Technical Report

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Project

Barnsley BSF
Wind Turbine Noise Assessment
Penistone School

Prepared for

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Summary

Surveys have been done to help assess the impact of noise from the proposed wind turbine installation at Penistone School on neighbouring dwellings. Surveys are reported of the measurement of background noise levels at different times of day and of the measurement of the variation of background noise with wind speed. The measurements have been assessed following the method recommended by the Working Group on Noise from Wind Turbines – Final Report (ETSU-R-97).

We conclude that at the dwellings closest to the proposed wind turbines, the ETSU criteria will be met at all wind speeds.





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Contents

1. Introduction

2. Proposed Wind Turbine Installation

3. Assessment Methodology

4. Wind Turbine Noise Levels

5. Background Noise Measurement

6. Assessment

7. Conclusions

Appendix 1

Plan Showing Measurement Locations

Appendix 2

Survey Details

Appendix 3

Survey Results

Appendix 4

Assessment Results

Appendix 5

Noise Measurement Parameter Definitions

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1. Introduction

As part of the first phase of the BSF development for Barnsley, it is proposed to erect one or more wind turbines at each of the schools in the scheme. In seeking planning approval for this, it is necessary to have assessed the acceptability of noise from the wind turbines affecting the nearby residents. This report considers the noise impact from the operation of four or five wind turbines at Penistone School.

2. Proposed Wind Turbine Installation

As part of the redevelopment of Penistone School it is proposed to erect four or possibly five wind turbines on the school playing fields. They would be located towards the far end of the playing fields not far from the western site boundary, as indicated on the plan in Appendix 1. To the north-east, dwellings along Huddersfield Road would have a clear view of the turbines at a distance of about 240 to 360m. Further south along that road the nearest dwellings, at 275m from the turbines, are surrounded by trees.

The type of wind turbine proposed is the Proven Energy WT 15000, with the turbine hub installed at 25 metres above ground level. The specifications for this turbine shows that it cuts in at a hub wind speed of 3m/s and starts overspeed control at 13m/s.

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3. Assessment Methodology

The method of assessing noise impact on-site follows that recommended by the Working Group on Noise from Wind Turbines – Final Report (ETSU-R-97).

The wind turbine noise level, expressed as L_{A90}, is predicted at the most affected dwelling(s). If appropriate a tonal correction is made. These predictions are based on measurements done by an independent test organisation of noise output as a function of wind speed. In this case the measurements were done by TUV NEL to an industry protocol, the Small Wind Turbine Performance and Safety Standard (29 February 2008) published by BWEA (British Wind Energy Association).

The background noise level, also expressed as $L_{A90\text{-}10min}$, is measured at the dwelling(s). This must be done at different times and at wind speeds over the range at which the wind turbine is expected to operate, because the background noise level will vary with wind speed. The wind speed as a 10 minute average is measured simultaneously, at the recommended reference height of 10 metres above ground level, at a location representative of the proposed wind turbine siting. The corresponding wind speed at hub height of the proposed turbine is calculated by adjusting the measured speeds according to the equation given in the ETSU report.

The predicted wind turbine noise level is then compared with both

- fixed noise level criteria
- the background noise level as a function of wind speed

The corrected wind turbine noise is considered acceptable outside dwellings if it is no greater than:

- 35dB $L_{A90\text{-}10min}$ during the daytime
- 43dB $L_{A90\text{-}10min}$ during the night-time

  or

- the background $L_{A90\text{-}10min}$ +5dB at any time

  whichever is the higher.

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4. Wind Turbine Noise Levels

The measured and declared sound power levels at 8m/s for the Proven Energy WT 1500 are 94.3 and 97 dBA (L_{wA}) with no tonal correction needed.

This is based on the measured noise levels which show a scatter of results at any given wind speed. Linear regression is done to derive the trend (equation of noise level versus wind speed) and standard deviation to measure the degree of scatter. The declared level is the calculated level at 8m/s plus 1.645 x the standard deviation.

The trend line is significantly different above and below an average speed of 9m/s, due to the way the turbine operates and interacts with the wind. The trend line is given by

$L_{Aeq} = 1.94u + 46.64$ $\quad 3 \leq u \leq 9$ m/s

$L_{Aeq} = 0.66u + 64.11$ $\quad 9 < u < 15$ m/s

where u is the wind speed at hub height.

The Working Party guidelines use the L_{A90} of the turbine noise as the index for assessment, using the relationship $L_{A90} = L_{Aeq}$-2dB. They recommend assessment is done up to an average wind speed of 12m/s (at 10m height). They also recommend that the wind speed at the hub height (u_h) is calculated from the averaged wind speed at the reference height (u_{10}) of 10 metres using the relationship:

$u_h/u_{10} = \ln(\frac{h}{z_o})/\ln(\frac{10}{z_o})$ where z_o is the roughness factor of the local ground cover. Examples of roughness factor that they give indicate a suitable value for this area to be of the order of z_o = 0.01.

5. Background Noise Measurement

Ambient noise levels (L_{A90} and L_{Aeq}) were measured at different times of day and under different conditions as follows:

i) During the middle of the night-time with no or low wind (below the speed at which the turbines would operate)

ii) During the late evening, as being representative of the quietest time of day, with no or low wind

iii) On at least two different days under different wind conditions. Measurements were done on different days in order to monitor a spread of wind speed within the range 3 to 12m/s

iv) During the middle of the day under no or low wind conditions.

The measurements were located close to residential properties that were thought most likely to be affected by wind turbine noise. These were houses along Huddersfield Road as shown in the plan in Appendix 1. Also shown is the location of the wind monitor, which was on a mast at 10 metres above ground level. During the surveys during windy conditions ((iii) above), average wind speed measurements were made every 10 minutes to correspond with the 10 minute background noise level (L_{A90}) measurements.

The equipment used to make the measurements and other survey details are given in Appendix 2. The large spherical B&K windshield was used to prevent noise generated at the windshield invalidating the results. It is less affected than other commercially available windshields.

The results are tabulated in Appendix 3. Measurements of L_{Aeq} are included for information although not used in this assessment.

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6. Assessment

The measured relationship between background noise and average wind speed (measured at 10m height) is plotted for locations 1 and 2 on figures 1 to 4 in Appendix 4. Linear and geometric regression (trend) lines have been calculated and superimposed on figures 1, 3 and 2, 4 respectively, together with the 'goodness' of fit (R^2). At low wind speeds the trend line goes below the measured 'no wind' background. In these circumstances the wind generated noise is not affecting the overall background level, so any such data points are not included in the regression analysis.

The predicted turbine noise at the nearest residence is also superimposed on the plots on figures 1 to 4 for four turbines and on figures 5 to 8 for five turbines. This calculation is based on the trend line equations, given in section 4, and the wind speed adjusted to a height of 25m.

Under no and low wind conditions the wind was considered not to be affecting the background noise levels. The background noise levels during the daytime, at the time of day when wind noise was monitored, generally ranged from 36 to 42 dBL_{A90}. There was one higher reading when buses were collecting children from the existing school. L_{A90} levels measured during wind noise surveys were all higher than this, which indicates that they were dependent on the wind rather than other noise sources in the locality.

The plot of background noise versus wind speed shows a very good correlation at both locations (R=0.9). There is insignificant difference between the linear and geometric regression curves over the range measured. As the wind speed drops, one would theoretically expect the wind generated noise to fall to nothing (-∞dBA) at zero wind speed, so a geometric fit would be better. However, other sources will determine the background noise level well before this point is reached.

With no or very low wind the lowest background (L_{A90}) levels measured were as follows:

		Location 1	Location 2
Daytime (evening)	dB L_{A90}	30	34
Nightime	dBL_{A90}	24	23

The impact of five turbines will be considered, the noise from four turbines being only 1dBA lower will have marginally less impact. Taking the two locations in turn:

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Location 1 - Daytime

- Lowest background is 30 dBL_{A90}
- Criterion for turbine noise is the higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 35 dBL_{A90}
- Therefore, the lowest daytime criterion for turbine noise is 35 dBL_{A90}, which they would reach at a wind speed of 4m/s at the reference height of 10m above ground level.
- At this wind speed of 4m/s (10m), the background noise (+5 dB) would be 50 dBL_{A90}, well above the turbine noise level.
- At higher wind speeds the background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Location 1 – Night-time

- Lowest background is 24 dBL_{A90}
- Criterion for turbine noise is the higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 29 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which they would reach at a wind speed of over 7m/s at the reference height of 10m above ground level.
- At this wind speed of >7m/s (10m), the background noise (+5dB) would be 55 dBL_{A90}, well above the turbine noise level.
- At higher wind speeds the predicted background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Therefore, at location 1 the data show with a high degree of confidence that the ETSU criteria would be met at all appropriate wind speeds by an installation of either four or five turbines as proposed.

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Location 2 – Daytime

- Lowest background is 34 dBL_{A90}
- Criterion for turbine noise is higher of 35 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 39 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 39 dBL_{A90}, which they would reach at a wind speed of nearly 6m/s at the reference height of 10m above ground level.
- At this wind speed of just under 6m/s (10m), the background noise (+5dB) would be 53 dBL_{A90}, well above the turbine noise level.
- At higher wind speeds the background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criteria of background level + 5 dB.

Location 2 – Night-time

- Lowest background is 23 dBL_{A90}
- Criterion for turbine noise higher of 43 dBL_{A90} and (background +5dB)
- The lowest background +5 dB is 28 dBL_{A90}
- Therefore, the lowest night-time criterion for turbine noise is 43 dBL_{A90}, which they would reach at a wind speed of over 7m/s at the reference height of 10m above ground level.
- At this wind speed of >7m/s (10m), the background noise (+5dB) would be 55 dBL_{A90}, well above the turbine noise level.
- At higher wind speeds the predicted background noise is greater than the predicted turbine noise. Therefore, the turbine noise would be well below the criterion of background level + 5 dB.

Therefore, at location 2 the data show, with a high degree of confidence, that the ETSU criteria would be met at all appropriate wind speeds by an installation of either four or five turbines as proposed.

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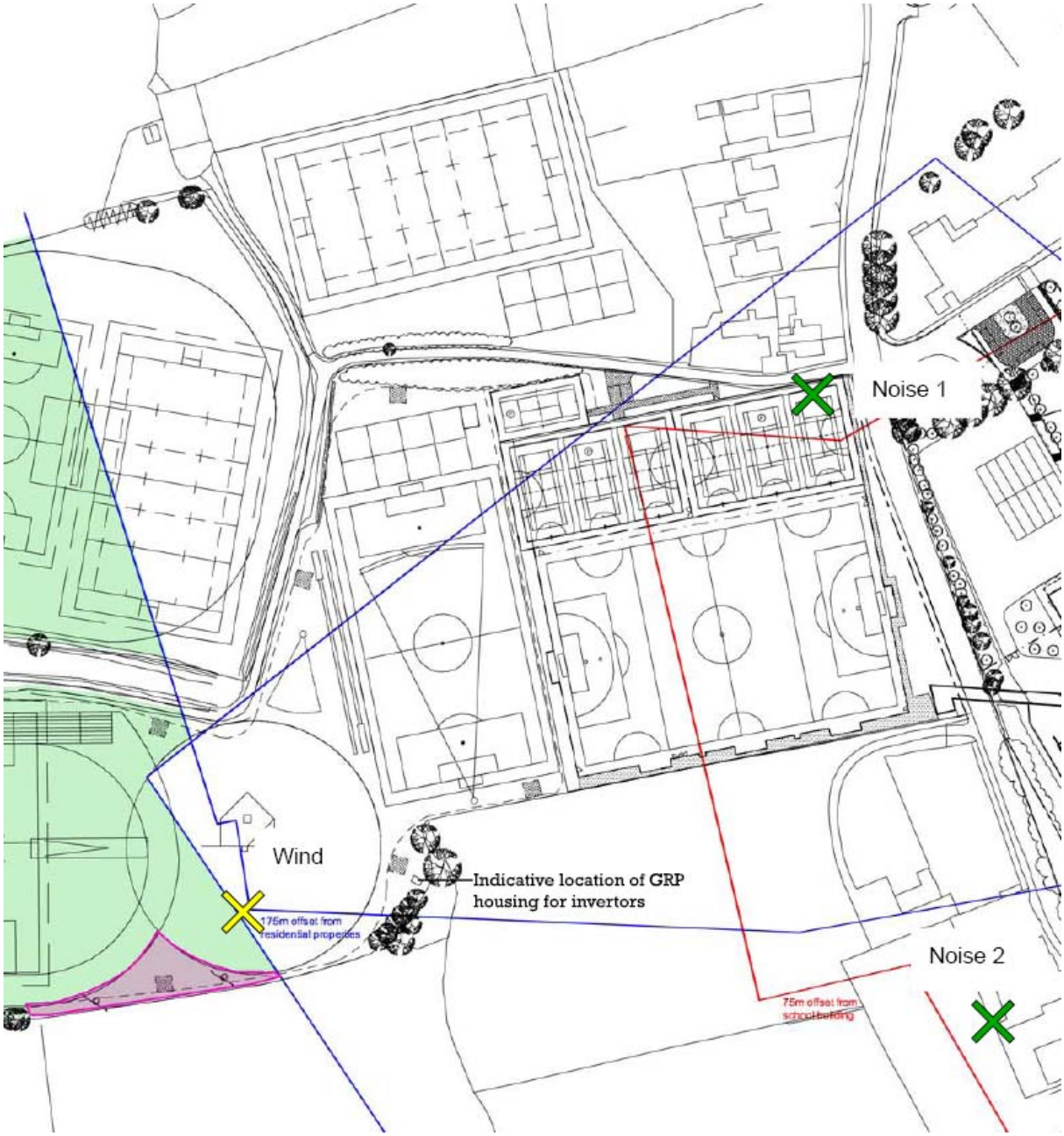
7. Conclusions

The measured data indicate that the ETSU criteria for the acceptability of wind turbine noise are likely to be met at all speeds for both daytime and night-time with either four or five turbines located as proposed.

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Appendix 1

Plan showing Measurement Locations



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Appendix 2

Survey Details

A1. Location of Surveys

Penistone, Barnsley. For measurement positions see Appendix 1

A2. Dates & Type of Surveys

7 & 18 October 2009 – Evening/Night-time, no/low wind
17 October 2009 – Daytime – no/low wind
20 October 2009 – Daytime, moderate wind
25 October 2009 – Daytime, moderate wind
19 November 2009 – Daytime, high wind

A3. Personnel Present During Surveys

Mark Hinds

A4. Instrumentation

Bruel & Kjaer
Type 2250 Sound Level Meter, S/N 2506736, S/N 2559287
Type 4189 Microphone, S/N 2529958, S/N 2556367
Type 4231 Sound Level Calibrator, S/N 2528393, S/N 2482655
Type 2270 Sound Level Meter, S/N 2623080
Type 4189 Microphone, S/N 2638475
Type 4231 Sound Level Calibrator, S/N 2665089

Davis
Type Vantage Pro 2 6152UK Weather Station, S/N A90708N037

A5. Calibration Procedure

Before and after the survey the sound level measurement apparatus was check calibrated to an accuracy of $\pm$ 0.3 dB using the type 4231 Sound Level Calibrator.

A.6 Survey Procedure

Ambient noise levels and average wind speed were monitored at various positions around the site as shown in Appendix 1. The measurements are tabulated in Appendix 3, and explanations of the parameters used are listed in Appendix 5.

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Appendix 3

Survey Results at Penistone School

Measured Ambient Noise Levels (dB re $2x10^{-5}$ Pa)

Evening/Night, Weather – no wind

Date Position	Time	L_{A90}	L_{Aeq}	Comments
07.10.09				
1	21:24	32	43	
2	21:39	35	61	Nearby vehicles
1	21:51	32	44	
2	22:04	34	64	Nearby vehicles
1	22:18	32	44	
2	22:32	35	61	Barking dog
1	22:45	30	42	
08.10.09				
1	01:57	26	35	
2	02:11	23	30	
1	02:24	24	29	
2	02:40	23	28	
1	02:57	26	32	
2	03:10	28	62	Nearby vehicles
1	03:23	27	36	
2	03:36	27	33	

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Daytime, Weather - low wind

Date Position	Time	L_{A90}	L_{Aeq}	Comments
17.10.09				
1	10:30	42	51	
	10:40	40	52	
	10:50	40	51	
	11:00	40	50	
	11:10	38	50	
	11:20	36	48	
	11:30	37	49	
	11:40	37	50	
	11:50	37	50	
	12:00	38	50	
	12:10	41	50	
	12:20	48	53	School bus
	12:30	41	53	
	12:40	39	48	
	12:50	38	49	
	13:00	36	47	
	13:10	39	49	
	13:20	40	50	
	13:30	37	52	
	13:40	38	50	
	13:50	40	49	
	14:00	37	50	
	14:10	35	46	
	14:20	38	51	
	14:30	38	47	
	14:40	37	49	
	14:50	39	49	

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Daytime, Weather - moderate wind

Date Position	Time	L_{A90}	L_{Aeq}	Wind speed m/s@10m	Comments
20.10.09					
2	10:50	49	52	4.9	
	11:00	48	51	4.9	
	11:10	49	53	5.8	Occasional construction noise
	11:20	49	52	5.8	
	11:30	49	51	5.4	
	11:40	48	51	5.4	
	11:50	48	51	5.4	
	12:00	48	51	5.8	
	12:10	48	51	5.4	
	12:20	47	50	5.8	
	12:30	48	50	5.8	
	12:40	48	51	4.9	
	12:50	48	54	6.3	
	13:00	46	50	4.9	
	13:10	-	-	-	Road sweeper
	13:20	49	51	5.8	
	13:30	48	50	6.3	

Daytime, Weather - moderate wind

Date Position	Time	L_{A90}	L_{Aeq}	Wind speed m/s@10m	Comments
25.10.09					
1	10:10	51	58	7.2	
	10:20	49	54	6.7	
	10:30	49	54	5.8	
	10:40	49	54	6.3	
	10:50	50	59	6.7	
	11:00	48	53	5.4	
	11:10	47	53	4.9	
	11:20	49	55	5.4	
	11:30	49	54	5.8	
	11:40	45	52	4.5	
	11:50	47	53	4.9	
	12:00	48	54	5.8	
	12:10	46	50	4.5	
	12:20	46	52	4.9	

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Daytime, Weather - high wind

Date Position	Time	L_{A90}	L_{Aeq}	Wind speed m/s@10m	Comments
19.11.09					
2	16:00	50	56	8.0	Minimal construction noise
	16:10	51	58	8.9	
	16:20	52	62	8.5	
	16:30	53	57	8.9	
	16:40	53	61	9.4	
	16:50	53	59	8.5	
	17:00	53	59	8.5	
	17:10	53	59	8.9	

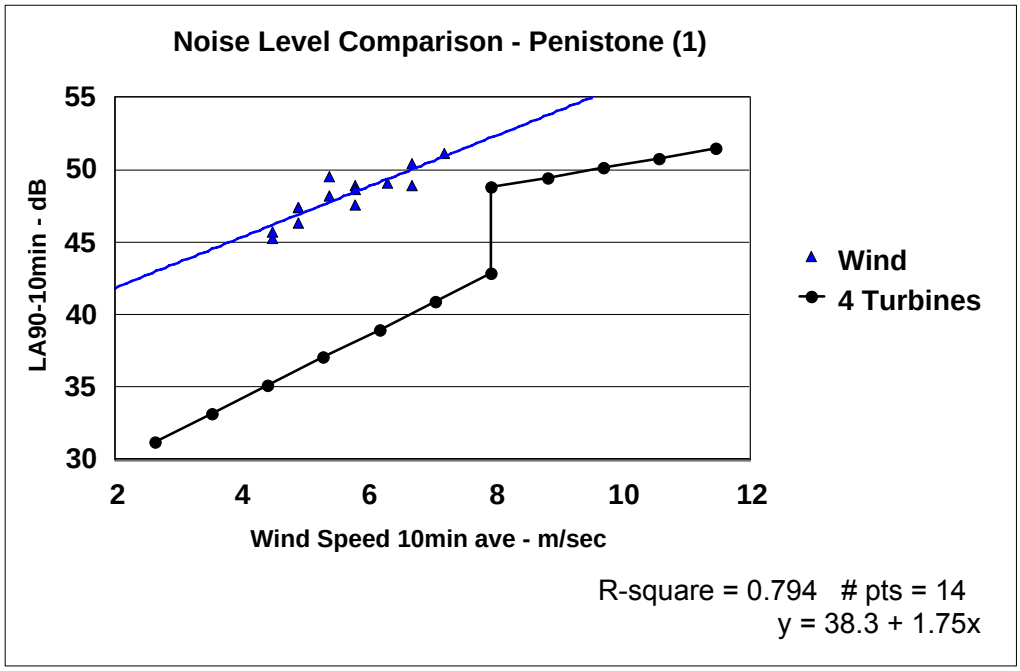
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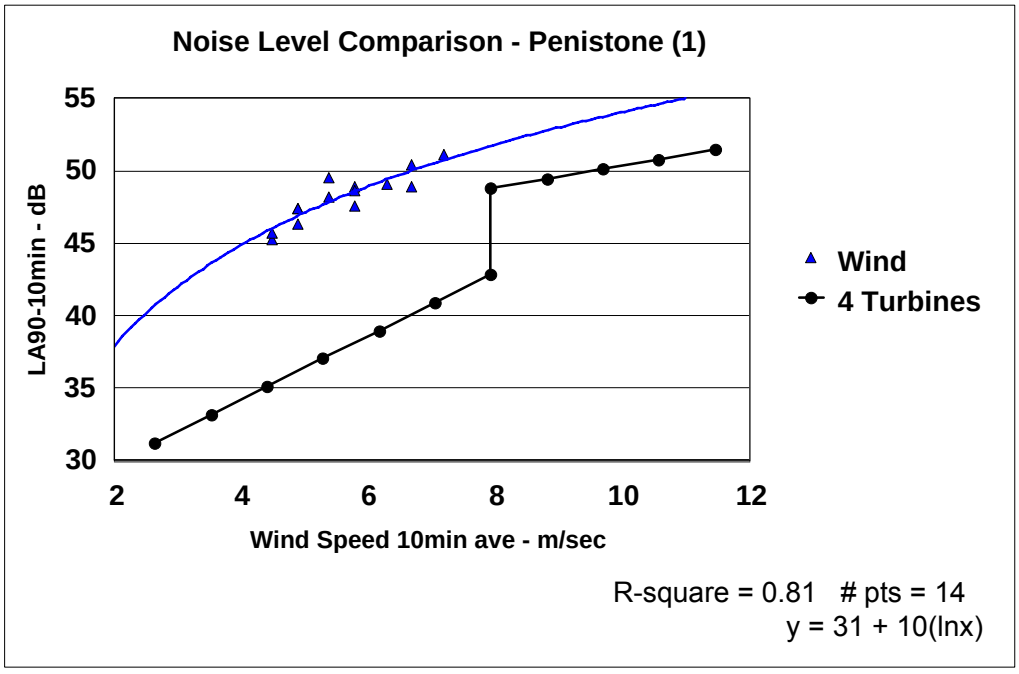
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Appendix 4

Assessment Results

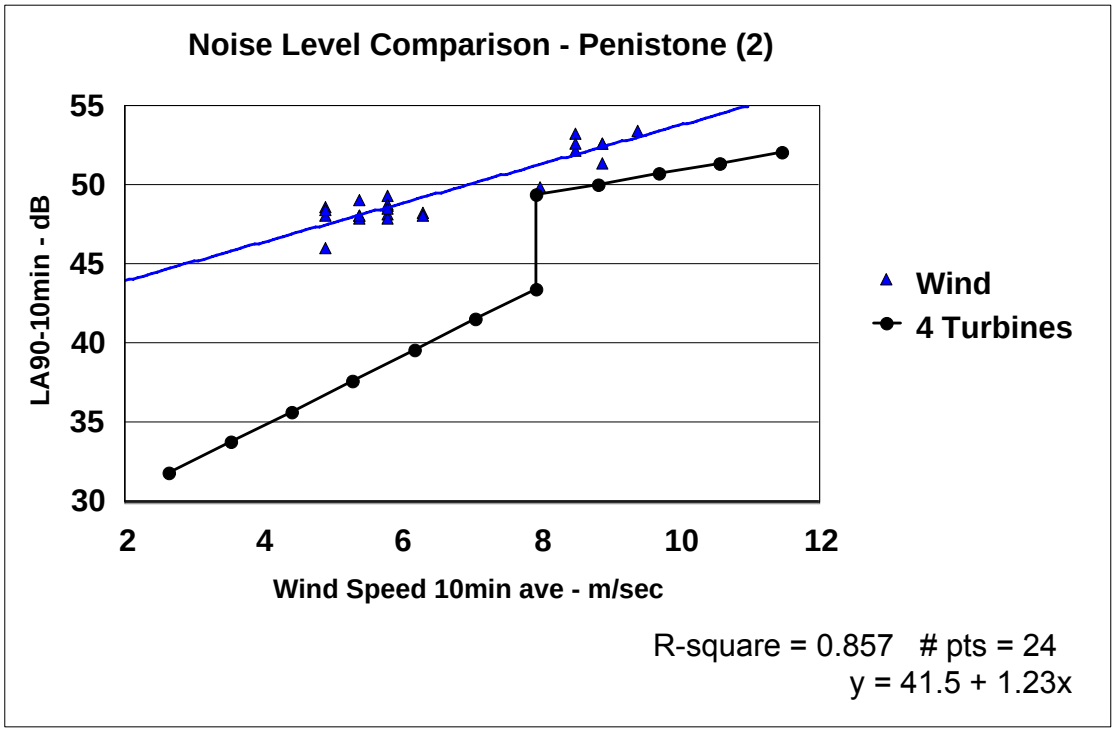
Figures 1 & 2 – Location 1 – 4 Turbines

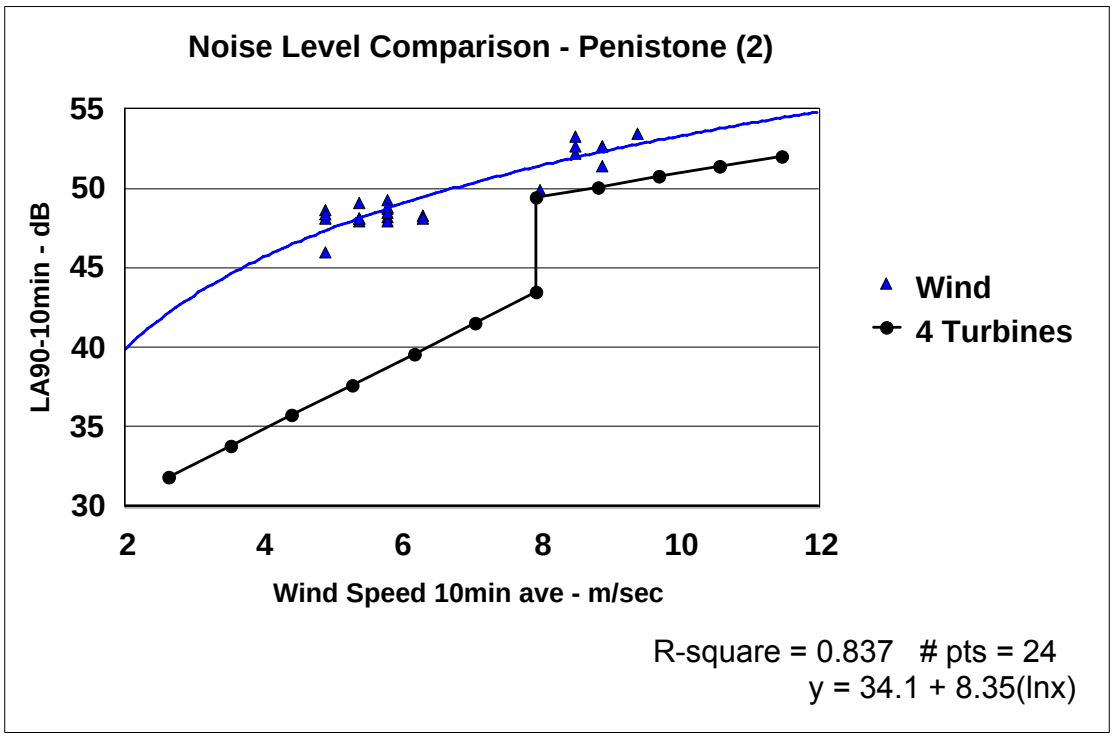




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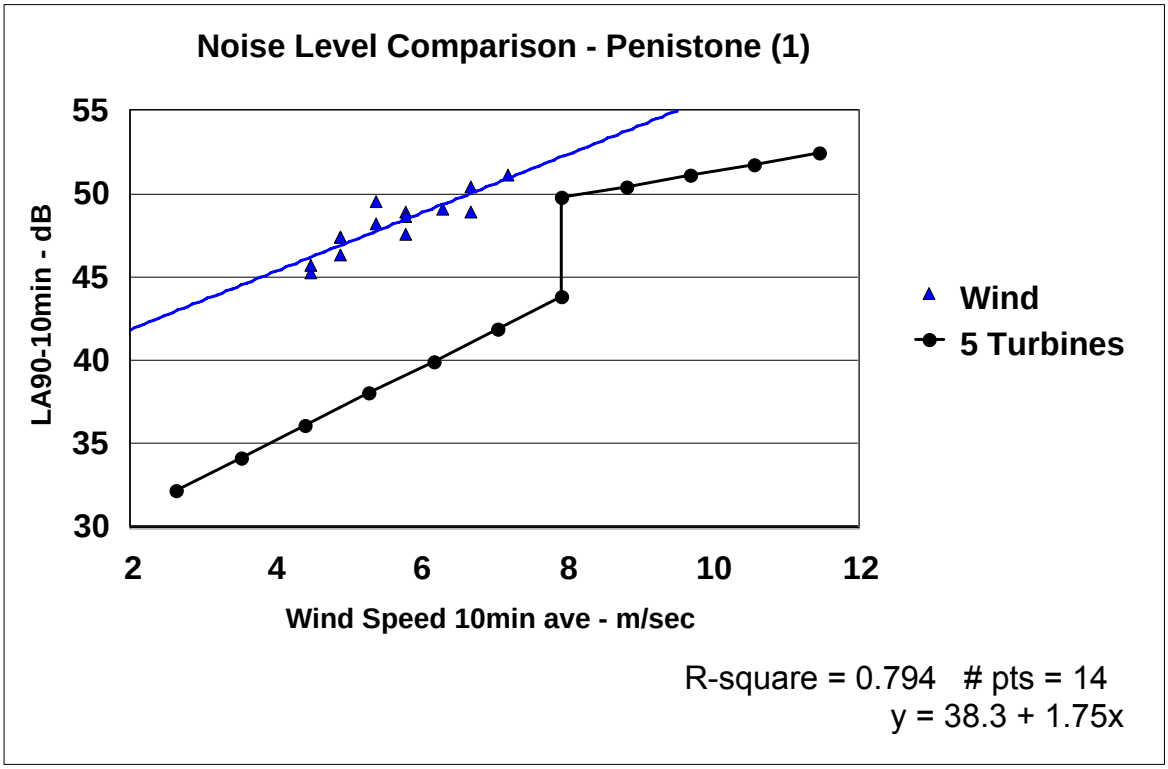
Figures 3 & 4 – Location 2 – 4 Turbines

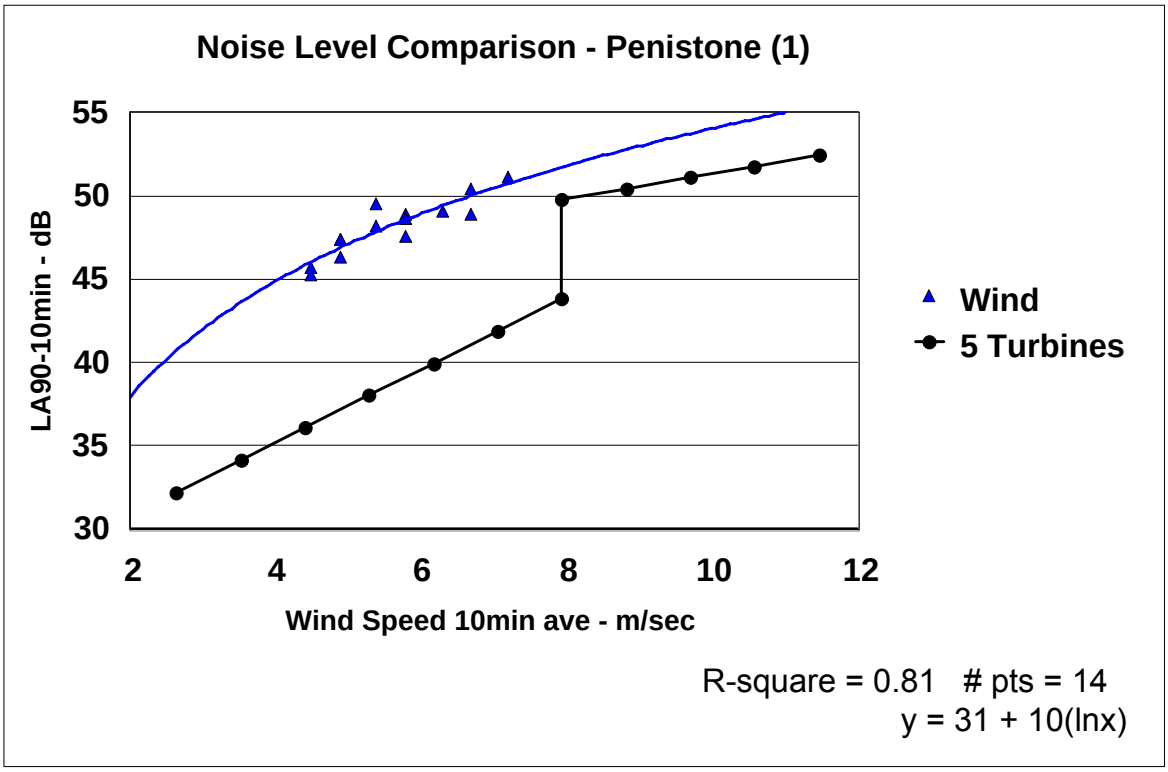




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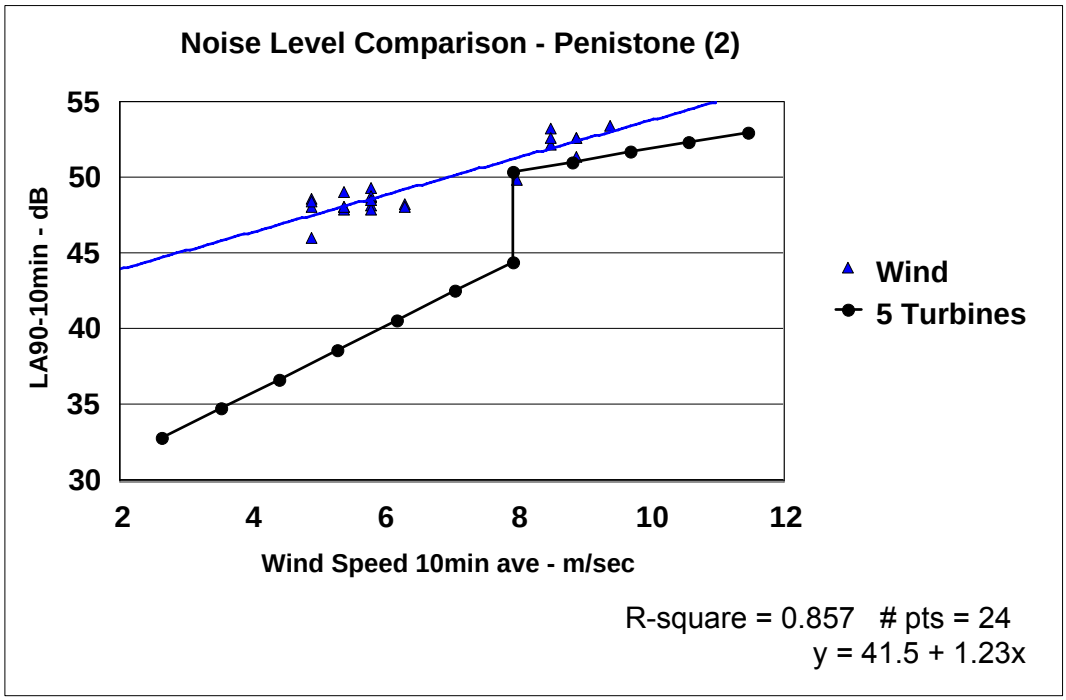
Figures 5 & 6 – Location 1 – 5 Turbines

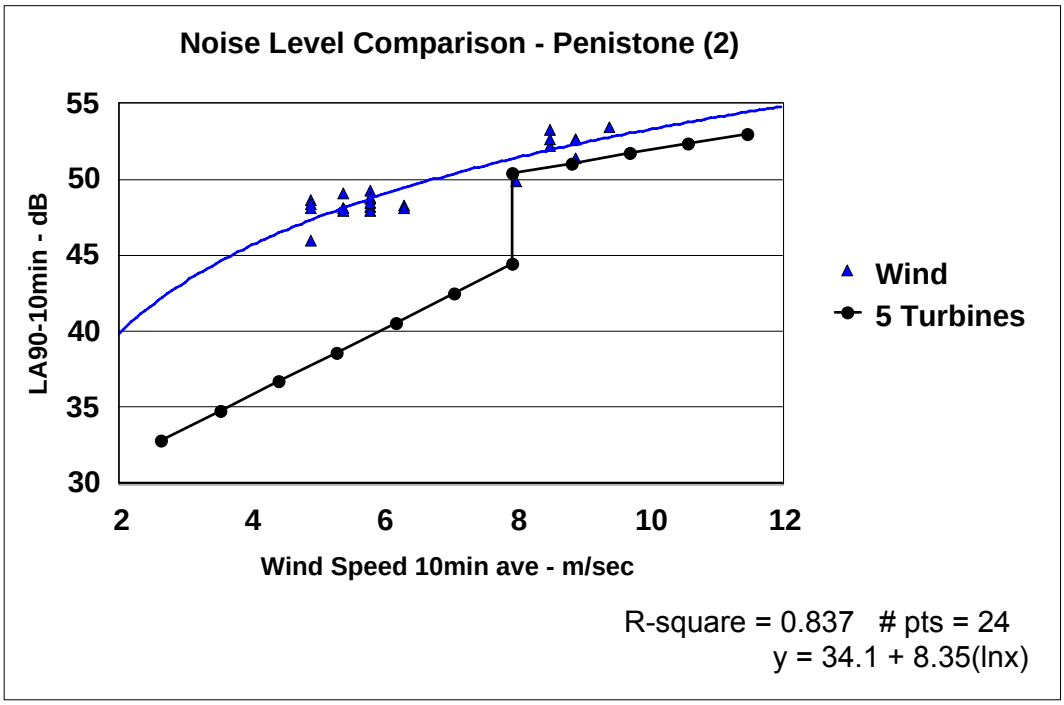




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Figures 7 & 8 – Location 2 – 5 Turbines





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Appendix 5

Noise Measurement Parameter Definitions

L_{A90} - The "A" weighted sound pressure level that is exceeded for 90% of the measurement period. It is commonly used as the "Background Noise Level".

L_{Aeq} - The "A" weighted equivalent continuous sound pressure level. A representation of a continuous sound level containing the same amount of sound energy as the measured varying noise, over the measurement period. It can be considered as the "average" noise level.

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