



**PRELIMINARY NOISE ASSESSMENT
FOR THE S. ELENA SANNITA WIND
FARM IN ITALY**

Client	Babcock & Brown
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Document No	100044/BR/01
Issue	B
Status	Final
Classification	Client's Discretion
Date	27 June 2008

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GH has not conducted measurements at the site and cannot, therefore, accept liability for the accuracy of the data supplied to it.

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REVISION HISTORY

Issue	Issue date	Summary
A	30.04.08	Original issue (electronic version only)
B	27.06.08	Update considering new turbine model and location of noise sensitive points

Circulation	Copy No.
B&B	1
GH Bristol	2
GH Imola	3

Copy No: _____

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1 INTRODUCTION

Babcock & Brown (B&B) is developing the S. Elena Sannita Wind Farm in Italy. B&B has instructed Garrad Hassan and Partners (GH) to undertake a preliminary assessment of the noise produced by the proposed turbines.

GH has previously conducted a preliminary energy production analysis of this wind farm [1.1] and the noise analysis reported here is based on the same 22 turbine layout, indicated as Layout B in [1.1], using the Nordex N90 2.3 MW turbine model.

2 PROJECT DESCRIPTION

A full description of the site is included in [1.1]. The wind farm is to be composed of 22 wind turbines with a hub height of 80 m. The majority of the proposed wind farm lies on a slope of elevation between 700 m and 1000 m. A second group of turbines is located on a ridge approximately 2 km to the east. Table 2.1 shows the turbine coordinates.

Background noise measurements at the noise sensitive points as well as the sound power level in the form of octave bands to comply with the model used were supplied by the client [2.1]. Table 2.2 shows the associated A-weighted sound power level spectrum in octave bands for the Nordex N90 2.3 MW.

3 DESCRIPTION OF NOISE MODEL

GH has conducted predictions in accordance with the ISO 9613-2 [3.1] standard using the WindFarmer 3.6 software package. GH used the Alternative method of calculation for the A-weighted sound pressure levels as specified in the ISO standard which is considered to work better in complex terrain. The following hypotheses have been considered:

- Hard ground effect;
- Burnt earth;
- Sound power level of the turbine specified in octave bands as reported in Table 2.2.
- Digital Terrain Model height data used;
- No allowance was made for the use of noise control strategies, or differences in day and night operation;
- The calculation considers only the noise emissions of the wind turbines and assumes outdoor conditions only.
- Background noise levels have been considered by GH at the noise sensitive points but not in the overall noise predictions.
- Results of the analysis are shown for the standard wind speed of 8 m/s at 10 m height at each turbine location.

For the environmental conditions, the following assumptions have been considered:

Average Temperature ¹	11.9° C
Relative humidity ²	64 %
Average air density ³	1.109 kg/m ³
Air pressure ³	90.7 kPa

Note 1 Based on the meteorological station of Roccamandolfi [3.2] and calculated using a lapse rate defined in [3.5] at an average hub height of 920 m above sea level.

Note 2 Based on the meteorological station of Campobasso [3.3].

Note 3 Based on [3.4].

Table 3.1 Environmental conditions at the site.

The sound power level of the wind turbine have been provided for a wind speed of 8.35 m/s at 10 m height [3.6]. These are reported in Table 2.2 and are equivalent to an absolute sound power level of 103.3 dB(A).

GH has considered the variation of the N90 2.3MW sound power level with the wind speed [3.6], in order to evaluate the noise pressure levels at the standard wind speed of 8 m/s.

The atmospheric attenuation coefficients have been calculated based on ISO standard for each frequency as shown in the table below:

Frequency [Hz]	31.5	63	125	250	500	1000	2000	4000	8000
α [dB/km]	0.04	0.15	0.48	1.11	1.98	4.03	11.57	40.55	141.96

Table 3.2 Atmospheric attenuation coefficient α for octave bands of noise.

No meteorological correction coefficient has been applied in the analysis.

4 RESULTS

Based on the assumptions detailed in Sections 2 and 3, the noise generated by the proposed S. Elena Sannita Wind Farm across the site area has been determined using the GH WindFarmer software package. Results have been calculated at 2 m height above ground level.

Figures 4.1 and 4.2 illustrate the noise propagation at the proposed wind farm based on the assumption above. The noise propagation shown in the figures does not include background noise.

A number of noise sensitive locations have been identified by the Client [4.1]. Table 4.1 indicates their coordinates. The noise levels at the noise sensitive locations have been calculated and are shown in Table 4.2. Also included are the overall noise levels considering the background noise values provided by the Client [4.1]. It should be noted that all the background noise measurements in [4.1] have been conducted during day time.

A brief overview on the noise requirements in Italy is given in Appendix A.

5 REFERENCES

- 1.1 Assessment of the Energy Production of the proposed S. Elena Sannita Wind Farm, GH ref. 12564/BR/01 issue A, 10 December 2007.
- 2.1 Email from Giulia Lo Bianco (B&B) to Davide Medici (GH) dated 20 June 2008.
- 3.1 ISO 9613-2:1996. Attenuation of sound during propagation outdoors. Part2: General method of calculation.
- 3.2 Profilo Climatico dell'Italia; S. Petrerca et al. ENEA, 1999.
- 3.3 ISTAT Statistiche meteorologiche. Years 1992-1996.
- 3.4 International Standard Atmosphere, ISO-2533, year 1975.
- 3.5 IEC 61400-11, Ed.1 1999. Wind turbine generator systems. Part 11: Acoustic measurement techniques.
- 3.6 Nordex N90/2300 – Noise level, Windtest document 6020 04 02823 06 dated 13 April 2005
- 4.1 “Relazione tecnica di valutazione d’impatto acustico”, by Armando Sarli, dated 20 December 2006.

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Turbine	WindFarmer ID	Eastings¹ [m]	Northings¹ [m]	Hub Height [m]
ELE1	1	454552	4601076	80
ELE2	2	454391	4601286	80
ELE4	3	454207	4601504	80
ELE5	4	454277	4601836	80
ELE6	5	454551	4602414	80
ELE7	6	454270	4602546	80
ELE9	7	454234	4602793	80
ELE12	8	454244	4603190	80
ELE13	9	454031	4603300	80
ELE15	10	453890	4603652	80
ELE17	11	454258	4603955	80
ELE19	12	454501	4604376	80
ELE21	13	454823	4604010	80
ELE23	14	454576	4603700	80
ELE25	15	454664	4603302	80
ELE26	16	454764	4602765	80
ELE27	17	454847	4602270	80
ELE29	18	457066	4603475	80
ELE30	19	457332	4603403	80
ELE31	20	457120	4603984	80
ELE32	21	457240	4604372	80
ELE33	22	457611	4604342	80

Note 1 Co-ordinate system is UTM zone 33T, European 1950 datum

Table 2.1 Turbine layout and hub height.

Frequency [Hz]	31.5	63	125	250	500	1000	2000	4000	8000
L_{WA} [dB]	76.4	86.2	94.4	97.1	96.6	95.3	96.0	90.6	77.7

Table 2.2 A-weighted octave band sound power level spectrum at 8.35 m/s for the N90 2.3 MW

Dwelling ID	Eastings ¹ [m]	Northings ¹ [m]	Distance from the nearest wind turbine [m]
1	456765	4603202	406
2	456952	4603478	114
3	456884	4603726	310
4	455144	4603212	488
5	453762	4600815	786
6	453950	4601246	364
7	453973	4601153	422
8	455380	4603858	577

Note 1 Co-ordinate system is UTM zone 33T, European 1950 datum

Table 4.1 Noise sensitive points and distance from nearest turbine

Dwelling ID	Noise from wind farm [dB(A)]	Background noise [dB(A)]	Overall noise [dB(A)]
1	42.2	40.5	44.4
2	52.4	42.5	52.8
3	46.8	43.5	48.4
4	42.7	44.5	46.7
5	37.7	50.0	50.2
6	44.4	46.5	48.6
7	43.6	44.5	47.1
8	40.0	53.5	53.7

Table 4.2 Overall noise levels at the noise sensitive points at 8 m/s

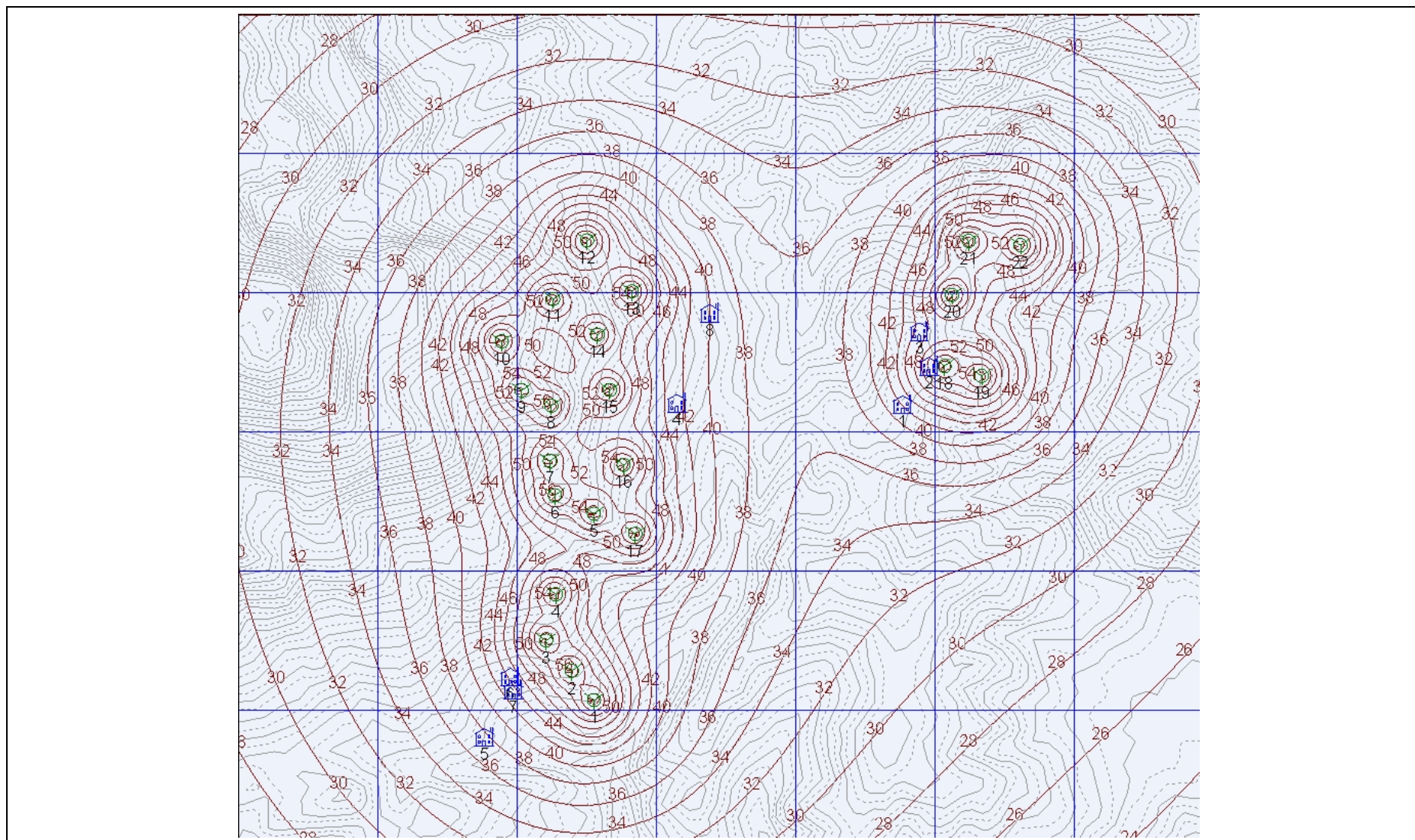


Figure 4.1 Predicted noise at the S. Elena Sannita Wind Farm (no background noise included), contour plot (Nordex N90 2.3 MW)

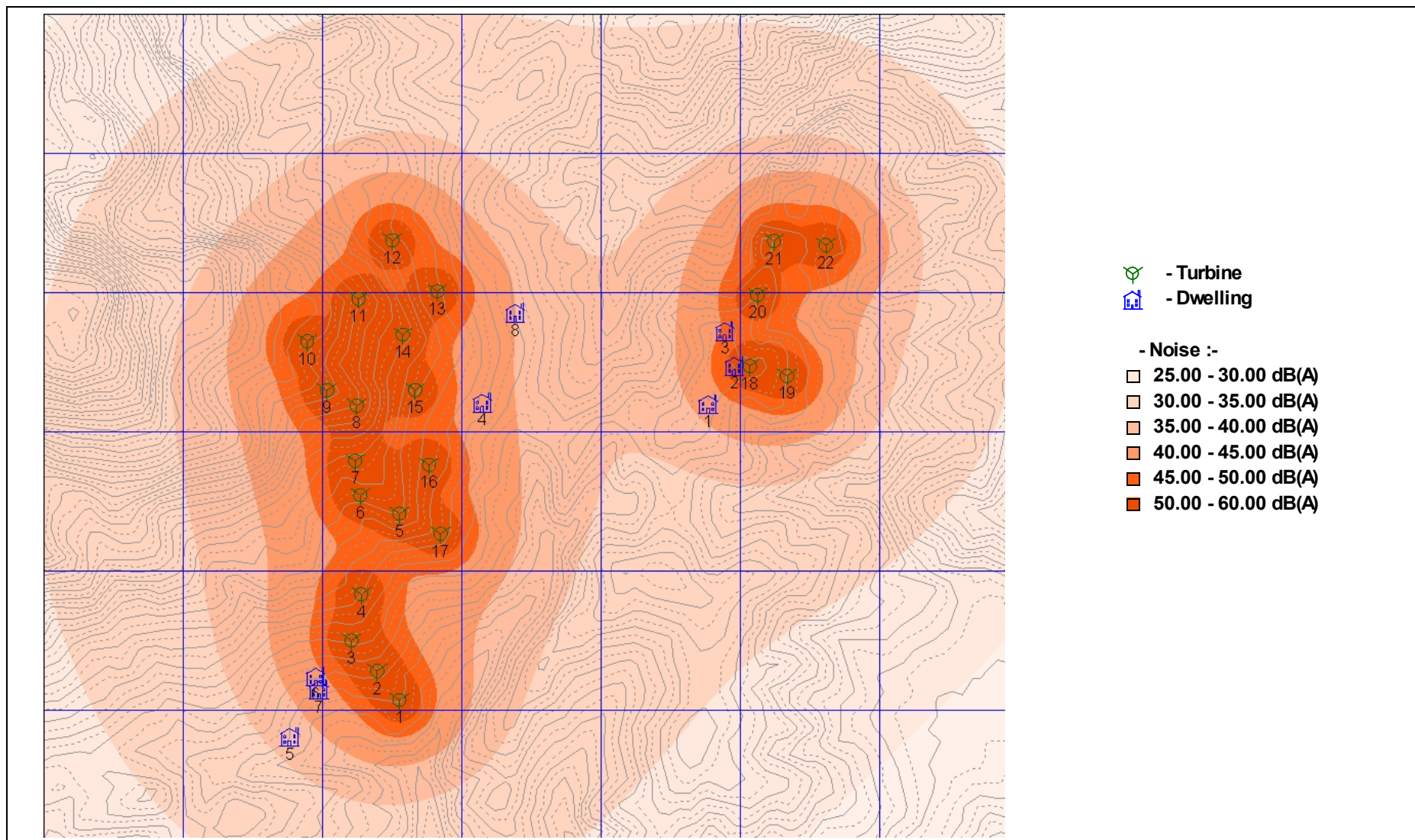


Figure 4.2 Predicted noise at the S. Elena Sannita Wind Farm (no background noise included), colour bands plot (Nordex N90 2.3 MW)

ANNEX A

Brief description of the legal requirements in terms of noise in Italy (3 pages).

Brief description of the legal requirements in terms of noise in Italy (3 pages).

GH is not a legal consultant and strongly suggests engaging a legal advisor to deal with all the legal requirements given by the Italian Law. The present section provides GH's interpretation of the Italian requirements in relation to noise. The analysis is based on a simplified model and a set of assumptions. In case a more detailed study is required and to carry out background noise measurements GH suggests engaging a noise consultant.

Noise evaluation is generally dealt within the environmental impact assessment (VIA). Results of the analysis are generally shown with noise contour maps and evaluation of noise at sensitive locations.

Latest Italian Law (DPCM 14/11/97) on noise requests that every Municipality divides their territory using the following land use classification:

Class	Description
I	Most protected areas
II	Mainly residential areas
III	Mixed areas
IV	High human activity areas
V	Mainly industrial areas
VI	Exclusively industrial areas

Table 1 Land classification according to DPCM 14-11-97.

DPCM 14/11/97 is the actualisation of the "Legge Quadro n.447" dated 26-10-95 which defines basic requirements giving general definitions and competences. In particular the following definitions are considered relevant:

- Emission limit: is the maximum noise emitted by a source measured in an area close to the source and in a space used for human activity.
- Immission limit: is the maximum noise from one or more noise sources measured close to a sensitive location. Immission limits are divided in absolute limit and differential limit (difference between environmental equivalent noise level and background noise).
- Emission and immission limits depend on the source type and on the time of the day (night and day time).

Law DPCM 14/11/97 defines the technical requirements in term of accepted noise level: values in Table 2 are measured outside the noise sensitive points (dwellings). These values are due to the sum of every single noise source and include background noise.

Class	Description	Daytime	Nocturnal
I	Most protected areas	50	40
II	Mainly residential areas	55	45
III	Mixed areas	60	50
IV	High human activity areas	65	55
V	Mainly industrial areas	70	60
VI	Exclusively industrial areas	70	70

Table 2 Maximum Absolute immission sound pressure limits [L_{eq} in dB(A)].

Values in Table 3 are calculated close to the source and in a space used for human activity.

Class	Description	Diurnal	Nocturnal
I	Most protected areas	45	35
II	Mainly residential areas	50	40
III	Mixed areas	55	45
IV	High human activity areas	60	50
V	Mainly industrial areas	65	55
VI	Exclusively industrial areas	65	65

Table 3 Maximum emission sound pressure limit [L_{eq} in dB(A)].

Value in Table 4 are calculated inside the sensible locations (dwellings). In this case there are two tests: with open and with close windows. Differential noise limits are applicable if noise with open window is higher than 50 dB(A) during day time and 40 dB(A) in night time and if noise with closed windows is higher than 35 dB(A) during day time and 25 dB(A) in night time.

Day time (Diurnal) stands for time between 6am and 10pm, night time (Nocturnal) for the remaining time.

Class	Description	Diurnal	Nocturnal
I	Most protected areas	5	3
II	Mainly residential areas	5	3
III	Mixed areas	5	3
IV	High human activity areas	5	3
V	Mainly industrial areas	5	3
VI	Exclusively industrial areas	N/A	N/A

Table 4 Maximum Differential noise limits [L_{eq} in dB(A)].

It is noted that classification according to the land use is still progressing and is covered only by a limited percentage of the Italian territory. In particular, GH is not aware if the S. Elena Sannita Municipality has already applied the land classification. For territories which are not yet classified the limits above are still undemanding and are specified within Law DPCM 01-03-91 which divides the Italian territory as described in the tables below:

Zone	Diurnal limit [L_{eq} (A)]	Diurnal limit [L_{eq} (A)]
The whole national territory	70	60
Zone A (protected areas)	65	55
Zone B (residential areas)	60	50
Industrial areas	70	70

Table 5. Maximum noise limits [L_{eq} in dB(A)].

Zone	Diurnal limit [L_{eq} (A)]	Diurnal limit [L_{eq} (A)]
The whole national territory	5	3
Zone A (protected areas)	5	3
Zone B (residential areas)	5	3
Industrial areas	N/A	N/A

Table 6. Maximum differential noise [L_{eq} in dB(A)].

Table 5 and Table 6 are the equivalent of Table 2 and Table 4. Differential method within Law DPCM 01-03-91 is applicable if noise with open window is higher than 60 dB(A) during day time and 45 dB(A) in night time and if noise with closed windows is higher than 40 dB(A)

during day time and 30 dB(A) in night time. Law DPCM 01-03-91 gives also details on the instrument and methodology for the noise measurement.

Details about how to carry out a noise measurement are described in Law DM 16-03-98. This law requires that the noise measurements are done with a wind speed less than 5 m/s (Apparently, this law was written without considering the application to wind farms).

No law gives details on the noise model to be used to forecast the noise level. All the noise limit in DPCM 01-03-91 and DPCM 14/11/97 are fixed and do not vary with the wind speed. Some specific requirements on this matter may be present in the regional guidelines.