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DyoCore Inc.

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Job #B00301N2

SUBJECT: NOISE MEASUREMENTS OF DYOCORE SOLAIR WIND TURBINE-TWIN OAKS VALLEY GENERIC REPORT OF DISTANCE REQUIREMENTS FOR NOISE COMPLIANCE

We have conducted a third set of noise level measurements of a DyoCore SolAir 800-watt wind turbine. The purpose of the measurements was to determine the noise level created by this model of wind turbine to have data available for determination of compliance with noise standards of the County of San Diego for permit applications for future turbine installations. This report can also serve as a generic report, indicating required distance to property lines for compliance with the County Noise Ordinance.

Noise Source Description

The noise source in question is a SolAir wind/solar hybrid turbine, manufactured by DyoCore. Some photographs taken at the site are provided as Appendix A.

This wind turbines is small, not on the scale of machines used in wind farms. The blade length is about 30 inches, and the overall blade pass diameter is approximately four feet. The turbine is mounted on a swivel, with a wind vane that the wind directs away from the wind, causing the turbine to rotate to a position with the blades perpendicular to the winds. These turbines have three blades, are designed solely for the purpose of residential use, and generate only 800 watts to 1 kilowatt of power.

Noise and Sound Level Descriptors

All noise level or sound level values presented herein are expressed in terms of decibels (dB), with A-weighting, abbreviated "dBA," to approximate the hearing sensitivity of humans. Time-averaged noise levels are expressed by the symbol "L_{EQ}." Frequency sound level data presented is not A-weighted.

Noise Measurement Equipment

The following equipment was used at the site to measure the equipment noise levels:

- Larson Davis Model 824, Type 1 Sound Level Meters, Serial #0342 & 0343, with microphones & windscreens
- Larson Davis Model CA250, Type 1 Calibrator, Serial #2625
- Distance measurement wheel, digital camera

The sound level meters were field-calibrated immediately prior to the noise measurement and checked afterwards, to ensure accuracy. All sound level measurements conducted and presented in this report, in accordance with the regulations, were made with sound level meters that conform to the American National Standards Institute specifications for sound level meters (ANSI SI.4-1983, R2001). All

instruments are maintained with National Bureau of Standards traceable calibration, per the manufacturers' standards.

Applicable Noise Regulations

According to the County of San Diego Noise Ordinance, it is unlawful for noise levels as measured at residential property lines to exceed noise level of 50 dBA at or beyond these property lines between the hours of 7 a.m. and 10 p.m., and 45 dBA between the hours of 10 p.m. and 7 a.m. Noise levels created by the SolAir Wind Turbines must be able to meet these property line noise limits in order to be approved for operation within the County.

There is no current wind turbine system policy/ordinance in effect for the County of San Diego; however, the County is in the process of preparing this document. According to Emmet Aquino, Land Use/Environmental Planner with the County, George W. Kamperman's article "The 'How To' Guide to Siting Wind Turbines to Prevent Health Risks from Sound" is considered a baseline document for how the County will be preparing this ordinance. This document refers primarily to industrial scale wind turbines, which have a much higher power rating and are much larger than the system in question.

On-Site Observations and Noise Level Measurements

A site and occasion was selected in order to increase the opportunity of experiencing higher wind speeds, while also having lower ambient noise levels than previous noise measurements of this product. The noise level measurements presented herein were taken between 3:30 and 4:30 pm on the afternoon of Thursday, April 29, 2010. This was the second of two consecutive days for which weather forecasts were for high and gusty winds, and wind warnings had been posted for mountain passes. The location for these tests was near the north end of Twin Oaks Valley Road, about ½ mile south of the Wyroc Quarry at the north end of the county maintained public road, and on a ridge about ½ mile west of Twin Oaks Valley Road. This location was near the summit of a moderate pass in this valley. Quarry operations were not noticeable, except for an occasional truck. There were few interfering noises; those that did occur were on occasional vehicle or light plane.

Maximum gusts of wind ranged from 10 to 15 mph, according to measurements made using a handheld anemometer. Noise level measurements of the turbine were with a Larson Davis 824 type 1 precision sound level meter (meter C), with 1/3-octave band capabilities; the microphone positioned about 5 feet from the center of the spindle of the turbine blades. This turbine was mounted on top of an SUV vehicle. This meter was used for brief sound level measurements during periods in which the wind speed was enough to spin the turbine blades and begin to produce any sound. Because of the variability of the wind speeds and gusts, these measurement periods ranged from 10 to 40 seconds. Even with the higher winds forecast, the total length of time within the hour of sound tests for which there was sufficient wind (10 mph or higher) to produce rapid blade rotation and noticeable sound, was less than 5 minutes. The vast majority of the time, the turbine was spinning only moderately, slowly or not at all.

Another identical sound level meter (meter A) was placed on a tripod about 60 feet away from the turbine, where the turbine would not be audible. This meter was set to obtain continuous 10-second interval sound levels containing 1/3-octave band data, and left to run for an extended time. Then, 10-second to 40-second sets of data were compared to sound levels from the meter located at the turbine, so that the noise level of the turbine could be calculated by decibel subtraction. As an indication of the remote, quiet location, one 10-second Leq at this location was 34.2 dBA.

Data Discussion

The most accurate and useful sound level data obtained, with the higher wind speeds of 7 to 15 mph, is presented in the attached table, printed from a spreadsheet used to calculate turbine noise levels. The tests are numbered for convenience of presentation. For presentation, the turbine noise levels and frequency data is highlighted in bold, and the tonal frequencies are underlined. The higher turbine noise levels of 50-50.2 dBA were measured during the highest wind speeds of close to 15 mph – Tests 2 and 3. Except for very unusual wind conditions, it is reasonable to consider the noise level for the turbine with this wind speed to be its maximum. This should account for 95-99% of the time that this type of equipment is in use in San Diego County, as it is rare to have sustained winds higher than this for any length of time, except for in the mountain pass areas or during a storm. Thus, for purposes of this analysis, the sound pressure level of this unit in operations is considered to be 50.2 dBA at a distance of 5 feet. However, the average sound level in most hourly periods, if not all, is likely to be in the range of 45 dBA or less at 5 feet.

As can be seen, the primary tonal content is indicated at the higher wind speeds at a frequency of 500 Hz. This is generally the only frequency range in which the sound level is at least 1 decibel higher than in the next lower 1/3-octave band. For the lower wind speed (Test 1), the only tonal content was at 1000 Hz, but is a low sound level. The overall observations of tonal content were that they were noticeable at the higher wind speeds, but not loud or significant; the noise was a combination of tone and wind noise on the blades, and the 1/3-octave band noise level where a tone was present was not much higher than the noise level of the next higher and lower 1/3-octave bands. The nature of the tone was somewhat like one a soft wind chime.

Property Line Distance Calculations

These wind turbines are typically located in a high place on a property, such as on a roof, trellis, hilltop, etc. Thus, there is usually little ground effect or reflection, so sound attenuation of 6 dB per doubling of distance is applicable. The distances to nearest property line for one to four units is presented below. This is considered conservative, because the units are typically separated by from a few feet to many feet, so the combined sound level at any given distance will actually be less than the level listed below.

Distance Attenuation for Single or Multiple 50.2 dBA Noise Sources			
# of Units	Maximum Total Noise Level, in dBA, at 5 feet	Distance to Property Line, in Feet, To Reduce Noise Level to 45 dBA	Distance to Property Line, in Feet, To Reduce Noise Level to 40 dBA
1	50.2	9	16
2	53.0	13	23
3	55.0	16	28
4	56.2	18	32

Conclusion and Recommendations

Based on observations, noise level measurements, and the data and calculations presented in this report, it is our professional opinion that for this model DyoCore SolAir wind turbine, one to four units can be installed on any property in the county and be in compliance with the noise ordinance, if the distance to the nearest property line is not less than the distance listed in the above table, for the number of units to be installed. The distance to achieve 45 dBA complies with the County Noise Ordinance. Since no sound barriers are included, this is valid regardless of the local topography. Noise levels in excess of 50.2 dBA are expected to be very infrequent and of short duration. Average hourly noise levels are actually expected to be at least 5 dB less than the maximum measured level of 50.2

dBA that was used in this analysis, so I believe that this is a conservative solution demonstrating compliance.

The distance to achieve 40 dBA is an even more conservative solution, which reduces the noise level to more closely approximate expected L_{90} noise levels at neighboring properties in conditions of 15 mph of wind. Although L_{90} noise levels at quieter properties in San Diego County are likely to be in the range of 35 dBA, this is likely to be the case only in absence of any significant wind. An background noise level of 40 dBA is considered a reasonable estimate, in keeping with the premise presented in the Kamperman report, for conditions of fairly high wind, on the order of 15 mph. But when winds are less, the wind turbine noise levels will be less than the calculated levels, which are based on the higher wind speed; thus, at the distances presented above for 40 dBA compliance, when the L_{90} is closer to 35 dBA, the wind turbine noise level should also be closer to 35 dBA.

In summary, as a result of this generic analysis, I recommend that the County accept permit applications for installations of these turbines on sites where the distances to neighboring property lines exceed the distance listed above for either 45 dBA or 40 dBA compliance. However, for any proposed installation in which the distance would be less than these figures, a site specific analysis can be required, and mitigation or design change be determined if necessary to comply with the County requirements.

This report was prepared by the undersigned, and is a true representation of data collected.

Sincerely,

EILAR ASSOCIATES, INC.



Douglas K. Eilar
Principal/Senior Acoustical Consultant

ATTACHMENT

Noise Measurement Data of April 29, 2010 Sound Tests