

APPENDIX B SAMPLE CALCULATION FOR NOISE MODELING

Resulting A-weighted sound pressure level at Receptors PoR 62 and VLR 210

The calculation of cumulative receptor noise levels from wind turbines uses the methodology of ISO 9613-2, “*Acoustics — Attenuation of sound during propagation outdoors: Part 2: General method of calculation*”. These calculations are conducted with CadnaA (*which is an implementation of ISO 9613-1 and ISO 9613-2*).

As an example, in this appendix, the results are presented at PoR 62 and VLR 210. The following conditions were used:

- Turbine locations (Appendix F);
- Receptor locations (Appendix C).

Turbine characteristics and modelling parameters:

- Hub-heights: 80 m (GE 1.6 100);
- Ambient air temperature: 10°C;
- Ambient barometric pressure: 101.32 kPa;
- Relative humidity: 70%;
- Wind speed (10 m agl): 6 m/s;
- Source ground factor: 0.7 (soft ground);
- Middle ground factor: 0.7; and
- Receptor ground factor: 0.7
- See Table 5-1 for broadband and octave band sound power level;

The following table presents an example result and intermediate values of the calculations as the A-weighted sound pressure levels at two chosen example receptors, due to each turbine or substation and each octave band. The net result, the A-weighted sound pressure level at the example receptors PoR 62 and VLR 210 for all bands and all noise sources within 5000 m of the example receptor, is 39.67 and 39.99 dB(A) respectively.

Sample Calculations

Sound Pressure Levels at PoR 62

Turbine ID	Distance* [m]	Octave Band Sound Pressure Levels [dB(A)]								Total A-Weighted Sound Pressure Level by Turbine and for all Octave Bands [dB(A)]
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
17	876	22.6	22.4	24.4	25.9	25.1	16.9	-10.4	N/A	31.5
3	884	22.6	22.3	24.3	25.8	24.9	16.7	-10.8	N/A	31.4
Subs.	950	16.0	18.6	22.4	30.4	26.2	16.6	-10.5	N/A	32.7
5	1426	18.3	17.9	19.6	20.6	18.8	7.3	-32.7	N/A	26.3
4	1459	18.1	17.6	19.3	20.3	18.5	6.8	-34.0	N/A	26.0
18	1532	17.7	17.2	18.8	19.7	17.8	5.7	-36.8	N/A	25.5
2	1561	17.5	17.0	18.6	19.5	17.5	5.3	-37.9	N/A	25.3
16	1598	17.3	16.8	18.4	19.2	17.2	4.7	-39.3	N/A	25.0
15	1758	16.5	15.9	17.4	18.1	15.8	2.3	-45.4	N/A	23.9
6	1789	16.3	15.7	17.2	17.9	15.5	1.9	-46.6	N/A	23.7
19	1933	15.6	15.0	16.4	16.9	14.3	-0.2	-52.0	N/A	22.9
7	2127	14.8	14.1	15.4	15.7	12.8	-2.9	-59.1	N/A	21.8
1	2132	14.8	14.1	15.3	15.7	12.7	-3.0	-59.3	N/A	21.7
14	2232	14.4	13.6	14.8	15.1	12.0	-4.3	-63.0	N/A	21.2
20	2299	14.1	13.3	14.5	14.7	11.5	-5.3	-65.5	N/A	20.9
33	2492	13.4	12.6	13.6	13.7	10.1	-7.8	-72.5	N/A	19.9
21	2570	13.1	12.3	13.3	13.3	9.5	-8.8	-75.3	N/A	19.6
8	2627	13.0	12.1	13.0	13.0	9.1	-9.6	-77.4	N/A	19.4
13	2637	13.0	12.0	13.0	12.9	9.1	-9.7	-77.7	N/A	19.3
36	2643	13.0	12.0	13.0	12.9	9.0	-9.8	-77.9	N/A	19.3
32	2705	12.8	11.8	12.7	12.6	8.6	-10.5	-80.1	N/A	19.1
35	2729	12.8	11.7	12.6	12.5	8.5	-10.8	-81.0	N/A	19.0
37	2748	12.7	11.7	12.5	12.4	8.3	-11.1	-81.7	N/A	18.9
31	2871	12.4	11.3	12.1	11.8	7.5	-12.6	-86.0	N/A	18.5
22	2887	12.4	11.2	12.0	11.7	7.4	-12.8	-86.6	N/A	18.4
48	2887	12.4	11.2	12.0	11.7	7.4	-12.8	-86.6	N/A	18.4
38	2942	12.3	11.1	11.8	11.5	7.1	-13.5	N/A	N/A	18.2
34	3003	12.1	10.9	11.6	11.2	6.7	-14.2	N/A	N/A	18.0
30	3171	11.8	10.4	11.0	10.4	5.7	-16.3	N/A	N/A	17.4
39	3205	11.7	10.3	10.9	10.3	5.4	-16.7	N/A	N/A	17.3
12	3231	11.7	10.2	10.8	10.2	5.3	-17.0	N/A	N/A	17.2
42	3288	11.5	10.0	10.6	9.9	4.9	-17.7	N/A	N/A	17.0
40	3327	11.5	9.9	10.4	9.8	4.7	-18.2	N/A	N/A	16.9
9	3331	11.5	9.9	10.4	9.7	4.7	-18.2	N/A	N/A	16.9
29	3558	11.0	9.3	9.7	8.8	3.3	-20.9	N/A	N/A	16.2
41	3649	10.8	9.0	9.3	8.4	2.8	-22.0	N/A	N/A	15.9
43	3718	10.7	8.9	9.1	8.1	2.4	-22.8	N/A	N/A	15.7
28	3762	10.6	8.8	9.0	7.9	2.1	-23.4	N/A	N/A	15.6
47	4138	9.9	7.8	7.8	6.4	0.0	-27.8	N/A	N/A	14.6
46	4247	9.7	7.6	7.5	6.0	-0.6	-29.0	N/A	N/A	14.3
10	4582	9.2	6.8	6.5	4.7	-2.5	-32.9	N/A	N/A	13.4
23	4793	8.8	6.4	5.9	4.0	-3.6	-35.3	N/A	N/A	13.0
Total A-Weighted Sound Pressure Level										39.67

* Includes the heights of noise sources and receptors.

N/A indicates values below -88.0 dBA

Sound Pressure Levels at VLR 210

Turbine ID	Distance* [m]	Octave Band Sound Pressure Levels [dB(A)]								Total A-Weighted Sound Pressure Level by Turbine and for all Octave Bands [dB(A)]
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
Subs.	649	19.0	22.5	25.9	34.2	30.5	22.8	2.6	-61.2	36.6
3	693	24.7	24.6	26.6	28.2	27.8	20.7	-2.4	-79.2	33.9
4	1359	18.8	18.3	20.0	21.1	19.5	8.4	-30.1	N/A	26.8
2	1405	18.5	18.0	19.7	20.7	19.0	7.7	-31.9	N/A	26.4
1	1584	17.4	16.9	18.5	19.3	17.3	4.9	-38.8	N/A	25.1
5	1742	16.6	16.0	17.5	18.2	15.9	2.5	-44.8	N/A	24.0
17	2154	14.7	14.0	15.2	15.6	12.6	-3.3	-60.1	N/A	21.6
6	2189	14.5	13.8	15.0	15.4	12.3	-3.8	-61.4	N/A	21.4
7	2607	13.0	12.1	13.1	13.1	9.3	-9.3	-76.6	N/A	19.5
15	2636	13.0	12.1	13.0	12.9	9.1	-9.7	-77.7	N/A	19.3
16	2665	12.9	12.0	12.9	12.8	8.9	-10.0	-78.7	N/A	19.2
18	2967	12.2	11.0	11.7	11.4	6.9	-13.8	N/A	N/A	18.1
8	3017	12.1	10.8	11.5	11.1	6.6	-14.4	N/A	N/A	17.9
14	3024	12.1	10.8	11.5	11.1	6.6	-14.5	N/A	N/A	17.9
19	3233	11.7	10.2	10.8	10.2	5.3	-17.0	N/A	N/A	17.2
13	3353	11.4	9.9	10.3	9.6	4.5	-18.5	N/A	N/A	16.8
48	3481	11.2	9.5	9.9	9.1	3.8	-20.0	N/A	N/A	16.4
20	3492	11.1	9.5	9.9	9.1	3.7	-20.2	N/A	N/A	16.4
9	3556	11.0	9.3	9.7	8.8	3.3	-20.9	N/A	N/A	16.2
21	3593	10.9	9.2	9.5	8.6	3.1	-21.4	N/A	N/A	16.1
12	3723	10.7	8.9	9.1	8.1	2.3	-22.9	N/A	N/A	15.7
33	3893	10.4	8.4	8.6	7.4	1.4	-24.9	N/A	N/A	15.2
22	3948	10.3	8.3	8.4	7.2	1.1	-25.6	N/A	N/A	15.1
32	4035	10.1	8.1	8.1	6.8	0.6	-26.6	N/A	N/A	14.8
31	4123	9.9	7.9	7.9	6.5	0.1	-27.6	N/A	N/A	14.6
36	4167	9.9	7.8	7.7	6.3	-0.2	-28.1	N/A	N/A	14.5
35	4221	9.8	7.6	7.6	6.1	-0.5	-28.7	N/A	N/A	14.3
37	4238	9.7	7.6	7.5	6.0	-0.6	-28.9	N/A	N/A	14.3
30	4313	9.6	7.4	7.3	5.8	-1.0	-29.8	N/A	N/A	14.1
34	4389	9.5	7.2	7.1	5.5	-1.4	-30.7	N/A	N/A	13.9
38	4400	9.5	7.2	7.0	5.4	-1.5	-30.8	N/A	N/A	13.9
29	4556	9.2	6.9	6.6	4.8	-2.3	-32.6	N/A	N/A	13.5
42	4622	9.1	6.7	6.4	4.6	-2.7	-33.4	N/A	N/A	13.3
28	4668	9.0	6.6	6.3	4.4	-2.9	-33.9	N/A	N/A	13.2
39	4722	8.9	6.5	6.1	4.2	-3.2	-34.5	N/A	N/A	13.1
40	4764	8.9	6.4	6.0	4.1	-3.5	-35.0	N/A	N/A	13.0
10	4914	8.6	6.1	5.6	3.5	-4.3	-36.7	N/A	N/A	12.7
Total A-Weighted Sound Pressure Level										39.99

* Includes the heights of noise sources and receptors.

N/A indicates values below -88.0 dBA

APPENDIX C COORDINATES OF POINTS OF RECEPTION

Coordinates of all modeled Points of Reception and Vacant Lot Receptors for the Bornish Wind Energy Centre (UTM17-NAD83 projection) are given in the tables below:

Point of Reception ID	Easting [m]	Northing [m]
PoR1	440492	4771514
PoR3	440033	4771602
PoR4	439966	4771712
PoR5	439532	4771702
PoR6	439562	4771796
PoR7	439422	4771758
PoR8	439363	4771853
PoR9	439361	4771770
PoR10	439307	4771775
PoR11	439071	4771955
PoR12	438788	4771895
PoR13	438402	4771331
PoR14	436943	4772310
PoR15	437210	4772352
PoR16	437540	4772183
PoR17	438244	4771973
PoR19	440754	4771654
PoR20	440685	4771333
PoR21	441164	4771421
PoR22	441310	4771389
PoR23	441490	4771253
PoR25	442335	4771021
PoR26	442469	4770950
PoR29	445950	4770504
PoR30	446671	4770136
PoR31	449038	4771469
PoR32	448751	4771458
PoR33	448414	4771614
PoR34	448177	4771580
PoR35	447805	4771673

Point of Reception ID	Easting [m]	Northing [m]
PoR36	447683	4771839
PoR37	447456	4771732
PoR38	447320	4771865
PoR39	447191	4771732
PoR41	446141	4772012
PoR42	444909	4772422
PoR43	444801	4772492
PoR44	444787	4772434
PoR45	444930	4772401
PoR46	444943	4772456
PoR47	444657	4772426
PoR51	441208	4773238
PoR54	436989	4774194
PoR55	437435	4775794
PoR56	437496	4775876
PoR57	437989	4775657
PoR58	438086	4775744
PoR59	438543	4775543
PoR62	441521	4774943
PoR63	442089	4774807
PoR65	444543	4774133
PoR66	444496	4774220
PoR67	444493	4773978
PoR68	445664	4773957
PoR69	446511	4773750
PoR70	446563	4773650
PoR73	448024	4773393
PoR74	448171	4773387
PoR76	448583	4773286
PoR77	448799	4773131

Point of Reception ID	Easting [m]	Northing [m]
PoR78	449553	4772906
PoR79	448486	4774894
PoR80	447960	4775018
PoR81	447316	4775164
PoR82	447105	4775353
PoR83	446795	4775234
PoR84	446545	4775477
PoR85	444009	4776036
PoR87	443235	4776297
PoR88	443429	4776574
PoR89	443349	4776596
PoR90	443471	4776774
PoR91	443526	4777025
PoR92	442955	4776289
PoR93	442456	4776303
PoR94	442311	4776526
PoR96	442012	4776698
PoR97	441091	4776727
PoR98	440782	4776706
PoR99	440666	4776840
PoR100	440538	4776746
PoR102	439421	4777027
PoR103	439351	4777038
PoR104	439165	4777198
PoR105	445721	4776028
PoR106	445829	4775845
PoR107	445553	4775384
PoR109	445333	4773628
PoR110	445068	4773388
PoR111	445193	4773159

Point of Reception ID	Easting [m]	Northing [m]
PoR112	444977	4773035
PoR113	444945	4773179
PoR116	444591	4771289
PoR117	444425	4770964
PoR118	444358	4770042
PoR119	444440	4770060
PoR120	446141	4769567
PoR121	446627	4770918
PoR122	436488	4772701
PoR123	447915	4775316
PoR126	440597	4771573
PoR127	439189	4771452
PoR128	443682	4775839
VLR129	445707	4775908
VLR130	441644	4776609
VLR131	446870	4775258
VLR132	444973	4772414
VLR133	444301	4770688
VLR134	443825	4776098
VLR135	446985	4775358
VLR136	448883	4771535
VLR137	446419	4774981
VLR138	446861	4771880
VLR139	447819	4771781
VLR140	436921	4774350
VLR141	448973	4771391
VLR142	447628	4775207
VLR143	445899	4770213
VLR144	449099	4771934
VLR145	442400	4776432

Point of Reception ID	Easting [m]	Northing [m]
VLR146	438947	4777122
VLR147	444669	4771475
VLR148	444713	4775890
VLR149	440306	4776925
VLR150	441388	4776671
VLR151	445634	4775674
VLR152	439639	4777082
VLR153	439918	4777743
VLR155	444315	4775983
VLR156	446787	4775404
VLR157	447218	4775303
VLR158	445481	4774483
VLR159	445406	4770328
VLR160	442694	4776362
VLR161	445724	4775530
VLR162	441551	4776633
VLR163	449588	4773068
VLR165	445603	4770282
VLR166	439756	4777055
VLR167	447378	4773582
VLR168	447032	4775224
VLR169	447693	4773507
VLR170	444715	4771743
VLR171	444748	4771867
VLR172	444779	4771980
VLR173	444804	4772098
VLR174	444656	4772531
VLR175	444768	4772504
VLR176	444442	4772583
VLR177	444939	4772702

Point of Reception ID	Easting [m]	Northing [m]
VLR178	445238	4773361
VLR179	444333	4770006
VLR180	440411	4771504
VLR181	440184	4771680
VLR182	439812	4771640
VLR183	439475	4771843
VLR184	438235	4772135
VLR185	438038	4772180
VLR186	437917	4772078
VLR187	436765	4772484
VLR188	441026	4771358
VLR189	441222	4771305
VLR190	441529	4771371
VLR191	441933	4771140
VLR192	442736	4770948
VLR193	443123	4770852
VLR194	444427	4770541
VLR195	444576	4770502
VLR196	444355	4770237
VLR197	443508	4770760
VLR198	446461	4770211
VLR199	447010	4771962
VLR200	445388	4774038
VLR201	443728	4775979
VLR202	438611	4775632
VLR203	439058	4775529
VLR204	437038	4774317
VLR205	437347	4774247
VLR206	437584	4774189
VLR207	437648	4774047

Point of Reception ID	Easting [m]	Northing [m]
VLR208	437312	4774120
VLR209	442232	4774787
VLR210	441581	4776492
VLR211	441048	4773237
VLR212	436544	4772431
VLR213	443867	4776602
VLR214	448138	4775084
VLR221	441536	4773146
VLR223	446561	4770059
VLR226	440877	4773298
VLR227	439253	4775378
VLR230	441039	4776637
VLR232	441336	4773207
VLR241	441021	4773387
VLR244	443596	4775913
VLR248	445827	4772140
VLR254	437557	4772297
VLR255	442369	4771150
VLR257	446826	4771275
VLR258	445323	4773814
VLR268	445236	4774083
PoR269	448795	4773832

APPENDIX D COORDINATES OF PARTICIPANTS

Coordinates of all modeled participants for the Bornish Wind Energy Centre (UTM17-NAD83 projection) are given in the table below:

Participant ID	Easting [m]	Northing [m]
PR2	440418	4771606
PR18	438688	4772081
PR24	441977	4771297
PR27	442804	4771133
PR28	445577	4770404
PR40	446689	4772025
PR48	443326	4772729
PR49	443253	4772892
PR50	442080	4773157
PR52	440110	4773577
PR53	439608	4773718
PR60	439974	4775313
PR61	440556	4775164
PR64	444080	4774330
PR71	447074	4773519
PR72	447611	4773383
PR75	448300	4773234
PR86	443148	4776144
PR95	441938	4776421
PR101	439911	4776901
PR108	445556	4774768
PR114	444972	4771983
PR115	444918	4771559
PR124	441090	4774106
PR125	443131	4773964
PV154	445618	4775074
PV164	447601	4775090
PV215	438901	4773767
PV216	440056	4775182
PV217	438919	4773859
PV218	446189	4772137
PV219	439002	4773842
PV220	440306	4773432
PV222	438344	4774001

Participant ID	Easting [m]	Northing [m]
PV224	444868	4771858
PV225	439692	4773576
PV228	442894	4772911
PV229	445477	4774997
PV231	446325	4772012
PV233	441358	4774889
PV234	437868	4774111
PV235	438986	4773748
PV236	443143	4770986
PV237	443492	4772771
PV238	442457	4772940
PV239	439363	4775352
PV240	447264	4773592
PV242	442893	4772828
PV243	442173	4772996
PV245	445387	4774609
PV246	443538	4770892
PV247	445002	4772467
PV249	444968	4772337
PV250	444986	4772908
PV251	445127	4772880
PV252	439661	4771799
PV253	437841	4772230
PV256	444821	4771249
PV259	444209	4774204
PV260	443234	4773956
PV261	443260	4774529
PV262	443372	4774501
PV263	442565	4774695
PV264	442122	4774705
PV265	441884	4774756
PV266	440467	4775090
PV267	441471	4776535

APPENDIX E TURBINE TECHNICAL SPECIFICATIONS

Noise Specifications of the GE 1.6 - 100

GE Energy

- Original Instructions -

Product Acoustic Specifications

2 Normal Operation Calculated Apparent Sound Power Level

The apparent sound power levels $L_{WA,k}$ are initially calculated as a function of the hub height wind speed v_{HH} . The corresponding wind speeds v_{10m} at 10 m height above ground level have been evaluated assuming a logarithmic wind profile. In this case a surface roughness of $z_{0ref} = 0.05$ m has been used, which is representative of average terrain conditions.

$$v_{10m} = v_{HH} \frac{\ln\left(\frac{10m}{z_{0ref}}\right)}{\ln\left(\frac{\text{hub height}}{z_{0ref}}\right)}$$

The calculated apparent sound power levels $L_{WA,k}$ and the associated octave-band spectra are given in Table 1 and Table 2 for two different hub heights. The values are provided as mean levels as a function of v_{10m} for Normal Operation (NO) over cut-in to cut-out wind speed range. The uncertainties for octave sound power levels are generally higher than for total sound power levels. Guidance is given in IEC 61400-11, Annex D.

1.6-100 with LNTE – A-weighted Octave Spectra (dB)									
Standardized WS at 10 m (m/s)	5	5.5	6	6.5	7	8	9	10-Cutout	
Hub height WS at 80 m (m/s)	7.0	7.7	8.4	9.1	9.7	11.1	12.5	14-Cutout	
Frequency (Hz)	32	72.1	74.2	76.0	77.8	79.6	80.1	80.2	80.1
	63	81.4	83.5	85.5	87.4	89.2	89.6	89.7	89.6
	125	86.5	88.8	90.8	92.3	93.9	94.4	94.4	94.3
	250	89.7	92.1	94.4	94.7	95.0	95.1	95.2	95.2
	500	89.7	92.4	95.0	95.7	96.3	96.1	96.1	96.5
	1000	86.9	89.1	91.3	93.9	96.4	96.9	97.0	97.2
	2000	87.9	90.1	91.9	93.4	95.0	95.2	94.9	94.3
	4000	83.5	86.1	88.4	88.6	89.0	88.6	87.9	87.2
	8000	63.5	66.7	69.8	69.3	69.7	70.0	68.8	68.7
16000	18.9	21.5	24.2	25.3	26.5	26.1	26.9	28.8	
Total Sound Power Level (dB)	95.8	98.2	100.5	101.6	102.8	103.0	103.0	103.0	

Table 1: Normal Operation Calculated Apparent Sound Power Level, 1.6-100 with LNTE with 80 m hub height as a function of 10 m wind speed ($z_{0ref} = 0.05$ m), the octave band spectra are for information only

* Simplified from IEC 61400-11, ed. 2.1: 2006 equation 7

APPENDIX F COORDINATES OF TURBINES

Coordinates of turbines considered in the Bornish Wind Energy Centre are listed below in UTM17-NAD83 projection, though only 45 turbines will be constructed:

Turbine ID	Easting [m]	Northing [m]
1	440000	4776435
2	440302	4775915
3	441679	4775810
4	442726	4775763
5	442888	4775342
6	443298	4775136
7	443646	4774902
8	444147	4774906
9	444848	4775090
10	446083	4774524
11	447155	4774304
12	438297	4774740
13	438935	4774435
14	439343	4774461
15	439811	4774541
16	440057	4774307
17	440771	4774498
18	442262	4773605
19	442807	4773502
20	443243	4773422
21	443709	4773598
22	443882	4773285
23	445877	4772947
24	446958	4772850
25	447480	4772818
26	447771	4772644
27	448192	4772544
28	438099	4773385
29	438407	4773226
30	438971	4773061
31	439437	4772972
32	439760	4772893
33	440119	4772886
34	439808	4772479
35	440509	4772411
36	442023	4772350
37	442348	4772325
38	442633	4772221
39	442186	4771810
40	442888	4771912
41	443189	4771699
42	443389	4772239
43	443706	4771937
44	445507	4770915
45	446168	4771350
46	437898	4772729
47	443792	4771485
48	438655	4774608
Substation	441363	4775880