



Pike Solar Noise Impact Study

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Introduction

Electric power generation facilities utilize electrical and mechanical machinery which have the potential to create a significant amount of audible sound in the form of noise. This noise has the potential to disturb the peace and present a nuisance to nearby property owners. The magnitude of this noise which is audible at the property boundary must be at a level that is within acceptable limits according to the local authority having jurisdiction, or AHJ.

Sound pressure level (sound level) is defined as the logarithmic measure of the effective pressure of a sound relative to the threshold of human hearing – $20\mu\text{Pa}$ – and is measured in A-weighted dB, or dBA. As the human ear is sensitive to frequencies only within a specific band, the sound pressure level created by industrial equipment is measured by recording instruments which apply a filter according to the A-weighting, meaning that sounds that fall outside of the human range of hearing are weighted less than sounds which fall inside the human range of hearing.

Sound power level is defined as the rate at which sound energy is emitted from the source and is also measured logarithmically relative to the threshold of human hearing – 10^{-12}W/m^2 – and is measured in dBA. For the purposes of this noise impact study, the standard specific acoustic impedance of air $Z_0=400\text{Pa}$ is assumed.

Acceptable Sound Level

The Pike Solar generating facility is proposed to be located in El Paso County, Colorado and will generate electric power as early as 5:30AM and as late as 8:30PM depending on the day of the year. According to El Paso County Ordinance No. 02-1 *Ordinance Concerning Noise Levels in Unincorporated El Paso County* (Appendix A), a maximum permissible sound pressure level of 50dBA shall be observed at the boundaries between the Pike Solar facility and any residential property, commercial, or non-specified area.

Equipment Identified

The following equipment was determined to create significant sound levels which will be considered in this noise impact study:

1. 184.8MVA substation transformer
2. 4.36MVA power station transformer
3. 4.56MVA BESS transformer
4. Solar PV inverter – SIEMENS/WSTECH APS4360

Power transformers

The power transformers for the Pike Solar facility have not yet been tested or built and no reference levels of sound power exist for power transformers, so two separate industry-accepted standards will be used to estimate the sound power level of the Pike Solar facility transformers. The largest of the two estimated values will be used for the estimation of sound level at the property boundaries.

Sound Power Level Estimation – IEEE Method

According to IEEE Standard C57.12.00-2015 Informative Annex C, the sound power level of power transformers may vary by manufacturer and the approximate sound power level L_{WA} may be calculated according to the following equation, with an error of +12dBA to -6dBA:

$$(1) \quad L_{WA, Ir} = 43.6 + 18 \log_{10}(S_r)$$

Where:

- $L_{WA, Ir}$ is the estimated A-weighted sound power level of the transformer at rated current and rated frequency at the short-circuit [test] condition.
- S_r is the rated power in MVA.

Per this equation, the maximum sound power levels of the power transformers at the Palmer Solar facility are estimated as follows:

1. 184.8MVA substation power transformer sound power level: $L_{WA} = 84.4\text{dBA} + 12\text{dBA} = \mathbf{96.4\text{dBA}}$
2. 4.36MVA power station transformer sound power level: $L_{WA} = 55.1\text{dBA} + 12\text{dBA} = \mathbf{67.1\text{dBA}}$
3. 4.56MVA BESS transformer sound power level: $L_{WA} = 55.5\text{dBA} + 12\text{dBA} = \mathbf{67.5\text{dBA}}$

Sound Power Level Estimation – NEMA Method

According to NEMA standard TR-1 Table 1, the transformer manufacturers must guarantee that the sound level of the transformers must not exceed the following values:

1. 184.8MVA substation power transformer sound level; manufacturer guaranteed: **82dBA**
2. 4.36MVA power station transformer sound level; manufacturer guaranteed: **65dBA**
3. 4.56MVA BESS transformer sound level; manufacturer guaranteed: **65dBA**

Since the sound levels calculated using the IEEE method are larger, those values will be used for determination of the sound level at the property boundary.

Inverters

The SIEMENS/WSTECH APS4360 inverter is proposed for the Pike Solar project and will be used in this study.

SIEMENS/WSTECH APS4360

The sound levels of the APS4360 inverter have not yet been measured in a test environment. The sound levels of an inverter of similar construction, the APS3200 has been measured in a test environment and that test data has been provided by WSTECH in Appendix B. The sound levels of the APS4360 inverter are not expected to exceed those measured by the APS3200.

The loudest sound pressure level measurement from this inverter at 1m away is **74.6dBA**

Method of Determination of Sound Level at Property Boundaries

In order to determine the audible noise levels at the property boundaries, the inverse square law is used. The following equation is used to determine the sound level at a distance away from the source:

$$(2) \quad I = \frac{P}{4\pi r^2}$$

Where:

- I is the sound intensity in W/m^2
- P is the sound power in W
- r is the distance away from the source in m

This equation may be generalized with the following rule: as the distance from the noise source is doubled, the sound level will drop by 6dB. As the distance is increased by a factor of 10, the sound level will drop by 20dB. Sound absorption or reflection of the surrounding equipment, ground, and plant life are not considered for this study.

Applicable Property Boundaries

Two property boundaries were identified within the scope of this noise impact study:

- A. The shortest distance from a power station inverter and transformer to the property boundary was identified to be **130ft**.
- B. The distance from the substation transformer to the substation property boundary was identified to be **1137ft**.

Calculation of Sound Level at Property Boundaries

Closest Power Station to Property Boundary

Since the power station transformers and inverters reside in roughly the same space, the loudest of the two will be considered for the sound level determined at the closest property boundary.

Since the sound power level of the power station transformers was calculated above, the sound pressure level at 1m away must be calculated for comparison with the inverter sound pressure level at 1m away. The power station transformer sound pressure level at 1m away is calculated per equation (2) to be **56.1dBA** based on a sound power level of 67.1dBA.

At the power stations, the source of the highest sound pressure level at 1m away was determined to be the inverters at **74.6dBA**.

At a distance of 130ft or 40m from the nearest power station, the highest sound level at the property boundary is calculated to be **49.7dBA** which is within the acceptable noise levels for unincorporated El Paso county.

Substation Property Boundary

At a distance of 1137ft or 347m from the substation transformer, the highest sound level at the substation property boundary is calculated per equation (2) to be **34.6dBA** which falls within the acceptable noise levels for unincorporated El Paso County.

Conclusion

The results of this noise impact study show that the *Ordinance Concerning Noise Levels in Unincorporated El Paso County* will not be violated and falls within the acceptable noise level at any of the property boundaries. This study shall be validated upon receipt of transformer and inverter test data from the manufacturers.

Appendix A

Ordinance Concerning Noise Levels in Unincorporated El Paso County

(E) Noise

Noise producing activity is regulated by Ordinance 02-1: Ordinance Concerning Noise Level in Unincorporated El Paso County. Uses and activities shall be conducted in conformance with Ordinance 02-1 including, but not limited to, the following standards.

(1) Maximum Permissible Noise Levels

Sound levels shall be measured in dBA as provided for in Section 6 of Ordinance 02-1. During the time periods indicated in Table 6-7, the sound levels allowed by Ordinance 02-1 shall be observed.

Table 6-7. Maximum Noise Standards by Land Use Type.

Land Use	Maximum Noise [dBA]	Maximum Noise [dBA]
	7:00 A.M. - 7:00 P.M.	7:00 P.M. Next 7:00 A.M.
Residential or Commercial Area	55	50
Industrial area or Construction Activities ¹	80	75
Non-specified Areas	55	50
¹ Construction activities are subject to the sound level allowed for industrial areas during construction conducted pursuant to a valid building or construction. At other times, construction activities are subject to the sound level specified.		

Appendix B

Measured Sound Pressure Levels for the SIEMENS/WSTECH APS3200 Inverter

Distance / isoline	Level of impact or distance	
	Full load	50 % of full load
1 m	74.6 dB(A)	67.3 dB(A)
5 m	66.4 dB(A)	59.0 dB(A)
10 m	61.3 dB(A)	53.9 dB(A)
20 m	55.7 dB(A)	48.3 dB(A)
50 m	47.7 dB(A)	40.2 dB(A)
100 m	41.3 dB(A)	33.8 dB(A)
ISO = 45 dB(A)	66 m	29 m
ISO = 40 dB(A)	113 m	50 m
ISO = 35 dB(A)	192 m	86 m