensitivity to sound over different frequencies, environmental noise sources are often described as ‘A’-weighted decibels, denoted as dB(A). This A-weighting is an internationally agreed standard that reflects the frequency sensitivity of the ear.

Since noise also often varies over time, statistical parameters (or metrics) are used to measure, and describe noise. Two common noise metrics used for environmental noise measurement are the $L_{Aeq}$ and $L_{A90}$.

The $L_{Aeq,T}$ metric is called the ‘continuous equivalent sound level’. It represents a varying noise level by calculating the constant sound level that would have the same sound energy content over the measurement period. The letter ‘A’ denotes that ‘A’-weighting has been used and the ‘eq’ indicates that an equivalent level has been calculated. So ‘$L_{Aeq,T}$’ is the A-weighted continuous sound level, measured over period ‘T’. $L_{Aeq}$ is a logarithmic average noise level over a period (instead of an arithmetic average) which gives a high weighting to high noise levels even if they are relatively short lived or infrequent events.

The $L_{A90,T}$ metric is a percentile noise level in dB(A). This represents the value exceeded for 90% of the time period (T) being considered. Note that it is higher than the minimum noise level but may be regarded as the typical noise level during ‘quiet periods’. 
1.3 NOISE PREDICTION MODEL

Wind Turbine Generated (WTG) noise predictions were carried out under down wind propagation conditions as described in the international standard ISO 9613 (1). The sound power levels used as a basis of the assessment are also measured under down wind conditions.

In undertaking predictions of noise levels from wind farms the following factors can be considered:

- the decrease in noise with distance;
- the absorption of noise in air;
- the attenuation of noise over acoustically ‘soft’ ground;
- screening of the turbines by topography and other obstacles; and
- meteorological conditions.

In predicting operational noise from the Project area, air absorption and distance attenuation were accounted for using the method described in ISO 9613 assuming 10°C and 70% humidity. No acoustic screening of the turbines is expected. No attenuation from ground absorption has been assumed in the model to present a conservative assumption.

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(1) ISO 9613-2 'Acoustics - Attenuation of Sound During Propagation Outdoors. Part 2: General Method of Calculation'.
ISO, 1996.
2.0 NOISE PREDICTIONS

2.1 WIND TURBINE NOISE SOURCE TERMS

Three types of wind turbines and layouts have been considered as discussed in Section 1.1 above.

Noise emissions of each turbine have been reported in independent tests undertaken in accordance with IEC 61400-11\(^{(2)}\) and used as the basis of the operational noise assessments.

Results have been reported as A-weighted octave band sound power levels for a wind speed of 10 m/s (22 mph), corrected to a height of 10 meters (33 feet) in Table 2-1, and as the A-weighted sound power level at wind speeds of 4 to 10 m/s in Table 2-2.

This is based on the following operating modes:
- Vestas V90 operating in mode 0, with the highest noise emission levels;
- Siemens SWT operating at normal operation as opposed to noise restricted operation; and
- GE 1.5 operating at normal operation as opposed to noise restricted operation.

### TABLE 2-1 Octave Band Sound Power Levels (dB) for the Vestas V90 3 MW, Siemens SWT 2.3MW and GE 1.5 MW Wind Turbines (hub height 80m/262 feet, corrected to 10m/33 feet) in Accordance with IEC 61400-11

<table>
<thead>
<tr>
<th>Frequency Hz</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
<th>dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas V90</td>
<td>93.5</td>
<td>96.9</td>
<td>102.0</td>
<td>104.0</td>
<td>99.7</td>
<td>93.7</td>
<td>80.7</td>
<td>109.3</td>
<td></td>
</tr>
<tr>
<td>Siemens SWT</td>
<td>86.3</td>
<td>95.3</td>
<td>102.0</td>
<td>102.6</td>
<td>99.0</td>
<td>95.0</td>
<td>90.2</td>
<td>107.0</td>
<td></td>
</tr>
<tr>
<td>GE 1.5</td>
<td>85.1</td>
<td>94.0</td>
<td>97.2</td>
<td>98.6</td>
<td>97.9</td>
<td>94.5</td>
<td>87.3</td>
<td>78.1</td>
<td>104.0</td>
</tr>
</tbody>
</table>

### TABLE 2-2 Wind Turbine Noise Levels (dB) for the Vestas V90 3 MW, Siemens SWT 2.3 MW and GE 1.3 MW Turbines (hub height 80m/262 feet, corrected to 10m/33 feet) at Increasing Wind Speeds

<table>
<thead>
<tr>
<th>Wind Speed (m/s) at 10m (mph in brackets)</th>
<th>Sound Power Level (LWA) for Vestas V90, dB</th>
<th>Sound Power Level (LWA) for Siemens SWT, dB</th>
<th>Sound Power Level (LWA) for GE 1.5, dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (9)</td>
<td>97.0</td>
<td>-</td>
<td>98.0</td>
</tr>
<tr>
<td>5 (11)</td>
<td>105.0</td>
<td>-</td>
<td>101.1</td>
</tr>
<tr>
<td>6 (13)</td>
<td>105.8</td>
<td>105.0</td>
<td>105.0</td>
</tr>
<tr>
<td>7 (16)</td>
<td>108.2</td>
<td>107.0</td>
<td>106.0</td>
</tr>
<tr>
<td>8 (18)</td>
<td>109.3</td>
<td>107.0</td>
<td>-</td>
</tr>
<tr>
<td>9 (20)</td>
<td>109.4</td>
<td>107.0</td>
<td>-</td>
</tr>
<tr>
<td>10 (22)</td>
<td>106.7</td>
<td>107.0</td>
<td>-</td>
</tr>
<tr>
<td>11 (25)</td>
<td>105.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12 (27)</td>
<td>105.7</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^{(1)}\) This includes a +2 dB uncertainty correction reported in the test report for this turbine

The location and elevations of the turbines layouts used in this analysis are illustrated in Figures 1-2, 1-3, and 1-4. The results of the assessment are presented in Table 2-3, Table 2-4 and Table 2-5 below.
### TABLE 2-3  Predicted WTG Noise from the Vestas V90 3 MW (mode 0) at the Closest Noise Sensitive Properties

<table>
<thead>
<tr>
<th>Noise Receptor</th>
<th>Predicted WTG Noise</th>
<th>Distance to Closest Turbine (feet)</th>
<th>Closest Turbine</th>
<th>Predicted WTG Noise by wind speed (m/s) (and mph in brackets)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L_{A90}$, dB</td>
<td>$L_{Aeq}$, dB</td>
<td>4 (9)</td>
<td>5 (11)</td>
</tr>
<tr>
<td>The Buttes</td>
<td>23</td>
<td>25</td>
<td>36,410</td>
<td>T55</td>
</tr>
<tr>
<td>Home 4 – Fish Creek</td>
<td>44</td>
<td>46</td>
<td>3,360</td>
<td>T79</td>
</tr>
<tr>
<td>Home 3 – Fish Creek</td>
<td>48</td>
<td>50</td>
<td>2,055</td>
<td>T79</td>
</tr>
<tr>
<td>Home 2 – Fish Creek</td>
<td>40</td>
<td>42</td>
<td>8,090</td>
<td>T79</td>
</tr>
<tr>
<td>Landowner 5</td>
<td>51</td>
<td>53</td>
<td>1,500</td>
<td>T95</td>
</tr>
<tr>
<td>Home 5</td>
<td>52</td>
<td>54</td>
<td>780</td>
<td>T44</td>
</tr>
</tbody>
</table>

### TABLE 2-4  Predicted WTG Noise from the Siemens SWT 2.3MW (normal operation) at the Closest Noise Sensitive Properties

<table>
<thead>
<tr>
<th>Noise Receptor</th>
<th>Predicted WTG Noise</th>
<th>Distance to Closest Turbine (m)</th>
<th>Closest Turbine</th>
<th>Predicted WTG Noise by wind speed (m/s) (and mph in brackets)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L_{A90}$, dB</td>
<td>$L_{Aeq}$, dB</td>
<td>6 (13)</td>
<td>7 (16)</td>
</tr>
<tr>
<td>The Buttes</td>
<td>21</td>
<td>23</td>
<td>36,320</td>
<td>T147</td>
</tr>
<tr>
<td>Home 4 – Fish Creek</td>
<td>44</td>
<td>46</td>
<td>3,210</td>
<td>T30</td>
</tr>
<tr>
<td>Home 3 – Fish Creek</td>
<td>47</td>
<td>49</td>
<td>2,045</td>
<td>T33</td>
</tr>
<tr>
<td>Home 2 – Fish Creek</td>
<td>40</td>
<td>42</td>
<td>7,610</td>
<td>T30</td>
</tr>
<tr>
<td>Tie Siding</td>
<td>39</td>
<td>41</td>
<td>7,190</td>
<td>T60</td>
</tr>
<tr>
<td>Home 1 – Tie Siding</td>
<td>42</td>
<td>44</td>
<td>4,790</td>
<td>T49</td>
</tr>
<tr>
<td>Landowner 5</td>
<td>49</td>
<td>51</td>
<td>1,475</td>
<td>T57</td>
</tr>
<tr>
<td>Home 5</td>
<td>47</td>
<td>49</td>
<td>1,350</td>
<td>T146</td>
</tr>
</tbody>
</table>
### TABLE 2-5  
**Predicted WTG Noise from the GE 1.5MW (normal operation) at the Closest Noise Sensitive Properties**

<table>
<thead>
<tr>
<th>Noise Receptor</th>
<th>Predicted WTG Noise</th>
<th>Distance to Closest Turbine (m)</th>
<th>Closest Turbine</th>
<th>Predicted WTG Noise by wind speed (m/s) (and mph in brackets)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L_{A90}$, dB</td>
<td></td>
<td></td>
<td>6 (13) 7 (16) 8 (18) 9 (20) 10 (22)</td>
</tr>
<tr>
<td>The Buttes</td>
<td>20</td>
<td>36,150</td>
<td>T116</td>
<td>15 15 18 22 23</td>
</tr>
<tr>
<td>Home 4 – Fish Creek</td>
<td>42</td>
<td>3,180</td>
<td>T44</td>
<td>36 36 40 43 44</td>
</tr>
<tr>
<td>Home 3 – Fish Creek</td>
<td>46</td>
<td>2,050</td>
<td>T47</td>
<td>40 40 43 47 48</td>
</tr>
<tr>
<td>Home 2 – Fish Creek</td>
<td>39</td>
<td>7,265</td>
<td>T164</td>
<td>33 33 36 40 41</td>
</tr>
<tr>
<td>Tie Siding</td>
<td>38</td>
<td>6,945</td>
<td>T92</td>
<td>32 32 35 39 40</td>
</tr>
<tr>
<td>Home 1 – Tie Siding</td>
<td>38</td>
<td>4,715</td>
<td>T73</td>
<td>32 32 35 39 40</td>
</tr>
<tr>
<td>Landowner</td>
<td>48</td>
<td>1,400</td>
<td>T85</td>
<td>42 42 45 49 50</td>
</tr>
<tr>
<td>Home 5</td>
<td>43</td>
<td>2,875</td>
<td>T89</td>
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</tr>
</tbody>
</table>
3.0 NOISE FROM WIND TURBINES, LOW FREQUENCY NOISE, INFRASOUND AND HEALTH EFFECTS

3.1 INTRODUCTION

Although wind turbines are generally considered to be quiet, concerns have been expressed about low frequency noise and infrasound causing health effects and distress to neighbors. There have been many notable studies published on these topics, some with conflicting viewpoints.

In December 2009, an expert panel was assembled by the American Wind Energy Association (AWEA) and Canadian Wind Energy Association (CanWEA) to ‘provide an authoritative reference document for legislators, regulators, and anyone who wants to make sense of the conflicting information about wind turbine sound’(3).

To avoid bias and conflict of interest, the expert panel selected consisted of independent experts in acoustics, audiology, medicine, and public health with a remit to address health concerns associated with wind turbine noise. The findings of the AWEA and CanWEA report are discussed here, however for the interested reader the full report can be found at:

http://www.awea.org/newsroom/releases/12-15-09-sound_panel_release.html

3.2 SOURCES OF NOISE

Wind turbine noise originates from mechanical sound (the gearbox and control mechanisms) and aerodynamic sound (produced by the rotation of the turbine blade through the air).

Aerodynamic noise is the dominant source and will be present over all frequencies, including the infrasound range (i.e. below 20Hz), but is generally within the mid frequency range (approximately 500Hz to 1KHz).

Noise within this range will rise and fall as the turbine blade rotates and this change or ‘modulation’ is described as ‘amplitude modulation’ which can be perceived by a listener as a fluctuation in sound occurring approximately every second. It has been suggested that under certain conditions such as wind shear (see below), this fluctuation can be heard some distance away, and because it is a noise that frequently changes, it is more noticeable for the listener.

3.3 WEATHER EFFECTS AND WIND SHEAR

Meteorological factors can affect the propagation of sound from wind turbines. For example, warm air at ground level would cause noise from the turbine to curve upwards which would reduce noise levels; whilst warm air during temperature inversions may cause noise from the turbine to curve downwards,

resulting in increased noise levels. Wind direction can also affect the level of turbine noise at a property (i.e. blowing towards or away from the property).

Wind shear is a measure of how much wind speed increases with height. Under certain circumstances such as very stable atmospheric conditions, which may occur at night, wind speed at the turbine hub height may be substantially increased over that which is expected. This means that masking of wind turbine noise at a property by the wind does not always occur. For example, the wind at turbine height may be sufficient to power the turbine (and generate noise), yet the wind speed at a property may be negligible and no masking of wind turbine noise will take place leading to higher source noise levels.

There is general agreement that wind turbine noise assessments are undertaken at a reference height of 10m based on the fact that the method\(^\text{4}\) used by wind turbine manufacturers to measure noise levels from wind turbines (in turn used to calculated wind turbine noise at properties) are also corrected to a reference height of 10 meters (33 feet). A mathematical correction for wind shear is applied to account for this.

Noise models err on the side of caution and present a reasonable worst-case noise assessment, calculating noise downwind and applying a ground roughness factor to account for wind shear effects.

Wind shear measurements reported in Table 1-2 are typical of smooth, level, grass covered terrain.

3.4 **INFRASOUND, LOW FREQUENCY NOISE AND ANNOYANCE**

The infrasound from wind turbines is at a level of 50 to 70dB, sometimes higher, but well below the audible threshold of hearing which ranges between 79dB at 20Hz and 107dB at 4Hz. Infrasound from natural sources such as the wind also surrounds us and is also below the threshold of audibility.

Some people attribute health effects to wind turbine noise exposure. When amplitude modulation occurs, this can provoke complaint and may be labeled as ‘low frequency noise’ or ‘infrasound’ by some, although this ‘swishing’ noise is in fact in the 500Hz to 1KHz range. It is this fluctuating noise (i.e. amplitude modulation) which only occurs under certain conditions that cause most complaints due to the more disturbing nature of a fluctuating noise compared to a non-fluctuating noise such as free-flowing traffic.

The AWEA and CanWEA report refers to a UK study\(^\text{5}\) that concluded that out of 130 wind farms, only 4 had a problem with amplitude modulation, and 3 of these had been resolved. Furthermore, this amplitude modulation when observed beneath a turbine does not always occur at greater separation distances.

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\(^4\) IEC 61400-11 'Wind Turbine Generator Systems Part 11: Acoustic Noise Measurement Techniques'.

Comprehensive research (6) on low frequency noise has been repeatedly shown by measurements of wind turbine noise undertaken in the USA, UK, Denmark and Germany over the past decade that the levels of infrasonic noise and vibration radiated from modern, wind turbines are at a very low level; so low that they lie below the threshold of perception, even for those people who are particularly sensitive to such noise, and even on an actual wind turbine site.

Claims of health effects from wind turbines are addressed within the AWEA and CanWEA report, in particular, the claim of ‘wind turbine syndrome’ promoted by Pierpont (7) based on the following assertions:

- low levels of airborne infrasound from wind turbines (1 – 2Hz) affect the vestibular system (this is the system that governs our balance and sense of orientation); and

- low levels of airborne infrasound from wind turbines at the 4 – 8Hz range enter the lungs and vibrate the diaphragm which in turn transmits vibration through other organs in the body.

Pierpont claims this combined effect causes a range of symptoms termed wind turbine syndrome.

The AWEA and CanWEA report, in response to these assertions states:

*There is no credible scientific evidence that low levels of wind turbine sound at 1 to 2Hz will directly affect the vestibular system. In fact, it is likely that the sound will be lost in the natural infrasonic background sound of the body. The second hypothesis is equally unsupported with appropriate scientific investigations. The body is a noisy system at low frequencies. In addition to the beating heart at a frequency of 1 to 2Hz, the body emits sounds from blood circulation, bowels, stomach, muscle contraction, and other internal sources. Body sounds can be detected externally to the body by the stethoscope.*

The report goes on to say:

*“Wind turbine syndrome” is not a recognized medical diagnosis, is essentially reflective symptoms associated with noise annoyance and is an unnecessary and confusing addition to the vocabulary on noise. This syndrome is not a recognized diagnosis in the medical community. There are no unique symptoms or combinations of symptoms that would lead to a specific pattern of this hypothesized disorder. The collective symptoms in some people exposed to wind turbines are more likely associated with annoyance to low sound levels.*

Furthermore, the evidence presented by Pierpont to support the hypothesis of wind turbine syndrome is based a single case series from a group of self-
nominated individuals and from a single investigator. This has limited
credibility in terms of scientific peer review.

In summary, following a review of available literature, the Expert Panel
assembled by the AWEA and CanWEA concluded the following.

1. Sound from wind turbines does not pose a risk of hearing loss or any other
   adverse health effect in humans.

2. Sub-audible, low frequency sound and infrasound from wind turbines do
   not present a risk to human health.

3. Some people may be annoyed at the presence of sound from wind turbines,
   but annoyance is not a pathological entity.

4. A major cause of concern about wind turbine sound is its fluctuating nature.
   Some may find this sound annoying, a reaction that depends on personal
   characteristics as opposed to the intensity of the sound level.

3.5 VIBRATION

A comprehensive study of vibration measurements in the vicinity of a modern
wind farm undertaken in 1997 (8) found that vibration levels 100 m from the
nearest turbine were a factor of 10 less than those recommended for human
exposure in sensitive buildings, such as hospitals or laboratories housing
precision measurement instruments.

(8) ETSU W/13/00392/REP ‘Low frequency noise and vibrations measurement at a modern wind far’. Department of Trade and
4.0 RESULTS

The Proposed Action includes construction/decommissioning related noises, as well as operation of a substation. Construction equipment associated with Projects such as this one typically generate noise levels ranging from approximately 75 to 90 dB(A) at 50 feet, depending on the equipment being used (U.S. Department of Transportation 2006: United States Department of Transportation. August 2006. FHWA Highway Construction Noise Handbook). Construction of the Proposed Action would cause temporary increases in ambient noise levels in the immediate vicinity of the construction sites. On-site construction noise would occur mainly from heavy-duty construction equipment (e.g., trucks, backhoes, excavators, loaders, and cranes). As a result, construction-generated noise would be considered a less-than-significant short-term impact.

The Wyoming Department of Transportation (WYDOT) completed noise studies along State Highway 287 as part of an Environmental Assessment (EA) for the expansion of State Highway 287 which was completed in 2009. Prior to the expansion of State Highway 287, WYDOT determined that the existing noise conditions at Tie Siding were between 54.8 and 63.3 dB(A) and these were attributed to wind effects and not traffic noise emanating from State Highway 287. Based on noise modeling, the post highway expansion noise conditions at Tie Siding were estimated to be between 56.7 and 70.0 dB(A). The EA determined that the expansion would only have a minor noise impact to one receptor (a single family home) and no mitigation measures were required. Additionally, the EA determined that noise impacts from construction activities would be temporary and minimal.

Substations typically produce between 60 and 70 L$_{A90}$, dB during operations. The proposed substation location is over 3,000 feet from the participating owner’s property line. Noise dissipates at approximately 6 dB(A) per doubling of distance based on a point source (and not taking account of additional mitigation from air and ground absorption which will be quite significant at distances greater than approximately 300 feet), and impacts would be considered less than significant.

In addition to the impacts discussed above, the Project would include wind turbine generated noise. The Albany County standard for noise is as follows.

Noise associated with wind energy operation shall not exceed fifty-five (55) dB(A) as measured at any point along the common property lines between a non-participating property and a participating property.

a. This level may be exceeded during short-term events such as utility outages, severe weather events, and construction or maintenance operations.

b. This standard shall not apply along any portion of the common property line where the participating property abuts state or federal property.
c. Noise levels may exceed the fifty-five (55) dB(A) limit along common property lines if written permission, as recorded with the Albany County Clerk, is granted by the affected adjacent non-participating property owners.

Based on the assessment performed, noise levels would not be expected to exceed fifty-five (55) dB(A) as measured at any point along the common property lines between a non-participating property and a participating property. During high wind events in excess of 10 m/s wind generated noise is likely to be masked from wind noise.

Other factors such as the existing ambient noise levels (especially from the nearby highway) and wind direction will also affect the perception of wind turbine noise at local properties.
Figures

March 2, 2010
Project No. 0111210

Environmental Resources Management Southwest, Inc.
15810 Park Ten Place, Suite 300
Houston, Texas 77084-5140
(281) 600-1000
FIGURE 1-1
VICINITY MAP
Shell Wind Energy
Hermosa West Wind Farm Project

Legend

- State Boundary
- Hermosa West Wind Farm Project Area
Figure 1-4
GE 1.5 MW Turbines and Receptors
Hermosa West Wind Farm Project
Albany County, Wyoming

Lease Boundaries and Owners
- Craig, Dennis P. & Carla
- Estate Of Wyoming
- Kilpatrick
- Reyes, Juan & Joni

Proposed GE 1.5 MW Turbine Location
Sensitive Receptor
Existing Transmission Lines
Hermosa West Wind Farm Project Area
Proposed Substation

Home 1
Home 2
Home 3
Home 4
Home 5
Landowner
Tie Siding

CLAIMANT:
Shell WindEnergy Inc.

SOURCE: NA
PROJECTION: WGS 1984 UTM Zone 13N