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Final Programmatic Environmental Impact Statement on

WIND ENERGY DEVELOPMENT

on BLM-Administered Lands in the Western United States

Volume 1: Main Text

U.S. Department of the Interior
Bureau of Land Management

TABLE 5.5.2-2 Noise Levels at Various Distances from Heavy Trucks[a]

	Noise Level $L_{eq(1\text{-}h)}$[b] at Distances [dB(A)]					
Hourly Vehicle Traffic	50 ft[c]	250 ft	500 ft	1,000 ft	2,500 ft	5,000 ft
1	50.7	43.8	40.7	37.7	33.8	30.7
10	60.7	53.8	50.7	47.7	43.8	40.7
50	67.7	60.7	57.7	54.7	50.7	47.7
100	70.7	63.8	60.7	57.7	53.8	50.7
	Noise Level L_{dn}[d] at Distances [dB(A)]					
Hourly Vehicle Traffic	50 ft	250 ft	500 ft	1,000 ft	2,500 ft	5,000 ft
1	46.0	39.0	36.0	33.0	29.0	26.0
10	56.0	49.0	46.0	43.0	39.0	36.0
50	63.0	56.0	53.0	50.0	46.0	43.0
100	66.0	59.0	56.0	53.0	49.0	46.0

a The EPA recommends an L_{dn} of 55 dB(A) for residential areas (EPA 1974).

b $L_{eq(1\text{-}h)}$ was estimated on the basis of an A-weighted peak pass-by noise level generated by a heavy truck operating at 50 mph (80 km/h) and traffic flow and distance adjustments.

c To convert feet to meters, multiply by 0.3048.

d L_{dn} was estimated by assuming an 8-hour daytime shift.

Source: Menge et al. (1998).

5.5.3.1 Wind Turbine Noise

Wind turbines produce two categories of noise: mechanical and aerodynamic. These categories are associated with four types of noise (tonal, broadband, impulsive, and low-frequency) (NWCC 1998). Recent improvements in the mechanical design of large wind turbines have resulted in significantly reduced mechanical noise. As a result, aerodynamic noise is the dominant source from modern wind turbines (Fégeant 1999). A brief discussion of each of these noise characteristics follows; a more detailed review is included in Wagner et al. (1996).

Mechanical noise, associated with the rotation of mechanical and electrical components, tends to be tonal, although a broadband component exists. It is primarily generated by the gearbox and other parts, such as generators, yaw drives, and cooling fans. However, the hub, rotor, and turbine may act as loudspeakers and transmit the mechanical noise over greater distances. Recent technological improvements have reduced mechanical noise. It can be further reduced through sound-proofing and noise insulation materials. Accordingly, mechanical noise must, to some extent, be viewed as an indication of poor design.

Aerodynamic noise from wind turbines originates mainly from the flow of air over and past the blades; therefore, the noise generally increases with tip speed. It is directly linked to the production of power and therefore inevitable, even though it could be reduced to some extent by altering the design of the blades (Wagner et al. 1996). The aerodynamic noise has a broadband character, often described as a "swishing" or "whooshing" sound, and is typically the dominant part of wind turbine noise today. The noise caused by this process is unavoidable. Inflow turbulent noise caused by the interaction of blades with atmospheric turbulence is a major contributor to broadband noise, but it has not yet been fully quantified (Wagner et al. 1996).

Although aerodynamic noise mostly has a broadband character, airfoil-related noise can also create a tonal component and there can be both impulsive and low-frequency components. Impulsive noise and low-frequency noise are primarily associated with older-model downwind turbines, the blades of which are on the downwind side of the tower; these types of noise are caused by the interaction of the blades with disturbed air flow around the tower. Impulsive noise is characterized by short acoustic impulses or thumping sounds that vary in amplitude (level) as a function of time. Low-frequency noise is a more steady sound in the range of 20 to 100 Hz. These types of noise can be avoided, however, with good engineering design.

There are many wind turbine designs. In general, upwind turbines are less noisy than downwind turbines and their lower rotational speed and pitch control results in lower noise generation. A variable speed wind turbine generates relatively lower noise emissions than a fixed speed turbine. A large variable speed wind turbine operates at slower speeds in low winds, resulting in much quieter operation in low winds than a comparable fixed speed wind turbine. As wind speed increases, the wind itself masks the increasing turbine noise.

To determine the potential noise impacts at nearby residences from wind turbine operations, sound level data would be needed. These data can be provided by the wind turbine manufacturer or vendor, obtained from field measurements, or from a literature survey. The sound power level from a single wind turbine is approximately 100 to 104 dB(A) for the rated power ranging from 1 to 1.4 MW (Rogers and Manwell 2002). Considering geometric spreading only, this results in a sound pressure level of 58 to 62 dB(A) at a distance of 50 m (164 ft) from the turbine, which is about the same level as conversational speech at a 1-m (3-ft) distance. At a receptor approximately 2,000 ft (600 m) away, the equivalent sound pressure level would be 36 to 40 dB(A) when the wind is blowing from the turbine toward the receptor. This level is typical of background levels of a rural environment (Section 4.5.2). To estimate combined noise levels from multiple turnbines, the sound pressure level from each turbine should be estimated and summed. Different arrangements of multiple wind turbines (e.g., in a line along a ridge versus in clusters) would result in different noise levels; however, the resultant noise levels would not vary by more than 10 dB.

On a clear night, temperature usually increases with height due to radiant cooling of the surface. Under this condition (called a temperature inversion), sound refracts or bends downward, which is a favorable condition for propagation (i.e., sound will travel farther). However, this condition would occur only at low wind speeds, approximately less than 9 ft/s (3 m/s), because stronger winds interfere with this effect. Modern-day wind turbines have a cut-in speed of about 8.2 to 13 ft/s (2.5 to 4 m/s) (see Appendix C, Table C-2); thus, increased noise propagation associated with temperature inversion would be minimal in most operations. The exception would be in sheltered valleys with relatively low ambient noise levels. In general, the effects of wind speed on noise propagation would generally dominate over those of temperature gradient.

Whether the turbine noise is intrusive or not depends not only on its distribution of amplitude and frequency but also on the background noise, which varies with the level of human and animal activities and meteorological conditions (primarily wind speed). In general, wind-generated background noise (i.e., noise caused by the interaction between wind and vegetation or structures) tends to increase more rapidly with wind speed than aerodynamic noise from wind turbines. Wind-generated noise would increase by about 2.5 dB(A) per each 3-ft/s (1-m/s) wind speed increase (Hau 2000); the noise level of a wind turbine, however, would increase only by about 1 dB(A) per 3-ft/s (1-m/s) increase. In general, if the background noise level exceeds the calculated noise level of a wind turbine by about 6 dB(A), the latter no longer contributes to a perceptible increase of noise. At a wind speed of about 33 ft/s (10 m/s), wind-generated noise is higher than aerodynamic noise. In addition, it is difficult to measure sound from modern wind turbines above a wind speed of 26 ft/s (8 m/s) because the background wind-generated noise masks the wind turbine noise at that speed (DWIA 2003). As a result, noise issues are more commonly a concern at lower wind speeds (Fégeant 1999).

5.5.3.2 Substation Noise

There are basically two sources of noise associated with substations: transformer noise and switchgear noise. Each has a characteristic noise spectrum and pattern of occurrence. A transformer produces a constant low-frequency humming noise primarily because of the vibration of its core. The core's tonal noise should be uniform in all directions and continuous. The average A-weighted core sound level at a distance of 492 ft (150 m) from a transformer would be about 43 and 46 dB(A) for 100 and 200 million volt-amperes (MVA) (corresponding to about 80 and 160 MW), respectively (Wood 1992). These noise levels at a distance of 1,640 ft (500 m) would be 33 and 36 dB(A), which are typical of background levels in a rural environment (Section 4.5.2). Current transformer design trends have shown decreases in noise levels. The cooling fans and oil pumps at large transformers produce broadband noise only when additional cooling is required; in general, this noise is less noticeable than the tonal noise.

Switchgear noise is generated by the operation of circuit breakers used to break high-voltage connections at 132 kV and above. An arc formed between the separating contacts has to be "blown out" using a blast of high-pressure gas. The resultant noise is impulsive in character (i.e., loud and of very short duration). The industry is moving toward the use of more modern circuit breakers that use a dielectric gas to extinguish the arc and generate significantly less noise. Frequency of switchgear activities, such as regular testing, maintenance, and rerouting, is an operational issue unique to a specific utility company. During an electrical fault due to line overloads, the switch would open to isolate the fault and thereby protect the equipment. However, these operations would occur infrequently, and, accordingly, potential impacts of switchgear noise would be temporary and minor in nature.