Large Filing Separator Sheet

CASE NUMBER: 08-666-EL-BGN

FILE DATE: November 24, 2009

SECTION: pt. 1 of 2

NUMBER OF PAGES: 198

DESCRIPTION OF DOCUMENT:
Exhibits

FILE

PUCO EXHIBIT FILING

Date of Hearing: 11/10/09

Case No. 08-666-EL-BGN

PUCO Case Caption: Buckeye Wind, LLC

Volume II

List of exhibits being filed:

Buckeye Exs. 4A.

Union Neighbors United Exs. 12-16-17-34-35-36-37-38-39-40-41-42-43-44-46-47-48-49-50 and 51.

Urbana Country Club Exs. L-M-N-O-P-Q-R-S-T-U

Reporter's Signature: Julieanna Kennedy

Date Submitted: 11/24/09

BEFORE THE OHIO POWER SITING BOARD

- - -

In the Matter of the Application of Buckeye Wind, LLC for a Certificate to Install Numerous Electricity Generating Wind Turbines in Champaign County to be Collected at an Electric Substation in Union Township, Champaign County.	:	Case No. 08-666-EL-BGN

- - -

PROCEEDINGS

before Ms. Greta See and Ms. Katie Stenman, Administrative Law Judges, at the Public Utilities Commission of Ohio, 180 East Broad Street, Room 11-A, Columbus, Ohio, called at 9:00 a.m. on Tuesday, November 10, 2009.

- - -

VOLUME II

- - -

ARMSTRONG & OKEY, INC.
222 East Town Street
Columbus, Ohio 43215-5201
(614) 224-9481 - (800) 223-9481
Fax - (614) 224-5724

- - -

BUCKEYE EX. 4A

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

Printed/Page
10/30/2009 5:00 PM / 1

Licensed user:
EAPC Architects Engineers
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Main Result

Calculation: *Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030*

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

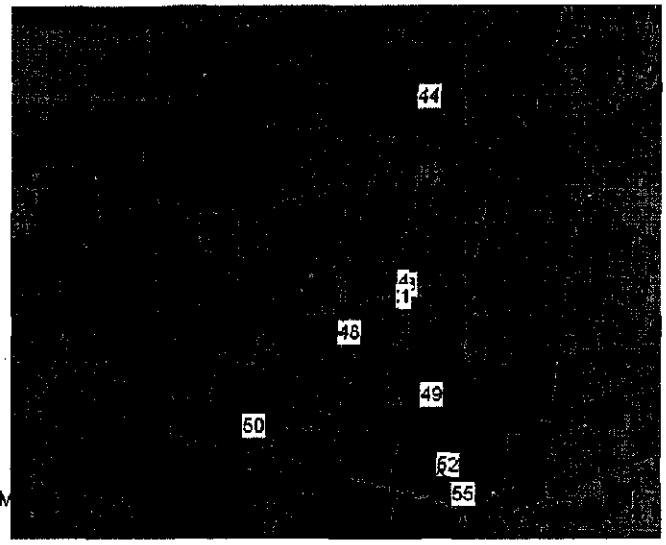
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational hours are calculated from WTGs in calculation and wind distribution:
EverPower Weibull

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	565	509	493	476	694	1,088	968	1,008	823	686	8,052

To avoid flicker from WTGs not visible a ZVI calculation is performed before the flicker calculation. The ZVI calculation is based on the following assumptions
Height contours used: Height Contours: optimized 2008.08.11 10 ft HCL UTM
Obstacles not used in calculation
Eye height: 1.5 m
Grid resolution: 10 m



Scale 1:75,000
New WTG Shadow receptor

WTGs

	UTM WGS84 Zone: 17 East	North	Z	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	RPM
	UTM WGS84 Zone: 17		[m]					[kW]	[m]	[m]	[RPM]
44	273,956.00	4,444,420.00	383.3	NORDEX N100 2500 100.0 !O! h..Yes		NORDEX	N100-2,500	2,500	100.0	100.0	15.0
48	273,125.00	4,442,024.00	376.8	NORDEX N100 2500 100.0 !O! h..Yes		NORDEX	N100-2,500	2,500	100.0	100.0	15.0
49	273,998.00	4,441,382.00	360.9	NORDEX N100 2500 100.0 !O! h..Yes		NORDEX	N100-2,500	2,500	100.0	100.0	15.0
50	272,129.00	4,441,065.00	345.1	NORDEX N100 2500 100.0 !O! h..Yes		NORDEX	N100-2,500	2,500	100.0	100.0	15.0
52	274,167.00	4,440,661.00	356.6	NORDEX N100 2500 100.0 !O! h..Yes		NORDEX	N100-2,500	2,500	100.0	100.0	15.0
55	274,318.00	4,440,370.00	355.7	NORDEX N100 2500 100.0 !O! h..Yes		NORDEX	N100-2,500	2,500	100.0	100.0	15.0

Shadow receptor-Input

No.	Name	UTM WGS84 Zone: 17 East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
1	Golf Course Receptor 1	273,726.68	4,442,261.17	373.9	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
2	Golf Course Receptor 2	273,689.32	4,442,269.89	375.2	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
3	Golf Course Receptor 3	273,782.72	4,442,385.72	374.9	1.0	1.0	1.0	-180.0	90.0	"Green house mode"
4	Golf Course Receptor 4	273,712.36	4,442,411.25	378.0	1.0	1.0	1.0	-180.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow, expected values Shadow hours per year [h/year]
1	Golf Course Receptor 1	23:45	50	0:36	7:26
2	Golf Course Receptor 2	27:22	55	0:38	8:19
3	Golf Course Receptor 3	23:56	58	0:32	6:11
4	Golf Course Receptor 4	42:07	88	0:35	10:16

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
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Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Main Result

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case [h/year]
44	NORDEX N100 2500 100.0 !O! hub: 100.0 m (213)	0:00
48	NORDEX N100 2500 100.0 !O! hub: 100.0 m (217)	84:12
49	NORDEX N100 2500 100.0 !O! hub: 100.0 m (218)	0:00
50	NORDEX N100 2500 100.0 !O! hub: 100.0 m (219)	0:00
52	NORDEX N100 2500 100.0 !O! hub: 100.0 m (221)	0:00
55	NORDEX N100 2500 100.0 !O! hub: 100.0 m (224)	0:00

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Buckeye - Shadow Flicker

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Description:

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Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **Shadow receptor:** 1 - Golf Course Receptor

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	565	509	493	476	694	1,088	968	1,008	823	686	8,052

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:57 - 17:20	07:45 - 17:53	07:10 - 17:10 (48)	07:20 - 17:28 (48)	06:36 - 17:13 (48)	06:08 - 17:19	06:09 - 17:26	06:33 - 17:08	07:02 - 17:27	07:31 - 16:49	07:04 - 16:35 (48)	07:37 - 17:10
2	07:58 - 17:21	07:44 - 17:55	07:08 - 16:27	07:19 - 17:24 (48)	06:36 - 20:00	06:08 - 20:29	06:10 - 20:58	06:33 - 21:08	07:03 - 20:50	07:32 - 20:08	07:05 - 16:37 (48)	07:38 - 17:10
3	07:58 - 17:22	07:43 - 17:56	07:07 - 18:28	07:17 - 20:00	06:33 - 20:30	06:08 - 20:58	06:10 - 21:08	06:34 - 20:49	07:04 - 20:06	07:33 - 19:15	07:06 - 16:39 (48)	07:39 - 17:10
4	07:58 - 17:22	07:42 - 17:57	07:05 - 18:30	07:15 - 20:01	06:32 - 20:31	06:07 - 20:59	06:11 - 21:08	06:35 - 20:48	07:05 - 20:05	07:34 - 19:14	07:07 - 16:41 (48)	07:40 - 17:10
5	07:58 - 17:23	07:41 - 17:58	07:04 - 18:31	07:14 - 20:02	06:31 - 20:32	06:07 - 21:00	06:11 - 21:08	06:36 - 20:47	07:06 - 20:03	07:35 - 19:12	07:08 - 16:44 (48)	07:41 - 17:10
6	07:58 - 17:24	07:40 - 17:59	17:13 (48) - 17:25 (48) 12	07:02 - 18:32	07:12 - 20:03	06:30 - 20:33	06:07 - 21:00	06:12 - 21:08	06:37 - 20:45	07:07 - 20:01	07:29 - 16:47 (48)	07:42 - 17:10
7	07:58 - 17:25	07:39 - 18:01	17:11 (48) - 17:28 (48) 17	07:01 - 18:33	07:11 - 20:04	06:29 - 20:34	06:06 - 21:01	06:13 - 21:07	06:38 - 20:44	07:08 - 20:00	07:28 - 16:50 (48)	07:43 - 17:09
8	07:57 - 17:26	07:37 - 18:02	17:09 (48) - 17:30 (48) 21	07:59 - 18:34	07:09 - 20:05	06:28 - 20:35	06:06 - 21:02	06:13 - 21:07	06:39 - 20:43	07:09 - 19:57	07:12 - 17:26	07:44 - 17:09
9	07:57 - 17:27	07:36 - 18:03	17:07 (48) - 17:32 (48) 25	07:57 - 18:35	07:08 - 20:06	06:26 - 20:36	06:06 - 21:02	06:14 - 21:07	06:40 - 20:42	07:10 - 19:55	07:13 - 17:25	07:45 - 17:09
10	07:57 - 17:28	07:35 - 18:04	17:06 (48) - 17:33 (48) 27	07:56 - 18:36	07:06 - 20:07	06:25 - 20:37	06:06 - 21:03	06:14 - 21:06	06:41 - 20:41	07:11 - 19:53	07:14 - 17:24	07:46 - 17:09
11	07:57 - 17:29	07:34 - 18:05	17:05 (48) - 17:35 (48) 30	07:54 - 18:37	07:04 - 20:08	06:24 - 20:38	06:06 - 21:03	06:15 - 21:06	06:42 - 20:39	07:12 - 19:52	07:15 - 17:23	07:47 - 17:10
12	07:57 - 17:30	07:33 - 18:07	17:04 (48) - 17:35 (48) 31	07:53 - 18:38	07:03 - 20:09	06:23 - 20:39	06:05 - 21:04	06:16 - 21:06	06:43 - 20:38	07:12 - 19:50	07:42 - 17:45 (48) 14	07:16 - 17:22	07:47 - 17:10
13	07:56 - 17:31	07:32 - 18:08	17:03 (48) - 17:36 (48) 33	07:51 - 18:39	07:01 - 20:10	06:22 - 20:40	06:05 - 21:04	06:17 - 21:05	06:44 - 20:37	07:13 - 19:48	07:43 - 17:58 (48) 19	07:17 - 17:21	07:48 - 17:10
14	07:56 - 17:32	07:30 - 18:09	17:03 (48) - 17:37 (48) 34	07:50 - 18:40	07:00 - 20:11	06:21 - 20:41	06:05 - 21:05	06:17 - 21:05	06:45 - 20:36	07:14 - 19:47	07:44 - 17:40 (48) 24	07:19 - 17:20	07:49 - 17:10
15	07:56 - 17:33	07:28 - 18:10	17:03 (48) - 17:38 (48) 36	07:48 - 18:41	06:58 - 20:12	06:20 - 20:42	06:05 - 21:05	06:18 - 21:04	06:46 - 20:34	07:15 - 19:45	17:39 (48) - 18:04 (48) 28	07:20 - 17:19	07:50 - 17:10
16	07:55 - 17:35	07:26 - 18:11	17:02 (48) - 17:37 (48) 36	07:46 - 18:42	06:57 - 20:13	06:19 - 20:43	06:05 - 21:04	06:19 - 21:04	06:47 - 20:33	07:16 - 19:43	18:05 (48) - 18:55 29	07:21 - 17:18	07:50 - 17:11
17	07:55 - 17:36	07:27 - 18:13	17:02 (48) - 17:38 (48) 36	07:45 - 18:43	06:55 - 20:14	06:18 - 20:44	06:05 - 21:06	06:20 - 21:03	06:48 - 20:32	07:17 - 19:42	18:54 - 18:06 (48) 30	07:22 - 17:18	07:51 - 17:11
18	07:55 - 17:37	07:25 - 18:14	17:02 (48) - 17:38 (48) 36	07:43 - 18:44	06:54 - 20:16	06:18 - 20:45	06:05 - 21:06	06:20 - 21:02	06:49 - 20:30	07:18 - 19:40	18:52 - 18:07 (48) 32	07:23 - 17:17	07:52 - 17:11
19	07:54 - 17:38	07:24 - 18:15	17:02 (48) - 17:37 (48) 35	07:41 - 18:45	06:52 - 20:16	06:17 - 20:46	06:06 - 21:07	06:21 - 21:02	06:50 - 20:29	07:18 - 19:38	07:48 - 18:51 33	07:24 - 17:16	07:52 - 17:12
20	07:53 - 17:39	07:23 - 18:16	17:02 (48) - 17:38 (48) 36	07:40 - 18:47	06:51 - 20:17	06:16 - 20:47	06:06 - 21:07	06:22 - 21:01	06:51 - 20:27	07:20 - 19:37	07:50 - 18:49 34	17:33 (48) - 18:07 (48) 34	07:53 - 17:15	07:25 - 17:12
21	07:53 - 17:40	07:21 - 18:17	17:02 (48) - 17:37 (48) 35	07:38 - 18:48	06:49 - 20:18	06:15 - 20:48	06:06 - 21:07	06:23 - 21:00	06:52 - 20:26	07:21 - 19:35	07:51 - 18:49 35	17:32 (48) - 18:07 (48) 35	07:27 - 17:15	07:53 - 17:13
22	07:52 - 17:41	07:20 - 18:18	17:02 (48) - 17:37 (48) 35	07:37 - 18:49	06:48 - 20:19	06:14 - 20:49	06:06 - 21:08	06:24 - 21:00	06:53 - 20:25	07:22 - 19:33	07:52 - 18:48 35	17:33 (48) - 18:08 (48) 35	07:28 - 17:14	07:54 - 17:13
23	07:52 - 17:43	07:18 - 18:19	17:03 (48) - 17:37 (48) 34	07:35 - 18:50	06:47 - 20:20	06:14 - 20:50	06:06 - 21:08	06:24 - 20:59	06:53 - 20:23	07:23 - 19:32	07:54 - 18:45 36	17:32 (48) - 18:08 (48) 36	07:29 - 17:14	07:54 - 17:14
24	07:51 - 17:44	07:17 - 18:21	17:03 (48) - 17:35 (48) 32	07:33 - 18:51	06:45 - 20:21	06:13 - 20:50	06:07 - 21:08	06:25 - 20:58	06:54 - 20:22	07:24 - 19:30	07:55 - 18:44 36	17:32 (48) - 18:08 (48) 36	07:30 - 17:13	07:55 - 17:14
25	07:50 - 17:45	07:16 - 18:22	17:04 (48) - 17:35 (48) 31	07:32 - 18:52	06:44 - 20:22	06:12 - 20:51	06:07 - 21:08	06:26 - 20:57	06:55 - 20:20	07:25 - 19:28	07:59 - 18:42 35	17:32 (48) - 18:07 (48) 35	07:31 - 17:13	07:55 - 17:15
26	07:50 - 17:46	07:14 - 18:23	17:06 (48) - 17:33 (48) 28	07:30 - 18:53	06:42 - 20:23	06:12 - 20:52	06:07 - 21:08	06:27 - 20:57	06:56 - 20:19	07:26 - 19:27	07:57 - 18:41 35	17:32 (48) - 18:07 (48) 35	07:32 - 17:12	07:56 - 17:16
27	07:49 - 17:47	07:13 - 18:24	17:07 (48) - 17:32 (48) 25	07:28 - 18:54	06:41 - 20:24	06:11 - 20:53	06:08 - 21:08	06:28 - 20:56	06:57 - 20:17	07:27 - 19:25	07:58 - 18:40 34	17:32 (48) - 18:06 (48) 34	07:33 - 17:12	07:56 - 17:16
28	07:48 - 17:49	07:11 - 18:25	17:08 (48) - 17:30 (48) 22	07:27 - 18:55	06:40 - 20:25	06:10 - 20:54	06:08 - 21:08	06:29 - 20:55	06:58 - 20:16	07:28 - 19:24	07:59 - 18:38 33	17:33 (48) - 18:06 (48) 33	07:34 - 17:11	07:56 - 17:17
29	07:47 - 17:50		07:25 - 19:56	06:38 - 20:26	06:10 - 20:55	06:08 - 21:08	06:30 - 20:54	06:59 - 20:14	07:29 - 19:22	08:00 - 18:37 33	17:33 (48) - 18:06 (48) 33	07:35 - 17:11	07:57 - 17:17
30	07:46 - 17:51		07:24 - 19:57	06:37 - 20:27	06:09 - 20:55	06:09 - 21:08	06:31 - 20:53	07:00 - 20:13	07:30 - 19:20	08:01 - 18:36 31	17:34 (48) - 18:05 (48) 31	07:36 - 17:11	07:57 - 17:18
31	07:45 - 17:52		07:22 - 19:58		06:09 - 20:56		06:32 - 20:52	07:01 - 20:11		08:02 - 18:35 29	17:34 (48) - 18:03 (48)		07:57 - 17:19
Potential sun hours	300	299	370	397	446	449	456	426	374	346	300	291		
Total, worst case		685	29							613	98			
Sun reduction		0.44	0.48							0.59	0.40			
Oper. time red.		0.92	0.92							0.92	0.92			
Wind dir. red.		0.68	0.68							0.68	0.68			
Total reduction		0.27	0.30							0.37	0.25			
Total, real		186	9							225	24			

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm) / Sun set (hh:mm)	Minutes with flicker	First time (hh:mm) with flicker / Last time (hh:mm) with flicker	(WTG causing flicker first time) / (WTG causing flicker last time)

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Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **Shadow receptor:** 2 - Golf Course Receptor

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	565	509	493	476	694	1,088	968	1,008	823	686	8,052

	January	February		March	April	May	June	July	August	September	October		November		December
1	07:57	07:46		17:07 (48)	07:10	07:20	06:36	06:08	06:09	06:33	07:02	07:31		07:04	16:24 (48)	07:37
	17:20	17:53	11	17:18 (48)	18:26	19:59	20:28	20:57	21:08	20:51	20:09	19:19		17:33	17:00 (48)	17:10
2	07:56	07:44		17:04 (48)	07:08	07:19	06:35	06:08	06:10	06:33	07:03	07:32		07:05	16:28 (48)	07:38
	17:21	17:55	17	17:21 (48)	18:27	20:00	20:29	20:58	21:08	20:50	20:08	19:17		17:32	17:00 (48)	17:10
3	07:56	07:43		17:02 (48)	07:07	07:17	06:33	06:08	06:10	06:34	07:04	07:33		07:06	16:28 (48)	07:39
	17:22	17:56	21	17:23 (48)	18:28	20:00	20:30	20:58	21:08	20:48	20:06	19:15		17:31	16:59 (48)	17:10
4	07:56	07:42		17:01 (48)	07:05	07:15	06:32	06:07	06:11	06:35	07:05	07:34		07:07	16:27 (48)	07:40
	17:22	17:57	24	17:25 (48)	18:30	20:01	20:31	20:59	21:08	20:48	20:05	19:14		17:30	16:58 (48)	17:10
5	07:55	07:41		16:59 (48)	07:04	07:14	06:31	06:07	06:11	06:36	07:06	07:35		07:08	16:28 (48)	07:41
	17:23	17:58	27	17:26 (48)	18:31	20:02	20:32	21:00	21:08	20:47	20:03	19:12		17:29	16:57 (48)	17:10
6	07:55	07:40		16:58 (48)	07:02	07:12	06:30	06:07	06:12	06:37	07:07	07:36		07:09	16:30 (48)	07:42
	17:24	17:59	29	17:27 (48)	18:32	20:03	20:33	21:00	21:08	20:45	20:01	19:11		17:28	16:56 (48)	17:10
7	07:55	07:39		16:57 (48)	07:01	07:11	06:29	06:06	06:13	06:38	07:08	07:37		07:10	16:31 (48)	07:43
	17:25	18:01	31	17:28 (48)	18:33	20:04	20:34	21:01	21:07	20:44	20:00	19:09		17:27	16:55 (48)	17:09
8	07:57	07:37		16:56 (48)	07:59	07:09	06:28	06:06	06:13	06:39	07:09	07:38		07:12	16:32 (48)	07:44
	17:26	18:02	33	17:29 (48)	19:34	20:06	20:36	21:02	21:07	20:43	19:57	19:07		17:26	16:53 (48)	17:09
9	07:57	07:36		16:56 (48)	07:57	07:06	06:26	06:06	06:14	06:40	07:10	07:39		07:13	16:34 (48)	07:45
	17:27	18:03	34	17:30 (48)	19:35	20:06	20:36	21:02	21:07	20:42	19:55	19:06		17:25	16:51 (48)	17:09
10	07:57	07:35		16:55 (48)	07:56	07:06	06:25	06:06	06:14	06:41	07:11	07:40		07:14	16:39 (48)	07:46
	17:28	18:04	36	17:31 (48)	19:36	20:07	20:37	21:03	21:06	20:41	19:53	19:04		17:24	16:48 (48)	17:09
11	07:57	07:34		16:55 (48)	07:54	07:04	06:24	06:06	06:15	06:42	07:12	07:41		07:15		07:47
	17:29	18:05	37	17:32 (48)	19:37	20:08	20:38	21:03	21:06	20:39	19:52	19:03		17:23		17:10
12	07:57	07:33		16:54 (48)	07:53	07:03	06:23	06:06	06:16	06:43	07:12	07:42		07:16		07:47
	17:30	18:07	37	17:31 (48)	19:38	20:09	20:39	21:04	21:06	20:38	19:50	19:01		17:22		17:10
13	07:56	07:32		16:54 (48)	07:51	07:01	06:22	06:05	06:17	06:44	07:13	07:43		07:17		07:48
	17:31	18:09	38	17:32 (48)	19:39	20:10	20:40	21:04	21:05	20:37	19:48	19:00		17:21		17:10
14	07:56	07:30		16:54 (48)	07:50	07:00	06:21	06:05	06:17	06:45	07:14	07:44		17:42 (48)	07:19	07:49
	17:32	18:09	38	17:32 (48)	19:40	20:11	20:41	21:05	21:05	20:36	19:47	18:58	8	17:50 (48)	17:20	17:10
15	07:56	07:29		16:55 (48)	07:48	06:58	06:20	06:05	06:18	06:46	07:15	07:45		17:37 (48)	07:20	07:50
	17:33	18:10	38	17:33 (48)	19:41	20:12	20:42	21:05	21:04	20:34	19:45	18:57	16	17:53 (48)	17:19	17:10
16	07:55	07:28		16:54 (48)	07:46	06:57	06:19	06:05	06:19	06:47	07:16	07:46		17:34 (48)	07:21	07:50
	17:35	18:11	38	17:32 (48)	19:42	20:13	20:43	21:06	21:04	20:33	19:43	18:55	22	17:56 (48)	17:18	17:11
17	07:55	07:27		16:55 (48)	07:45	06:55	06:18	06:05	06:20	06:48	07:17	07:47		17:32 (48)	07:22	07:51
	17:36	18:13	37	17:32 (48)	19:43	20:14	20:44	21:06	21:03	20:32	19:42	18:54	25	17:57 (48)	17:18	17:11
18	07:55	07:25		16:55 (48)	07:43	06:54	06:18	06:05	06:20	06:49	07:18	07:48		17:30 (48)	07:23	07:52
	17:37	18:14	37	17:32 (48)	19:44	20:15	20:45	21:07	21:02	20:30	19:40	18:52	28	17:58 (48)	17:17	17:11
19	07:54	07:24		16:55 (48)	07:41	06:52	06:17	06:06	06:21	06:50	07:19	07:49		17:29 (48)	07:24	07:52
	17:38	18:16	36	17:31 (48)	19:45	20:16	20:46	21:07	21:02	20:29	19:38	18:51	30	17:59 (48)	17:16	17:12
20	07:53	07:23		16:56 (48)	07:40	06:51	06:16	06:06	06:22	06:51	07:20	07:50		17:27 (48)	07:25	07:53
	17:39	18:16	35	17:31 (48)	19:47	20:17	20:47	21:07	21:01	20:27	19:37	18:49	33	18:00 (48)	17:15	17:12
21	07:53	07:21		16:56 (48)	07:38	06:49	06:15	06:06	06:23	06:52	07:21	07:51		17:26 (48)	07:27	07:53
	17:40	18:17	33	17:29 (48)	19:48	20:18	20:48	21:07	21:00	20:26	19:35	18:48	34	18:00 (48)	17:15	17:13
22	07:52	07:20		16:57 (48)	07:37	06:48	06:14	06:06	06:24	06:53	07:22	07:52		17:26 (48)	07:28	07:54
	17:41	18:18	32	17:29 (48)	19:48	20:19	20:49	21:08	21:00	20:25	19:33	18:46	36	18:02 (48)	17:14	17:13
23	07:52	07:18		16:58 (48)	07:35	06:47	06:14	06:06	06:24	06:53	07:23	07:54		17:25 (48)	07:29	07:54
	17:43	18:19	30	17:28 (48)	19:50	20:20	20:50	21:08	20:59	20:23	19:32	18:45	37	18:02 (48)	17:14	17:14
24	07:51	07:17		16:59 (48)	07:33	06:45	06:13	06:07	06:25	06:54	07:24	07:55		17:25 (48)	07:30	07:55
	17:44	18:21	27	17:26 (48)	19:51	20:21	20:50	21:08	20:58	20:22	19:30	18:44	37	18:02 (48)	17:13	17:14
25	07:50	07:16		17:01 (48)	07:32	06:44	06:12	06:07	06:26	06:55	07:25	07:56		17:24 (48)	07:31	07:55
	17:45	18:22	24	17:25 (48)	19:52	20:22	20:51	21:08	20:57	20:20	19:28	18:42	38	18:02 (48)	17:13	17:15
26	07:50	07:14		17:03 (48)	07:30	06:42	06:12	06:07	06:27	06:56	07:26	07:57		17:24 (48)	07:32	07:56
	17:46	18:23	19	17:22 (48)	19:53	20:23	20:52	21:08	20:57	20:19	19:27	18:41	38	18:02 (48)	17:12	17:15
27	07:49	07:13		17:06 (48)	07:28	06:41	06:11	06:08	06:28	06:57	07:27	07:58		17:23 (48)	07:33	07:56
	17:47	18:24	14	17:20 (48)	19:54	20:24	20:53	21:08	20:56	20:17	19:25	18:40	38	18:01 (48)	17:12	17:16
28	07:48	07:11			07:27	06:40	06:10	06:08	06:29	06:58	07:28	07:59		17:24 (48)	07:34	07:56
	17:49	18:25			19:55	20:25	20:54	21:08	20:55	20:16	19:24	18:38	38	18:02 (48)	17:11	17:17
29	07:47				07:25	06:38	06:10	06:08	06:30	06:59	07:29	08:00		17:24 (48)	07:35	07:57
	17:50				19:56	20:26	20:55	21:08	20:54	20:14	19:22	18:37	39	18:02 (48)	17:11	17:17
30	07:46				07:24	06:37	06:09	06:09	06:31	07:00	07:30	08:01		17:24 (48)	07:36	07:57
	17:51				19:57	20:27	20:55	21:08	20:53	20:13	19:20	18:36	37	18:01 (48)	17:11	17:18
31	07:45				07:22		06:09		06:32	07:01		08:02		17:24 (48)		07:57
	17:52				19:58		20:56		20:52	20:11		18:36	36	18:00 (48)		17:19
Potential sun hours	300	299			370	397	446	449	456	428	374	346			300		291
Total, worst case			813										569		260	
Sun reduction			0.44										0.59		0.40	
Oper. time red.			0.92										0.92		0.82	
Wind dir. red.			0.68										0.68		0.68	
Total reduction			0.28										0.37		0.25	
Total, real			224										210		65	

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

Printed/Page
10/30/2009 5:00 PM / 5

Licensed user:
EAPC Architects Engineers
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **Shadow receptor:** 3 - Golf Course Reception

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	566	509	493	476	694	1,088	968	1,008	823	686	8,052

	January		February		March	April	May	June	July	August	September	October	November	December
1	07:57		07:45		16:48 (48)	07:10	07:20	06:36	06:06	06:09	06:33	07:02	07:31	07:04	16:22 (48)	07:37
	17:20		17:53	32	17:18 (48)	18:25	19:58	20:28	20:57	21:08	20:51	20:09	19:19	17:33	16:41 (48)	17:10
2	07:56		07:44		16:48 (48)	07:08	07:18	06:35	06:06	06:10	06:33	07:03	07:32	07:05	16:21 (48)	07:38
	17:21		17:55	32	17:16 (48)	18:27	20:00	20:29	20:56	21:08	20:50	20:08	19:17	17:32	16:43 (48)	17:10
3	07:56		07:43		16:47 (48)	07:07	07:17	06:33	06:06	06:10	06:34	07:04	07:33	07:06	16:20 (48)	07:39
	17:22		17:56	31	17:16 (48)	18:28	20:00	20:30	20:56	21:08	20:49	20:06	19:15	17:31	16:44 (48)	17:10
4	07:56		07:42		16:47 (48)	07:05	07:15	06:32	06:07	06:11	06:35	07:05	07:34	07:07	16:19 (48)	07:40
	17:22		17:57	30	17:17 (48)	18:30	20:01	20:31	20:59	21:08	20:48	20:05	19:14	17:30	16:45 (48)	17:10
5	07:56		07:41		16:47 (48)	07:04	07:14	06:31	06:07	06:11	06:36	07:06	07:35	07:08	16:18 (48)	07:41
	17:23		17:58	29	17:16 (48)	18:31	20:02	20:32	21:00	21:08	20:47	20:03	19:12	17:29	16:46 (48)	17:10
6	07:56		07:40		16:48 (48)	07:02	07:12	06:30	06:07	06:12	06:37	07:07	07:36	07:09	16:18 (48)	07:42
	17:24		17:59	28	17:16 (48)	18:32	20:03	20:33	21:00	21:08	20:45	20:01	19:11	17:28	16:47 (48)	17:09
7	07:56		07:39		16:49 (48)	07:01	07:11	06:29	06:06	06:13	06:38	07:08	07:37	07:10	16:17 (48)	07:43
	17:25		18:01	25	17:15 (48)	18:33	20:04	20:34	21:01	21:07	20:44	20:00	19:09	17:27	16:47 (48)	17:09
8	07:57		07:37		16:50 (48)	07:59	07:09	06:28	06:06	06:13	06:39	07:09	07:38	07:12	16:17 (48)	07:44
	17:26		18:02	24	17:14 (48)	18:34	20:05	20:35	21:02	21:07	20:43	19:57	19:07	17:26	16:48 (48)	17:09
9	07:57		07:36		16:52 (48)	07:57	07:08	06:26	06:06	06:14	06:40	07:10	07:39	07:13	16:16 (48)	07:45
	17:27		18:03	21	17:13 (48)	18:35	20:06	20:36	21:02	21:07	20:42	19:55	19:06	17:25	16:48 (48)	17:09
10	07:57		07:35		16:54 (48)	07:56	07:06	06:25	06:06	06:14	06:41	07:11	07:40	07:14	16:17 (48)	07:46
	17:28		18:04	18	17:12 (48)	18:36	20:07	20:37	21:03	21:06	20:41	19:53	19:04	17:24	16:49 (48)	17:09
11	07:57		07:34		16:56 (48)	07:54	07:04	06:24	06:06	06:15	06:42	07:12	07:41	07:15	16:17 (48)	07:47
	17:29		18:05	14	17:10 (48)	18:37	20:08	20:38	21:03	21:06	20:39	19:52	19:03	17:23	16:49 (48)	17:10
12	07:57		07:33		16:59 (48)	07:53	07:03	06:23	06:06	06:16	06:43	07:12	07:42	07:16	16:16 (48)	07:47
	17:30		18:07	8	17:05 (48)	18:38	20:09	20:39	21:04	21:06	20:38	19:50	19:01	17:22	16:48 (48)	17:10
13	07:56		07:32			07:51	07:01	06:22	06:06	06:17	06:44	07:13	07:43	07:17	16:16 (48)	07:48
	17:31		18:08			19:38	20:10	20:40	21:04	21:06	20:37	19:48	19:00	17:21	16:48 (48)	17:10
14	07:56		07:30			07:50	07:00	06:21	06:05	06:17	06:45	07:14	07:44	07:19	16:17 (48)	07:49
	17:32		18:09			19:40	20:11	20:41	21:05	21:05	20:36	19:47	18:58	17:20	16:48 (48)	17:10
15	07:56		16:53 (48)	07:29		07:48	06:58	06:20	06:05	06:18	06:46	07:15	07:45	07:20	16:18 (48)	07:50
	17:33	6	17:01 (48)	18:10		19:41	20:12	20:42	21:05	21:04	20:34	19:45	18:57	17:19	16:49 (48)	17:10
16	07:55		16:50 (48)	07:28		07:46	06:57	06:19	06:05	06:19	06:47	07:16	07:46	07:21	16:18 (48)	07:50
	17:35	13	17:03 (48)	18:11		19:42	20:13	20:43	21:06	21:04	20:33	19:43	18:55	17:18	16:48 (48)	17:11
17	07:55		16:50 (48)	07:27		07:45	06:55	06:18	06:05	06:20	06:48	07:17	07:47	07:22	16:18 (48)	07:51
	17:36	16	17:06 (48)	18:13		19:43	20:14	20:44	21:06	21:03	20:32	19:42	18:54	17:16	16:48 (48)	17:11
18	07:55		16:48 (48)	07:25		07:43	06:54	06:18	06:05	06:20	06:49	07:18	07:48	07:23	16:19 (48)	07:52
	17:37	19	17:07 (48)	18:14		19:44	20:15	20:45	21:07	21:02	20:30	19:40	18:52	17:17	16:47 (48)	17:11
19	07:54		16:48 (48)	07:24		07:41	06:52	06:17	06:06	06:21	06:50	07:19	07:49	07:24	16:20 (48)	07:52
	17:38	21	17:09 (48)	18:15		19:45	20:16	20:46	21:07	21:02	20:29	19:38	18:51	17:16	16:48 (48)	17:12
20	07:53		16:47 (48)	07:23		07:40	06:51	06:16	06:06	06:22	06:51	07:20	07:50	07:25	16:21 (48)	07:53
	17:39	23	17:10 (48)	18:16		19:47	20:17	20:47	21:07	21:01	20:27	19:37	18:49	17:15	16:47 (48)	17:12
21	07:53		16:46 (48)	07:21		07:38	06:49	06:15	06:06	06:23	06:52	07:21	07:51	07:27	16:22 (48)	07:53
	17:40	26	17:11 (48)	18:17		19:48	20:18	20:48	21:07	21:00	20:26	19:35	18:48	17:15	16:47 (48)	17:12
22	07:52		16:46 (48)	07:20		07:37	06:48	06:14	06:06	06:24	06:53	07:22	07:52	07:28	16:23 (48)	07:54
	17:41	26	17:12 (48)	18:18		19:49	20:19	20:49	21:08	21:00	20:25	19:33	18:46	17:14	16:46 (48)	17:13
23	07:52		16:45 (48)	07:18		07:35	06:47	06:14	06:06	06:24	06:53	07:23	07:54	07:29	16:24 (48)	07:54
	17:43	28	17:13 (48)	18:19		19:50	20:20	20:50	21:08	20:59	20:23	19:32	18:45	17:14	16:45 (48)	17:14
24	07:51		16:45 (48)	07:17		07:33	06:45	06:13	06:07	06:25	06:54	07:24	07:55	07:30	16:26 (48)	07:55
	17:44	28	17:13 (48)	18:21		19:51	20:21	20:50	21:08	20:58	20:22	19:30	18:44	17:13	16:45 (48)	17:14
25	07:50		16:45 (48)	07:16		07:32	06:44	06:12	06:07	06:26	06:55	07:25	07:56	07:31	16:28 (48)	07:55
	17:45	30	17:15 (48)	18:22		19:52	20:22	20:51	21:08	20:57	20:20	19:28	18:42	17:13	16:44 (48)	17:15
26	07:50		16:45 (48)	07:14		07:30	06:42	06:12	06:07	06:27	06:56	07:26	07:57	07:32	16:29 (48)	07:56
	17:48	30	17:15 (48)	18:23		19:53	20:23	20:52	21:08	20:57	20:19	19:27	18:41	17:12	16:42 (48)	17:15
27	07:49		16:45 (48)	07:13		07:26	06:41	06:11	06:08	06:28	06:57	07:27	07:58	07:33	16:32 (48)	07:56
	17:47	31	17:16 (48)	18:24		19:54	20:24	20:53	21:08	20:56	20:17	19:25	18:40	17:12	16:40 (48)	17:16
28	07:48		16:45 (48)	07:11		07:27	06:40	06:10	06:08	06:29	06:58	07:28	07:59	07:34		07:56
	17:49	31	17:16 (48)	18:25		19:55	20:25	20:54	21:08	20:55	20:16	19:24	18:38	17:11		17:17
29	07:47		16:45 (48)			07:25	06:38	06:10	06:08	06:30	06:59	07:29	08:00	07:35		07:57
	17:50	31	17:16 (48)			19:56	20:26	20:55	21:08	20:54	20:14	19:22	18:37	17:11		17:17
30	07:46		16:45 (48)			07:24	06:37	06:09	06:09	06:31	07:00	07:30	08:01	17:28 (48)	07:36	07:57
	17:51	32	17:17 (48)			19:57	20:27	20:55	21:08	20:53	20:13	19:20	18:36	8 17:36 (48)	17:11	17:18
31	07:45		16:46 (48)			07:22		06:09		06:32	07:01		08:02	17:24 (48)		07:57
	17:52	32	17:18 (48)			19:58		20:56		20:52	20:11		18:35	15 17:39 (48)		17:19
Potential sun hours	300		299			370	397	446	449	458	428	374	346	300		291
Total, worst case	424		291										23	698		
Sun reduction	0.40		0.44										0.59	0.40		
Oper. time red.	0.92		0.92										0.92	0.92		
Wind dir. red.	0.68		0.68										0.68	0.68		
Total reduction	0.25		0.26										0.37	0.25		
Total, real	107		81										9	176		

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

Printed/Page
10/30/2009 5:00 PM / 6

Licensed user:
EAPC Architects Engineers
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **Shadow receptor:** 4 - Golf Course Receptor

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	565	509	493	476	694	1,088	968	1,008	823	686	8,052

	January		February		March	April	May	June	July	August	September	October	November		December	
1	07:57	16:23 (48)	07:45	16:37 (48)	07:10	07:20	06:36	06:09	06:09	06:33	07:02	07:31	07:04		07:37	16:06 (48)
	17:20	26 16:49 (48)	17:53	21 16:58 (48)	18:26	19:59	20:28	20:57	21:08	20:51	20:09	19:19	17:33		17:10	33 16:39 (48)
2	07:58	16:23 (48)	07:44	16:39 (48)	07:08	07:19	06:35	06:08	06:10	06:33	07:03	07:32	07:05		07:38	16:06 (48)
	17:21	27 16:50 (48)	17:55	17 16:58 (48)	18:27	20:00	20:29	20:58	21:08	20:50	20:08	19:17	17:32		17:10	33 16:39 (48)
3	07:58	16:23 (48)	07:43	16:42 (48)	07:07	07:17	06:33	06:08	06:10	06:34	07:04	07:33	07:06		07:39	16:07 (48)
	17:22	27 16:50 (48)	17:56	11 16:53 (48)	18:28	20:00	20:30	20:58	21:08	20:49	20:06	19:15	17:31		17:10	32 16:39 (48)
4	07:58	16:23 (48)	07:42		07:06	07:15	06:32	06:07	06:11	06:35	07:05	07:34	07:07		07:40	16:08 (48)
	17:22	28 16:51 (48)	17:57		18:30	20:01	20:31	20:59	21:08	20:48	20:05	19:14	17:30		17:10	31 16:39 (48)
5	07:58	16:23 (48)	07:41		07:04	07:14	06:31	06:07	06:11	06:36	07:06	07:35	07:08		07:41	16:09 (48)
	17:23	29 16:52 (48)	17:58		18:31	20:02	20:32	21:00	21:08	20:47	20:03	19:12	17:29		17:10	30 16:39 (48)
6	07:58	16:23 (48)	07:40		07:02	07:12	06:30	06:07	06:12	06:37	07:07	07:36	07:09		07:42	16:09 (48)
	17:24	30 16:53 (48)	17:59		18:32	20:03	20:33	21:00	21:08	20:46	20:01	19:11	17:28		17:10	30 16:39 (48)
7	07:58	16:24 (48)	07:39		07:01	07:11	06:29	06:06	06:13	06:38	07:08	07:37	07:10		07:43	16:10 (48)
	17:25	30 16:54 (48)	18:01		18:33	20:04	20:34	21:01	21:07	20:44	20:00	19:08	17:27		17:09	29 16:39 (48)
8	07:57	16:24 (48)	07:37		07:59	07:09	06:28	06:06	06:13	06:39	07:09	07:38	07:12		07:44	16:11 (48)
	17:26	31 16:55 (48)	18:02		19:34	20:05	20:35	21:02	21:07	20:43	19:57	19:07	17:26	13 16:24 (48)	17:09	28 16:39 (48)
9	07:57	16:24 (48)	07:36		07:57	07:08	06:26	06:06	06:14	06:40	07:10	07:39	07:13		16:09 (48)	07:46 16:12 (48)
	17:27	32 16:56 (48)	18:03		19:35	20:06	20:36	21:02	21:07	20:42	19:55	19:06	17:25	17 16:26 (48)	17:08	28 16:40 (48)
10	07:57	16:24 (48)	07:35		07:56	07:06	06:25	06:06	06:14	06:41	07:11	07:40	07:14		16:08 (48)	07:46 16:13 (48)
	17:28	33 16:57 (48)	18:04		19:36	20:07	20:37	21:03	21:06	20:41	19:53	19:04	17:24	21 16:29 (48)	17:09	27 16:40 (48)
11	07:57	16:24 (48)	07:34		07:54	07:04	06:24	06:06	06:15	06:42	07:12	07:41	07:15		16:06 (48)	07:47 16:14 (48)
	17:29	32 16:58 (48)	18:05		19:37	20:08	20:38	21:03	21:06	20:39	19:52	19:03	17:23	24 16:30 (48)	17:10	26 16:40 (48)
12	07:57	16:24 (48)	07:33		07:53	07:03	06:23	06:05	06:16	06:43	07:12	07:42	07:16		16:05 (48)	07:47 16:14 (48)
	17:30	33 16:57 (48)	18:07		19:38	20:09	20:39	21:04	21:06	20:38	19:50	19:01	17:22	26 16:31 (48)	17:10	25 16:39 (48)
13	07:56	16:25 (48)	07:32		07:51	07:01	06:22	06:05	06:17	06:44	07:13	07:43	07:17		16:04 (48)	07:48 16:14 (48)
	17:31	33 16:58 (48)	18:08		19:39	20:10	20:40	21:04	21:05	20:37	19:48	19:00	17:21	28 16:32 (48)	17:10	26 16:40 (48)
14	07:56	16:24 (48)	07:30		07:50	07:00	06:21	06:05	06:17	06:45	07:14	07:44	07:19		16:03 (48)	07:49 16:15 (48)
	17:32	34 16:58 (48)	18:09		19:40	20:11	20:41	21:05	21:05	20:36	19:47	18:58	17:20	29 16:32 (48)	17:10	25 16:40 (48)
15	07:56	16:25 (48)	07:29		07:48	06:56	06:20	06:05	06:18	06:46	07:15	07:45	07:20		16:03 (48)	07:50 16:16 (48)
	17:33	34 16:59 (48)	18:10		19:41	20:12	20:42	21:05	21:04	20:34	19:45	18:57	17:19	31 16:34 (48)	17:10	25 16:41 (48)
16	07:55	16:25 (48)	07:28		07:46	06:57	06:19	06:05	06:19	06:47	07:16	07:46	07:21		16:03 (48)	07:50 16:16 (48)
	17:35	34 16:59 (48)	18:11		19:42	20:13	20:43	21:06	21:04	20:33	19:43	18:55	17:18	31 16:34 (48)	17:11	24 16:40 (48)
17	07:55	16:26 (48)	07:27		07:45	06:55	06:18	06:06	06:20	06:48	07:17	07:47	07:22		16:02 (48)	07:51 16:17 (48)
	17:36	34 17:00 (48)	18:13		19:43	20:14	20:44	21:06	21:03	20:32	19:42	18:54	17:16	33 16:35 (48)	17:11	24 16:41 (48)
18	07:55	16:25 (48)	07:25		07:43	06:54	06:18	06:05	06:20	06:49	07:18	07:48	07:23		16:02 (48)	07:52 16:18 (48)
	17:37	35 17:00 (48)	18:14		19:44	20:15	20:45	21:07	21:02	20:30	19:40	18:52	17:17	33 16:35 (48)	17:11	24 16:42 (48)
19	07:54	16:26 (48)	07:24		07:41	06:52	06:17	06:06	06:21	06:50	07:19	07:49	07:24		16:03 (48)	07:52 16:18 (48)
	17:38	35 17:01 (48)	18:15		19:45	20:16	20:46	21:07	21:02	20:29	19:38	18:51	17:16	33 16:36 (48)	17:12	23 16:41 (48)
20	07:53	16:26 (48)	07:23		07:40	06:51	06:16	06:06	06:22	06:51	07:20	07:50	07:25		16:02 (48)	07:53 16:19 (48)
	17:39	35 17:01 (48)	18:16		19:47	20:17	20:47	21:07	21:01	20:27	19:37	18:49	17:15	36 16:37 (48)	17:12	23 16:42 (48)
21	07:53	16:26 (48)	07:21		07:38	06:48	06:15	06:06	06:23	06:52	07:21	07:51	07:27		16:02 (48)	07:53 16:19 (48)
	17:40	35 17:01 (48)	18:17		19:48	20:18	20:48	21:07	21:00	20:26	19:35	18:48	17:15	35 16:37 (48)	17:12	23 16:42 (48)
22	07:52	16:27 (48)	07:20		07:37	06:48	06:14	06:06	06:24	06:53	07:22	07:52	07:28		16:02 (48)	07:54 16:20 (48)
	17:41	35 17:02 (48)	18:18		19:49	20:19	20:49	21:08	21:00	20:25	19:33	18:46	17:14	35 16:37 (48)	17:13	23 16:43 (48)
23	07:52	16:28 (48)	07:18		07:35	06:47	06:14	06:06	06:24	06:53	07:23	07:54	07:29		16:02 (48)	07:54 16:20 (48)
	17:43	33 17:01 (48)	18:19		19:50	20:20	20:50	21:08	20:59	20:23	19:32	18:45	17:14	35 16:37 (48)	17:14	23 16:43 (48)
24	07:51	16:28 (48)	07:17		07:33	06:45	06:13	06:07	06:26	06:54	07:24	07:55	07:30		16:03 (48)	07:55 16:20 (48)
	17:44	33 17:01 (48)	18:21		19:51	20:21	20:51	21:08	20:58	20:22	19:30	18:44	17:13	35 16:38 (48)	17:14	23 16:43 (48)
25	07:50	16:29 (48)	07:16		07:32	06:44	06:12	06:07	06:26	06:55	07:25	07:56	07:31		16:04 (48)	07:56 16:21 (48)
	17:45	33 17:02 (48)	18:22		19:52	20:22	20:51	21:08	20:57	20:20	19:28	18:42	17:13	34 16:38 (48)	17:15	24 16:45 (48)
26	07:50	16:30 (48)	07:14		07:30	06:42	06:12	06:07	06:27	06:56	07:25	07:57	07:32		16:04 (48)	07:56 16:21 (48)
	17:46	31 17:01 (48)	18:23		19:53	20:23	20:52	21:08	20:57	20:19	19:27	18:41	17:12	34 16:38 (48)	17:15	24 16:45 (48)
27	07:49	16:30 (48)	07:13		07:28	06:41	06:11	06:08	06:28	06:57	07:27	07:58	07:33		16:04 (48)	07:56 16:21 (48)
	17:47	31 17:01 (48)	18:24		19:54	20:24	20:53	21:08	20:56	20:17	19:25	18:40	17:12	34 16:38 (48)	17:16	24 16:45 (48)
28	07:48	16:31 (48)	07:11		07:27	06:40	06:10	06:08	06:29	06:58	07:28	07:59	07:34		16:04 (48)	07:56 16:22 (48)
	17:49	29 17:00 (48)	18:25		19:55	20:25	20:54	21:08	20:55	20:16	19:24	18:38	17:11	34 16:38 (48)	17:17	25 16:47 (48)
29	07:47	16:32 (48)			07:25	06:38	06:10	06:08	06:30	06:59	07:29	08:00	07:35		16:05 (48)	07:57 16:22 (48)
	17:50	28 17:00 (48)			19:56	20:26	20:55	21:08	20:54	20:14	19:22	18:37	17:11	33 16:38 (48)	17:17	26 16:47 (48)
30	07:46	16:33 (48)			07:24	06:37	06:09	06:09	06:31	07:00	07:30	08:01	07:36		16:05 (48)	07:57 16:22 (48)
	17:51	26 16:59 (48)			19:57	20:27	20:58	21:08	20:53	20:13	19:20	18:36	17:11	34 16:39 (48)	17:18	26 16:48 (48)
31	07:45	16:35 (48)			07:22		06:09		06:32	07:01		08:02			07:57	16:23 (48)
	17:52	24 16:59 (48)			19:58		20:56		20:52	20:11		18:35			17:19	25 16:48 (48)
Potential sun hours	300		289		370	397	446	449	456	426	374	346	300		291	
Total, worst case		970		49										897		811
Sun reduction		0.40		0.44										0.40		0.36
Oper. time red.		0.92		0.82										0.92		0.92
Wind dir. red.		0.66		0.66										0.66		0.66
Total reduction		0.25		0.28										0.25		0.23
Total, real		244		14										175		184

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)		First time (hh:mm) with flicker	(WTG causing flicker first time)
	Sun set (hh:mm)	Minutes with flicker	Last time (hh:mm) with flicker	(WTG causing flicker last time)

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

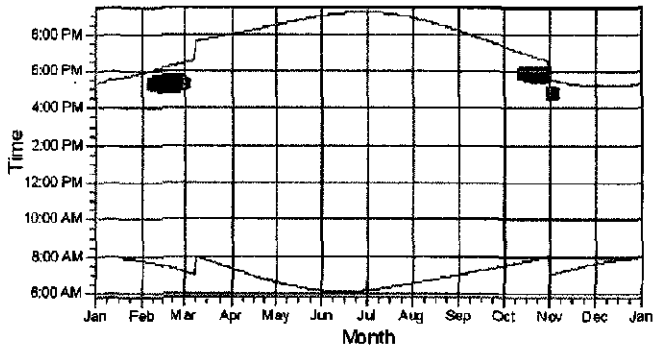
Licensed user:
EAPC Architects Engineers
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

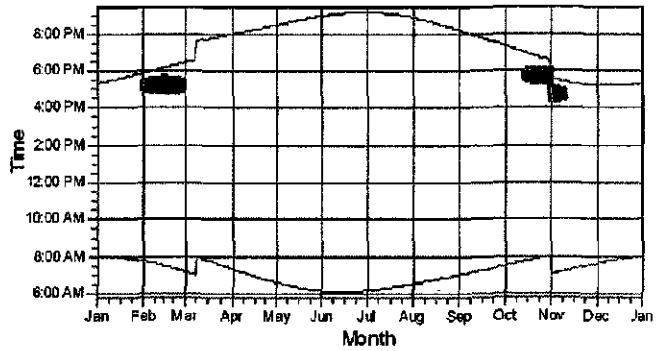
SHADOW - Calendar, graphical

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030

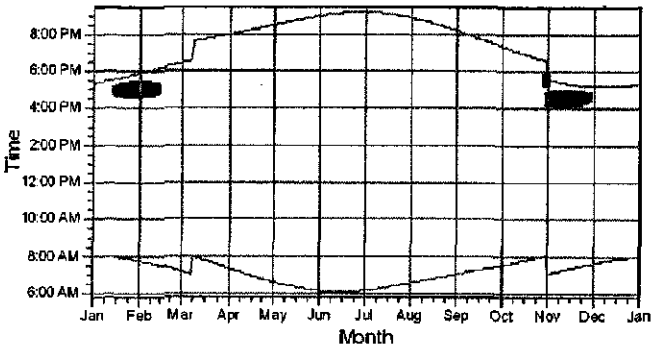
1: Golf Course Receptor 1



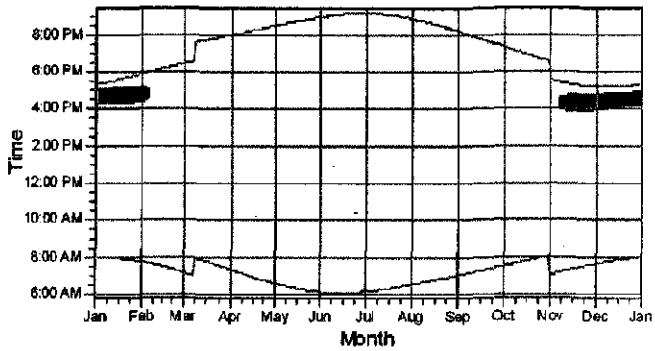
2: Golf Course Receptor 2



3: Golf Course Receptor 3



4: Golf Course Receptor 4



WTGs

48: NORDEX N100 2500 100.0 IOI hub: 100.0 m (217)

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

Printed/Page
10/30/2009 5:00 PM / 8

Licensed user:
EAPC Architects Engineers
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar per WTG

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **WTG:** 44 - NORDEX N100 2500 100.0 (0) hub: 100.0 m (213)

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	565	509	493	476	694	1,088	968	1,003	823	686	8,052

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:57	07:45	07:10	07:20	06:36	06:08	06:09	06:32	07:02	07:31	07:04	07:37
	17:20	17:53	18:26	19:59	20:28	20:57	21:08	20:51	20:09	19:19	17:33	17:10
2	07:58	07:44	07:08	07:19	06:35	06:08	06:10	06:33	07:03	07:32	07:05	07:38
	17:21	17:55	18:27	20:00	20:29	20:58	21:08	20:50	20:08	19:17	17:32	17:10
3	07:58	07:43	07:07	07:17	06:33	06:07	06:10	06:34	07:04	07:33	07:06	07:39
	17:22	17:56	18:28	20:00	20:30	20:58	21:08	20:49	20:06	19:15	17:31	17:10
4	07:58	07:42	07:05	07:15	06:32	06:07	06:11	06:35	07:05	07:34	07:07	07:40
	17:22	17:57	18:29	20:01	20:31	20:59	21:08	20:48	20:05	19:14	17:30	17:10
5	07:58	07:41	07:04	07:14	06:31	06:07	06:11	06:36	07:06	07:35	07:08	07:41
	17:23	17:58	18:31	20:02	20:32	21:00	21:08	20:47	20:03	19:12	17:29	17:10
6	07:58	07:40	07:02	07:12	06:30	06:06	06:12	06:37	07:07	07:36	07:09	07:42
	17:24	17:59	18:32	20:03	20:33	21:01	21:08	20:45	20:01	19:11	17:28	17:09
7	07:58	07:39	07:01	07:11	06:29	06:06	06:12	06:38	07:08	07:37	07:11	07:43
	17:25	18:01	18:33	20:04	20:34	21:01	21:07	20:44	20:00	19:09	17:27	17:09
8	07:58	07:37	07:59	07:09	06:28	06:06	06:13	06:39	07:09	07:38	07:12	07:44
	17:26	18:02	19:34	20:05	20:35	21:02	21:07	20:43	19:57	19:07	17:26	17:09
9	07:57	07:36	07:57	07:08	06:26	06:06	06:14	06:40	07:10	07:39	07:13	07:45
	17:27	18:03	19:35	20:06	20:36	21:02	21:07	20:42	19:55	19:06	17:25	17:09
10	07:57	07:35	07:56	07:06	06:25	06:06	06:14	06:41	07:11	07:40	07:14	07:46
	17:28	18:04	19:36	20:07	20:37	21:03	21:06	20:41	19:53	19:04	17:24	17:09
11	07:57	07:34	07:54	07:04	06:24	06:05	06:15	06:42	07:12	07:41	07:15	07:47
	17:29	18:05	19:37	20:08	20:38	21:03	21:06	20:39	19:52	19:03	17:23	17:10
12	07:57	07:33	07:53	07:03	06:23	06:05	06:16	06:43	07:12	07:42	07:16	07:47
	17:30	18:07	19:38	20:09	20:39	21:04	21:06	20:38	19:50	19:01	17:22	17:10
13	07:57	07:32	07:51	07:01	06:22	06:05	06:16	06:44	07:13	07:43	07:17	07:48
	17:31	18:08	19:39	20:10	20:40	21:05	21:05	20:37	19:48	19:00	17:21	17:10
14	07:56	07:30	07:50	07:00	06:21	06:05	06:17	06:45	07:14	07:44	07:19	07:49
	17:32	18:09	19:40	20:11	20:41	21:05	21:05	20:36	19:47	18:58	17:20	17:10
15	07:56	07:29	07:48	06:58	06:20	06:05	06:18	06:46	07:15	07:45	07:20	07:50
	17:33	18:10	19:41	20:12	20:42	21:05	21:04	20:34	19:45	18:57	17:19	17:10
16	07:55	07:28	07:46	06:57	06:19	06:05	06:19	06:47	07:16	07:46	07:21	07:50
	17:35	18:11	19:42	20:13	20:43	21:06	21:04	20:33	19:43	18:55	17:18	17:11
17	07:55	07:27	07:45	06:55	06:18	06:05	06:19	06:48	07:17	07:47	07:22	07:51
	17:36	18:12	19:43	20:14	20:44	21:06	21:03	20:32	19:42	18:54	17:18	17:11
18	07:55	07:25	07:43	06:54	06:18	06:05	06:20	06:49	07:18	07:48	07:23	07:52
	17:37	18:14	19:44	20:15	20:45	21:07	21:03	20:30	19:40	18:52	17:17	17:11
19	07:54	07:24	07:41	06:52	06:17	06:06	06:21	06:50	07:19	07:49	07:24	07:52
	17:38	18:15	19:45	20:16	20:46	21:07	21:02	20:29	19:38	18:51	17:16	17:12
20	07:54	07:23	07:40	06:51	06:16	06:06	06:22	06:51	07:20	07:50	07:25	07:53
	17:39	18:16	19:47	20:17	20:47	21:07	21:01	20:27	19:37	18:49	17:15	17:12
21	07:53	07:21	07:38	06:49	06:15	06:06	06:23	06:52	07:21	07:51	07:27	07:53
	17:40	18:17	19:48	20:18	20:48	21:07	21:01	20:26	19:35	18:48	17:15	17:12
22	07:52	07:20	07:37	06:48	06:14	06:06	06:24	06:52	07:22	07:52	07:28	07:54
	17:41	18:18	19:49	20:19	20:49	21:08	21:00	20:25	19:33	18:46	17:14	17:13
23	07:52	07:18	07:35	06:47	06:14	06:06	06:24	06:53	07:23	07:54	07:29	07:55
	17:43	18:19	19:50	20:20	20:50	21:08	20:59	20:23	19:32	18:45	17:14	17:13
24	07:51	07:17	07:33	06:45	06:13	06:07	06:25	06:54	07:24	07:55	07:30	07:55
	17:44	18:21	19:51	20:21	20:51	21:08	20:58	20:22	19:30	18:44	17:13	17:14
25	07:50	07:16	07:32	06:44	06:12	06:07	06:26	06:56	07:25	07:56	07:31	07:56
	17:45	18:22	19:52	20:22	20:51	21:08	20:57	20:20	19:28	18:42	17:13	17:15
26	07:50	07:14	07:30	06:42	06:12	06:07	06:27	06:56	07:26	07:57	07:32	07:56
	17:46	18:23	19:53	20:23	20:52	21:08	20:57	20:19	19:27	18:41	17:12	17:15
27	07:49	07:13	07:28	06:41	06:11	06:08	06:28	06:57	07:27	07:58	07:33	07:56
	17:47	18:24	19:54	20:24	20:53	21:08	20:56	20:17	19:25	18:40	17:12	17:16
28	07:48	07:11	07:27	06:40	06:10	06:08	06:29	06:58	07:28	07:59	07:34	07:56
	17:48	18:25	19:55	20:25	20:54	21:08	20:55	20:16	19:24	18:38	17:11	17:17
29	07:47		07:25	06:38	06:10	06:08	06:30	06:59	07:29	08:00	07:35	07:57
	17:50		19:56	20:26	20:55	21:08	20:54	20:14	19:22	18:37	17:11	17:17
30	07:46		07:24	06:37	06:09	06:09	06:31	07:00	07:30	08:01	07:36	07:57
	17:51		19:57	20:27	20:56	21:08	20:53	20:13	19:20	18:36	17:11	17:18
31	07:46		07:22		06:09		06:32	07:01		08:02		07:57
	17:52		19:58		20:56		20:52	20:11		18:35		17:19
Potential sun hours	300	299	370	397	446	449	456	427	374	346	300	291
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

Licensed user:
EAPC Architects Engineers
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar per WTG

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **WTG:** 48 - NORDEX N100 2500 100.0 101 hub: 100.0 m (17)

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	565	509	493	476	694	1,088	968	1,008	823	686	8,052

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:57 16:23-16:49/26 17:20	07:45 16:37-17:18/41 17:53	07:10 17:10-17:28/18 18:26	07:20 19:59	06:36 20:28	06:06 20:57	06:09 21:08	06:33 20:51	07:02 20:09	07:31 19:19	07:04 16:22-17:02/40 17:33	07:37 16:06-16:39/33 17:10
2	07:58 16:23-16:50/27 17:21	07:44 16:39-17:21/42 17:55	07:08 17:13-17:24/11 18:27	07:19 20:00	06:35 20:29	06:06 20:58	06:10 21:08	06:33 20:50	07:03 20:08	07:32 19:17	07:05 16:21-17:01/40 17:32	07:38 16:06-16:39/33 17:10
3	07:58 16:23-16:50/27 17:22	07:43 16:42-17:23/41 17:56	07:07 18:28	07:17 20:00	06:33 20:30	06:06 20:58	06:10 21:08	06:34 20:49	07:04 20:06	07:33 19:15	07:06 16:20-17:00/40 17:31	07:39 16:07-16:39/32 17:10
4	07:58 16:23-16:51/28 17:22	07:42 16:47-17:25/36 17:57	07:05 18:30	07:16 20:01	06:32 20:31	06:07 20:58	06:11 21:08	06:35 20:48	07:05 20:05	07:34 19:14	07:07 16:19-16:58/39 17:30	07:40 16:08-16:39/31 17:10
5	07:58 16:23-16:52/29 17:23	07:41 16:47-17:26/39 17:58	07:04 18:31	07:14 20:02	06:31 20:32	06:07 21:00	06:11 21:08	06:36 20:47	07:06 20:03	07:35 19:12	07:08 16:18-16:57/39 17:29	07:41 16:09-16:39/30 17:10
6	07:58 16:23-16:53/30 17:24	07:40 16:48-17:27/39 17:59	07:02 18:32	07:12 20:03	06:30 20:33	06:07 21:01	06:12 21:08	06:37 20:45	07:07 20:02	07:36 19:11	07:08 16:18-16:56/38 17:28	07:42 16:09-16:39/30 17:10
7	07:58 16:24-16:54/30 17:25	07:39 16:49-17:28/39 18:01	07:01 18:33	07:11 20:04	06:29 20:34	06:06 21:01	06:13 21:07	06:38 20:44	07:08 20:00	07:37 19:09	07:11 16:17-16:55/38 17:27	07:43 16:10-16:39/29 17:09
8	07:58 16:24-16:55/31 17:26	07:37 16:50-17:30/40 18:02	07:00 18:35	07:09 20:05	06:28 20:35	06:06 21:02	06:13 21:07	06:39 20:43	07:09 19:57	07:38 19:07	07:12 16:11-16:53/42 17:26	07:44 16:11-16:39/28 17:09
9	07:57 16:24-16:56/32 17:27	07:36 16:52-17:32/40 18:03	07:57 19:36	07:08 20:06	06:26 20:36	06:06 21:02	06:14 21:07	06:40 20:42	07:10 19:55	07:39 19:06	07:13 16:09-16:51/42 17:25	07:45 16:12-16:40/28 17:09
10	07:57 16:24-16:57/33 17:28	07:35 16:54-17:33/39 18:04	07:56 19:38	07:06 20:07	06:25 20:37	06:06 21:03	06:14 21:06	06:41 20:41	07:11 19:53	07:40 19:04	07:14 16:08-16:49/41 17:24	07:46 16:13-16:40/27 17:10
11	07:57 16:24-16:58/32 17:29	07:34 16:55-17:35/40 18:05	07:54 19:37	07:04 20:08	06:24 20:39	06:06 21:03	06:15 21:06	06:42 20:39	07:12 19:52	07:41 19:03	07:15 16:06-16:49/43 17:23	07:47 16:14-16:40/26 17:10
12	07:57 16:24-16:57/33 17:30	07:33 16:54-17:35/41 18:07	07:53 19:38	07:03 20:09	06:23 20:39	06:05 21:04	06:16 21:06	06:43 20:38	07:12 19:50	07:42 17:45-17:59/14 18:01	07:16 16:05-16:48/43 17:22	07:47 16:14-16:39/25 17:10
13	07:56 16:25-16:58/33 17:31	07:32 16:54-17:36/42 18:08	07:51 19:39	07:01 20:10	06:22 20:40	06:05 21:04	06:17 21:05	06:44 20:37	07:13 19:48	07:43 17:43-18:02/19 19:00	07:17 16:04-16:48/44 17:21	07:48 16:14-16:40/26 17:10
14	07:56 16:24-16:58/34 17:32	07:30 16:54-17:37/43 18:09	07:50 19:40	07:00 20:11	06:21 20:41	06:05 21:05	06:17 21:05	06:45 20:36	07:14 19:47	07:44 17:40-18:04/24 18:58	07:19 16:03-16:48/45 17:20	07:49 16:15-16:40/25 17:10
15	07:56 16:25-17:01/36 17:34	07:29 16:55-17:38/43 18:10	07:48 19:41	06:58 20:12	06:20 20:42	06:05 21:06	06:18 21:04	06:46 20:34	07:15 19:45	07:46 17:37-18:06/28 18:57	07:20 16:03-16:49/46 17:19	07:50 16:16-16:41/25 17:10
16	07:55 16:25-17:03/38 17:35	07:28 16:54-17:37/43 18:11	07:46 19:42	06:57 20:13	06:19 20:43	06:05 21:06	06:19 21:04	06:47 20:33	07:16 19:43	07:46 17:34-18:08/32 18:55	07:21 16:03-16:48/45 17:18	07:50 16:16-16:40/24 17:11
17	07:55 16:26-17:06/40 17:36	07:27 16:55-17:38/43 18:13	07:45 19:43	06:55 20:14	06:18 20:44	06:05 21:06	06:20 21:03	06:48 20:32	07:17 19:42	07:47 17:32-18:09/34 18:54	07:22 16:02-16:48/46 17:16	07:51 16:17-16:41/24 17:11
18	07:55 16:25-17:07/42 17:37	07:25 16:55-17:38/43 18:14	07:43 19:44	06:54 20:15	06:16 20:45	06:06 21:07	06:20 21:02	06:49 20:30	07:18 19:40	07:48 17:30-18:07/37 18:52	07:23 16:02-16:47/45 17:17	07:52 16:18-16:42/24 17:11
19	07:54 16:26-17:09/43 17:38	07:24 16:55-17:37/42 18:15	07:41 19:46	06:52 20:16	06:17 20:46	06:06 21:07	06:21 21:02	06:50 20:29	07:19 19:38	07:49 17:29-18:07/38 18:51	07:24 16:03-16:48/45 17:16	07:52 16:18-16:41/23 17:12
20	07:54 16:26-17:10/44 17:39	07:23 16:56-17:38/42 18:16	07:40 19:47	06:51 20:17	06:16 20:47	06:06 21:07	06:22 21:01	06:51 20:27	07:20 19:37	07:50 17:27-18:07/40 18:49	07:25 16:02-16:47/46 17:16	07:53 16:19-16:42/23 17:12
21	07:53 16:26-17:11/45 17:40	07:21 16:56-17:37/41 18:17	07:38 19:48	06:50 20:18	06:15 20:48	06:06 21:07	06:23 21:00	06:52 20:26	07:21 19:35	07:51 17:26-18:07/41 18:48	07:27 16:02-16:47/45 17:15	07:53 16:19-16:42/23 17:13
22	07:52 16:27-17:12/45 17:41	07:20 16:57-17:37/40 18:18	07:37 19:49	06:48 20:19	06:14 20:49	06:06 21:08	06:24 21:00	06:53 20:25	07:22 19:33	07:52 17:26-18:08/42 18:46	07:28 16:02-16:46/44 17:14	07:54 16:20-16:43/23 17:13
23	07:52 16:28-17:13/45 17:43	07:18 16:58-17:37/39 18:19	07:35 19:50	06:47 20:20	06:14 20:50	06:06 21:08	06:25 20:59	06:53 20:23	07:23 19:32	07:54 17:25-18:08/43 18:45	07:29 16:02-16:45/43 17:14	07:54 16:20-16:43/23 17:14
24	07:51 16:28-17:13/45 17:44	07:17 16:59-17:35/36 18:21	07:33 19:51	06:45 20:21	06:13 20:51	06:07 21:08	06:25 20:58	06:54 20:22	07:24 19:30	07:55 17:25-18:08/43 18:44	07:30 16:03-16:45/42 17:13	07:55 16:20-16:43/23 17:14
25	07:50 16:29-17:15/46 17:45	07:15 17:01-17:35/34 18:22	07:32 19:52	06:44 20:22	06:12 20:51	06:07 21:08	06:26 20:57	06:55 20:20	07:25 19:29	07:56 17:24-18:07/43 18:42	07:31 16:04-16:44/40 17:13	07:55 16:21-16:45/24 17:15
26	07:50 16:30-17:15/46 17:46	07:14 17:03-17:33/30 18:23	07:30 19:53	06:43 20:23	06:12 20:52	06:07 21:08	06:27 20:57	06:56 20:19	07:26 19:27	07:57 17:24-18:07/43 18:41	07:32 16:04-16:42/38 17:12	07:56 16:21-16:45/24 17:15
27	07:49 16:30-17:16/46 17:47	07:13 17:05-17:32/26 18:24	07:28 19:54	06:41 20:24	06:11 20:53	06:08 21:08	06:28 20:56	06:57 20:17	07:27 19:25	07:58 17:23-18:06/43 18:40	07:33 16:04-16:40/36 17:12	07:56 16:21-16:45/24 17:16
28	07:48 16:31-17:16/45 17:49	07:11 17:08-17:30/22 18:25	07:27 19:55	06:40 20:25	06:10 20:54	06:08 21:08	06:29 20:55	06:58 20:16	07:28 19:24	07:59 17:24-18:06/42 18:38	07:34 16:04-16:38/34 17:11	07:56 16:22-16:47/25 17:17
29	07:47 16:32-17:16/44 17:50		07:25 19:56	06:39 20:26	06:10 20:55	06:08 21:08	06:30 20:54	06:59 20:14	07:29 19:22	08:00 17:24-18:06/42 18:37	07:35 16:05-16:38/33 17:11	07:57 16:22-16:47/25 17:17
30	07:46 16:33-17:17/44 17:51		07:24 19:57	06:37 20:27	06:09 20:55	06:09 21:08	06:31 20:53	07:00 20:13	07:30 19:20	08:01 17:24-18:05/41 18:36	07:36 16:05-16:39/34 17:11	07:57 16:22-16:48/26 17:18
31	07:46 16:35-17:18/43 17:52		07:22 19:58		06:08 20:56		06:32 20:52	07:01 20:11		08:02 17:24-18:03/39 18:35		07:57 16:23-16:48/25 17:19
Potential sun hours	300	299	370	397	446	449	456	426	374	346	300	291
Sum of minutes with flicker	1161	1088	29	0	0	0	0	0	0	728	1235	811

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

Printed/Page
10/30/2009 5:00 PM / 10

Licensed user:
EAPC Architects Engineers
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar per WTG

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **WTG:** 49 - NORDEX N100 2500 100.0 (OI hub: 100.0 m (18)

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	565	509	493	476	694	1,088	968	1,008	823	686	8,052

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:57	07:45	07:10	07:20	06:36	06:08	06:09	06:33	07:02	07:31	07:04	07:37
	17:20	17:53	18:26	19:59	20:28	20:57	21:08	20:51	20:09	19:19	17:33	17:10
2	07:57	07:44	07:08	07:19	06:35	06:08	06:10	06:33	07:03	07:32	07:05	07:38
	17:21	17:55	18:27	20:00	20:29	20:58	21:08	20:50	20:08	19:17	17:32	17:10
3	07:58	07:43	07:07	07:17	06:33	06:08	06:10	06:34	07:04	07:33	07:06	07:39
	17:22	17:56	18:28	20:00	20:30	20:58	21:08	20:49	20:06	19:15	17:31	17:10
4	07:58	07:42	07:05	07:15	06:32	06:07	06:11	06:35	07:05	07:34	07:07	07:40
	17:22	17:57	18:30	20:01	20:31	20:59	21:08	20:48	20:05	19:14	17:30	17:10
5	07:58	07:41	07:04	07:14	06:31	06:07	06:11	06:36	07:06	07:35	07:08	07:41
	17:23	17:58	18:31	20:02	20:32	21:00	21:08	20:47	20:03	19:12	17:29	17:10
6	07:58	07:40	07:02	07:12	06:30	06:07	06:12	06:37	07:07	07:36	07:09	07:42
	17:24	17:59	18:32	20:03	20:33	21:00	21:08	20:45	20:01	19:11	17:28	17:10
7	07:58	07:39	07:01	07:11	06:29	06:06	06:13	06:38	07:08	07:37	07:10	07:43
	17:25	18:01	18:33	20:04	20:34	21:01	21:07	20:44	20:00	19:09	17:27	17:09
8	07:57	07:37	07:59	07:09	06:28	06:06	06:13	06:39	07:09	07:38	07:12	07:44
	17:26	18:02	19:34	20:05	20:35	21:02	21:07	20:43	19:57	19:07	17:26	17:09
9	07:57	07:36	07:57	07:08	06:26	06:06	06:14	06:40	07:10	07:39	07:13	07:45
	17:27	18:03	19:35	20:06	20:36	21:02	21:07	20:42	19:55	19:06	17:25	17:09
10	07:57	07:35	07:56	07:06	06:25	06:06	06:14	06:41	07:11	07:40	07:14	07:46
	17:28	18:04	19:36	20:07	20:37	21:03	21:06	20:41	19:53	19:04	17:24	17:09
11	07:57	07:34	07:54	07:04	06:24	06:06	06:15	06:42	07:12	07:41	07:15	07:47
	17:29	18:05	19:37	20:08	20:38	21:03	21:06	20:39	19:52	19:03	17:23	17:10
12	07:57	07:33	07:53	07:03	06:23	06:05	06:16	06:43	07:12	07:42	07:16	07:47
	17:30	18:07	19:38	20:09	20:39	21:04	21:06	20:38	19:50	19:01	17:22	17:10
13	07:56	07:32	07:51	07:01	06:22	06:05	06:17	06:44	07:13	07:43	07:17	07:48
	17:31	18:08	19:39	20:10	20:40	21:04	21:05	20:37	19:48	19:00	17:21	17:10
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	17:32	18:09	19:40	20:11	20:41	21:05	21:05	20:36	19:47	18:58	17:20	17:10
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	17:33	18:10	19:41	20:12	20:42	21:05	21:04	20:34	19:45	18:57	17:19	17:10
16	07:55	07:28	07:46	06:57	06:19	06:05	06:19	06:47	07:16	07:46	07:21	07:50
	17:35	18:11	19:42	20:13	20:43	21:06	21:04	20:33	19:43	18:55	17:18	17:11
17	07:55	07:27	07:45	06:55	06:18	06:05	06:20	06:48	07:17	07:47	07:22	07:51
	17:36	18:13	19:43	20:14	20:44	21:06	21:03	20:32	19:42	18:54	17:18	17:11
18	07:54	07:25	07:43	06:54	06:18	06:05	06:20	06:49	07:18	07:48	07:23	07:52
	17:37	18:14	19:44	20:15	20:45	21:06	21:02	20:30	19:40	18:52	17:17	17:11
19	07:54	07:24	07:41	06:52	06:17	06:06	06:21	06:50	07:19	07:49	07:24	07:52
	17:38	18:15	19:45	20:16	20:46	21:07	21:02	20:29	19:38	18:51	17:16	17:12
20	07:53	07:23	07:40	06:51	06:16	06:06	06:22	06:51	07:20	07:50	07:25	07:53
	17:39	18:16	19:47	20:17	20:47	21:07	21:01	20:27	19:37	18:49	17:15	17:12
21	07:53	07:21	07:38	06:49	06:15	06:06	06:23	06:52	07:21	07:51	07:27	07:53
	17:40	18:17	19:48	20:18	20:48	21:07	21:00	20:26	19:35	18:48	17:15	17:13
22	07:52	07:20	07:37	06:48	06:14	06:06	06:24	06:53	07:22	07:52	07:28	07:54
	17:41	18:18	19:49	20:19	20:49	21:08	21:00	20:25	19:33	18:46	17:14	17:13
23	07:52	07:18	07:35	06:47	06:14	06:06	06:24	06:53	07:23	07:54	07:29	07:54
	17:43	18:19	19:50	20:20	20:50	21:08	20:59	20:23	19:32	18:45	17:14	17:14
24	07:51	07:17	07:33	06:45	06:13	06:07	06:25	06:54	07:24	07:55	07:30	07:55
	17:44	18:21	19:51	20:21	20:50	21:08	20:58	20:22	19:30	18:44	17:13	17:14
25	07:50	07:16	07:32	06:44	06:12	06:07	06:26	06:55	07:25	07:56	07:31	07:55
	17:45	18:22	19:52	20:22	20:51	21:08	20:57	20:20	19:28	18:42	17:13	17:15
26	07:50	07:14	07:30	06:42	06:12	06:07	06:27	06:56	07:26	07:57	07:32	07:56
	17:46	18:23	19:53	20:23	20:52	21:08	20:56	20:19	19:27	18:41	17:12	17:15
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	17:47	18:24	19:54	20:24	20:53	21:08	20:56	20:17	19:25	18:40	17:12	17:16
28	07:48	07:11	07:27	06:40	06:10	06:08	06:29	06:58	07:28	07:59	07:34	07:56
	17:49	18:25	19:55	20:25	20:54	21:08	20:55	20:16	19:24	18:38	17:11	17:17
29	07:47		07:25	06:38	06:10	06:08	06:30	06:59	07:29	08:00	07:35	07:57
	17:50		19:56	20:26	20:55	21:08	20:54	20:14	19:22	18:37	17:11	17:17
30	07:46		07:24	06:37	06:09	06:09	06:31	07:00	07:30	08:01	07:36	07:57
	17:51		19:57	20:27	20:55	21:08	20:53	20:13	19:20	18:36	17:11	17:18
31	07:45		07:22		06:09		06:32	07:01		08:02		07:57
	17:52		19:58		20:56		20:52	20:11		18:35		17:19
Potential sun hours	300	299	370	397	446	449	456	426	374	346	300	291
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

Printed/Page
10/30/2009 5:00 PM / 11

Licensed user:
EAPC Architects Engineers
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar per WTG

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **WTG:** 50 - NORDEX N100 2500 100.0 (OI hub, 100.0 m (319)

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	585	509	493	476	694	1,088	968	1,008	823	686	8,052

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:57	07:45	07:10	07:20	06:36	06:08	06:09	06:33	07:02	07:31	07:04	07:37
	17:20	17:53	18:26	19:59	20:28	20:57	21:08	20:51	20:09	19:19	17:34	17:10
2	07:58	07:44	07:08	07:19	06:35	06:08	06:10	06:34	07:03	07:32	07:05	07:38
	17:21	17:55	18:27	20:00	20:29	20:58	21:08	20:50	20:08	19:17	17:32	17:10
3	07:58	07:43	07:07	07:17	06:34	06:08	06:10	06:34	07:04	07:33	07:06	07:39
	17:22	17:56	18:28	20:00	20:30	20:58	21:08	20:49	20:06	19:15	17:31	17:10
4	07:58	07:42	07:05	07:16	06:32	06:07	06:11	06:35	07:05	07:34	07:07	07:40
	17:23	17:57	18:30	20:01	20:31	20:59	21:08	20:48	20:05	19:14	17:30	17:10
5	07:58	07:41	07:04	07:14	06:31	06:07	06:11	06:36	07:06	07:35	07:08	07:41
	17:23	17:58	18:31	20:02	20:32	21:00	21:08	20:47	20:03	19:12	17:29	17:10
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	17:24	17:59	18:32	20:03	20:33	21:01	21:08	20:46	20:02	19:11	17:28	17:10
7	07:58	07:39	07:01	07:11	06:29	06:06	06:13	06:38	07:08	07:37	07:11	07:43
	17:25	18:01	18:33	20:04	20:34	21:01	21:07	20:44	20:00	19:09	17:27	17:10
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	17:26	18:02	19:34	20:05	20:35	21:02	21:07	20:43	19:57	19:07	17:26	17:10
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	17:28	18:04	19:36	20:07	20:37	21:03	21:06	20:41	19:53	19:04	17:24	17:10
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	17:32	18:09	19:40	20:11	20:41	21:05	21:05	20:36	19:47	18:58	17:20	17:10
15	07:56	07:29	07:48	06:58	06:20	06:05	06:18	06:46	07:15	07:45	07:20	07:50
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16	07:55	07:28	07:46	06:57	06:19	06:05	06:19	06:47	07:16	07:46	07:21	07:50
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	17:36	18:13	19:43	20:14	20:44	21:06	21:03	20:32	19:42	18:54	17:18	17:11
18	07:55	07:25	07:43	06:54	06:18	06:06	06:20	06:49	07:18	07:48	07:23	07:52
	17:37	18:14	19:45	20:15	20:45	21:07	21:03	20:30	19:40	18:52	17:17	17:11
19	07:54	07:24	07:42	06:52	06:17	06:06	06:21	06:50	07:19	07:49	07:24	07:52
	17:38	18:15	19:46	20:16	20:46	21:07	21:02	20:29	19:39	18:51	17:16	17:12
20	07:54	07:23	07:40	06:51	06:16	06:06	06:22	06:51	07:20	07:50	07:25	07:53
	17:39	18:16	19:47	20:17	20:47	21:07	21:01	20:27	19:37	18:49	17:16	17:12
21	07:53	07:21	07:38	06:50	06:15	06:06	06:23	06:52	07:21	07:51	07:27	07:53
	17:40	18:17	19:48	20:18	20:48	21:07	21:00	20:26	19:35	18:48	17:15	17:13
22	07:52	07:20	07:37	06:48	06:14	06:06	06:24	06:53	07:22	07:52	07:28	07:54
	17:42	18:18	19:49	20:19	20:49	21:06	21:00	20:25	19:34	18:47	17:14	17:13
23	07:52	07:18	07:35	06:47	06:14	06:06	06:25	06:54	07:23	07:54	07:29	07:54
	17:43	18:20	19:50	20:20	20:50	21:06	20:59	20:23	19:32	18:45	17:14	17:14
24	07:51	07:17	07:33	06:45	06:13	06:07	06:25	06:55	07:24	07:55	07:30	07:55
	17:44	18:21	19:51	20:21	20:51	21:06	20:58	20:22	19:30	18:44	17:13	17:14
25	07:50	07:16	07:32	06:44	06:12	06:07	06:26	06:55	07:25	07:56	07:31	07:55
	17:45	18:22	19:52	20:22	20:51	21:06	20:57	20:20	19:29	18:42	17:13	17:15
26	07:50	07:14	07:30	06:43	06:12	06:07	06:27	06:56	07:26	07:57	07:32	07:56
	17:46	18:23	19:53	20:23	20:52	21:06	20:57	20:19	19:27	18:41	17:12	17:15
27	07:49	07:13	07:28	06:41	06:11	06:08	06:28	06:57	07:27	07:58	07:33	07:56
	17:47	18:24	19:54	20:24	20:53	21:06	20:56	20:17	19:25	18:40	17:12	17:16
28	07:48	07:11	07:27	06:40	06:10	06:08	06:29	06:58	07:28	07:59	07:34	07:56
	17:49	18:25	19:55	20:25	20:54	21:06	20:55	20:16	19:24	18:38	17:11	17:17
29	07:47		07:25	06:39	06:10	06:09	06:30	06:59	07:29	08:00	07:35	07:57
	17:50		19:56	20:26	20:55	21:06	20:54	20:14	19:22	18:37	17:11	17:17
30	07:46		07:24	06:37	06:09	06:09	06:31	07:00	07:30	08:01	07:36	07:57
	17:51		19:57	20:27	20:55	21:06	20:53	20:13	19:20	18:36	17:11	17:18
31	07:46		07:22		06:09		06:32	07:01		08:03		07:57
	17:52		19:58		20:56		20:52	20:11		18:35		17:19
Potential sun hours	300	299	370	397	445	449	456	426	374	348	300	291
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

Printed/Page
10/30/2009 5:00 PM / 12

Licensed user:
EAPC Architects Engineers
3100 DeMers Avenue
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar per WTG

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **WTG:** 52 - NORDEX N100 2500 100.0 101 hub: 100.0 m (221)

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	565	509	493	476	694	1,088	968	1,008	823	686	8,052

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:57	07:45	07:10	07:20	06:36	06:08	06:09	06:33	07:02	07:31	07:04	07:37
	17:20	17:53	18:26	19:59	20:28	20:57	21:08	20:51	20:09	19:19	17:33	17:10
2	07:57	07:44	07:08	07:19	06:35	06:08	06:10	06:33	07:03	07:32	07:05	07:38
	17:21	17:55	18:27	20:00	20:29	20:58	21:08	20:50	20:08	19:17	17:32	17:10
3	07:58	07:43	07:07	07:17	06:33	06:08	06:10	06:34	07:04	07:33	07:06	07:39
	17:22	17:56	18:28	20:00	20:30	20:58	21:08	20:49	20:06	19:15	17:31	17:10
4	07:58	07:42	07:05	07:15	06:32	06:07	06:11	06:35	07:05	07:34	07:07	07:40
	17:22	17:57	18:29	20:01	20:31	20:59	21:08	20:48	20:05	19:14	17:30	17:10
5	07:58	07:41	07:04	07:14	06:31	06:07	06:11	06:36	07:06	07:35	07:08	07:41
	17:23	17:58	18:31	20:02	20:32	21:00	21:08	20:47	20:03	19:12	17:29	17:10
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7	07:58	07:39	07:01	07:11	06:29	06:08	06:13	06:38	07:08	07:37	07:10	07:43
	17:25	18:01	18:33	20:04	20:34	21:01	21:07	20:44	20:00	19:09	17:27	17:09
8	07:57	07:37	07:59	07:09	06:28	06:06	06:13	06:39	07:09	07:38	07:12	07:44
	17:26	18:02	19:34	20:05	20:35	21:02	21:07	20:43	19:57	19:07	17:26	17:09
9	07:57	07:36	07:57	07:08	06:26	06:06	06:14	06:40	07:10	07:39	07:13	07:45
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	17:30	18:07	19:38	20:09	20:39	21:04	21:06	20:38	19:50	19:01	17:22	17:10
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	17:32	18:09	19:40	20:11	20:41	21:05	21:05	20:36	19:47	18:58	17:20	17:10
15	07:56	07:29	07:48	06:58	06:20	06:05	06:18	06:46	07:15	07:45	07:20	07:50
	17:33	18:10	19:41	20:12	20:42	21:05	21:04	20:34	19:45	18:57	17:19	17:10
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	17:44	18:21	19:51	20:21	20:50	21:08	20:58	20:22	19:30	18:44	17:13	17:14
25	07:50	07:16	07:32	06:44	06:12	06:07	06:26	06:55	07:25	07:56	07:31	07:55
	17:45	18:22	19:52	20:22	20:51	21:08	20:57	20:20	19:28	18:42	17:13	17:15
26	07:50	07:14	07:30	06:42	06:12	06:07	06:27	06:56	07:26	07:57	07:32	07:56
	17:46	18:23	19:53	20:23	20:52	21:08	20:56	20:19	19:27	18:41	17:12	17:15
27	07:49	07:13	07:28	06:41	06:11	06:08	06:28	06:57	07:27	07:58	07:33	07:56
	17:47	18:24	19:54	20:24	20:53	21:08	20:56	20:17	19:25	18:40	17:12	17:16
28	07:48	07:11	07:27	06:40	06:10	06:08	06:29	06:58	07:28	07:59	07:34	07:56
	17:49	18:25	19:55	20:25	20:54	21:08	20:55	20:16	19:24	18:38	17:11	17:17
29	07:47		07:25	06:39	06:10	06:08	06:30	06:59	07:29	08:00	07:35	07:57
	17:50		19:56	20:26	20:55	21:08	20:54	20:14	19:22	18:37	17:11	17:17
30	07:46		07:24	06:37	06:09	06:09	06:31	07:00	07:30	08:01	07:36	07:57
	17:51		19:57	20:27	20:55	21:08	20:53	20:13	19:20	18:36	17:11	17:18
31	07:45		07:22		06:09		06:32	07:01		08:02		07:57
	17:52		19:58		20:56		20:52	20:11		18:35		17:19
Potential sun hours	300	299	370	397	446	449	456	426	374	346	300	291
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
217 Montgomery Street Suite 1000
Syracuse, New York 13202

Description:

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10/30/2009 5:00 PM / 13

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+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Calendar per WTG

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **WTG:** 55 - NORDEX N100 2500 100.0 tOI hub: 100.0 m (124)

Assumptions for shadow calculations

Maximum distance for influence	1,700 m
Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sun shine probabilities (part of time from sun rise to sun set with sun shine)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.40	0.44	0.48	0.52	0.58	0.66	0.66	0.67	0.65	0.59	0.40	0.36

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
299	444	565	509	493	476	694	1,068	968	1,008	823	666	8,052

	January	February	March	April	May	June	July	August	September	October	November	December
1	07:57	07:45	07:10	07:20	06:36	06:06	06:09	06:33	07:02	07:31	07:04	07:37
	17:20	17:53	18:26	19:59	20:28	20:57	21:06	20:51	20:09	19:19	17:33	17:10
2	07:57	07:44	07:08	07:19	06:35	06:06	06:10	06:33	07:03	07:32	07:05	07:38
	17:21	17:55	18:27	20:00	20:29	20:58	21:06	20:50	20:08	19:17	17:32	17:10
3	07:58	07:43	07:07	07:17	06:33	06:06	06:10	06:34	07:04	07:33	07:06	07:39
	17:22	17:56	18:28	20:00	20:30	20:58	21:06	20:49	20:06	19:16	17:31	17:10
4	07:58	07:42	07:05	07:15	06:32	06:07	06:11	06:35	07:05	07:34	07:07	07:40
	17:22	17:57	18:29	20:01	20:31	20:59	21:06	20:48	20:05	19:14	17:30	17:10
5	07:58	07:41	07:04	07:14	06:31	06:07	06:11	06:36	07:06	07:35	07:08	07:41
	17:23	17:58	18:31	20:02	20:32	21:00	21:06	20:47	20:03	19:12	17:29	17:10
6	07:58	07:40	07:02	07:12	06:30	06:07	06:12	06:37	07:07	07:36	07:09	07:42
	17:24	17:59	18:32	20:03	20:33	21:00	21:06	20:45	20:01	19:11	17:28	17:10
7	07:58	07:38	07:01	07:11	06:29	06:06	06:13	06:38	07:08	07:37	07:10	07:43
	17:25	18:01	18:33	20:04	20:34	21:01	21:07	20:44	20:00	19:09	17:27	17:09
8	07:57	07:37	07:59	07:09	06:28	06:06	06:13	06:39	07:09	07:38	07:12	07:44
	17:26	18:02	19:34	20:05	20:35	21:02	21:07	20:43	19:57	19:07	17:26	17:09
9	07:57	07:36	07:57	07:08	06:26	06:06	06:14	06:40	07:10	07:39	07:13	07:45
	17:27	18:03	19:35	20:06	20:36	21:02	21:07	20:42	19:55	19:06	17:25	17:09
10	07:57	07:35	07:56	07:06	06:25	06:06	06:14	06:41	07:11	07:40	07:14	07:46
	17:28	18:04	19:36	20:07	20:37	21:03	21:06	20:41	19:53	19:04	17:24	17:10
11	07:57	07:34	07:54	07:04	06:24	06:06	06:15	06:42	07:12	07:41	07:15	07:47
	17:29	18:05	19:37	20:08	20:38	21:03	21:06	20:39	19:52	19:03	17:23	17:10
12	07:57	07:33	07:53	07:03	06:23	06:05	06:16	06:43	07:12	07:42	07:16	07:47
	17:30	18:07	19:38	20:09	20:39	21:04	21:06	20:38	19:50	19:01	17:22	17:10
13	07:56	07:32	07:51	07:01	06:22	06:05	06:17	06:44	07:13	07:43	07:17	07:48
	17:31	18:08	19:39	20:10	20:40	21:04	21:05	20:37	19:48	19:00	17:21	17:10
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15	07:56	07:29	07:48	06:58	06:20	06:05	06:18	06:46	07:15	07:45	07:20	07:50
	17:33	18:10	19:41	20:12	20:42	21:05	21:04	20:34	19:45	18:57	17:19	17:10
16	07:55	07:28	07:46	06:57	06:19	06:05	06:19	06:47	07:16	07:46	07:21	07:50
	17:35	18:11	19:42	20:13	20:43	21:06	21:04	20:33	19:43	18:55	17:18	17:11
17	07:55	07:27	07:45	06:55	06:18	06:05	06:20	06:48	07:17	07:47	07:22	07:51
	17:36	18:13	19:43	20:14	20:44	21:06	21:03	20:32	19:42	18:54	17:18	17:11
18	07:54	07:25	07:43	06:54	06:18	06:06	06:20	06:49	07:18	07:48	07:23	07:52
	17:37	18:14	19:44	20:15	20:45	21:06	21:02	20:30	19:40	18:52	17:17	17:11
19	07:54	07:24	07:41	06:52	06:17	06:06	06:21	06:50	07:19	07:49	07:24	07:52
	17:38	18:15	19:45	20:16	20:46	21:07	21:02	20:29	19:38	18:51	17:16	17:12
20	07:53	07:23	07:40	06:51	06:16	06:06	06:22	06:51	07:20	07:50	07:25	07:53
	17:39	18:16	19:46	20:17	20:47	21:07	21:01	20:27	19:37	18:49	17:15	17:12
21	07:53	07:21	07:38	06:49	06:15	06:06	06:23	06:52	07:21	07:51	07:27	07:53
	17:40	18:17	19:48	20:18	20:48	21:07	21:00	20:26	19:35	18:48	17:15	17:13
22	07:52	07:20	07:37	06:48	06:14	06:06	06:24	06:53	07:22	07:52	07:28	07:54
	17:41	18:18	19:49	20:19	20:49	21:08	21:00	20:24	19:33	18:46	17:14	17:13
23	07:52	07:18	07:35	06:47	06:14	06:06	06:24	06:53	07:23	07:53	07:29	07:54
	17:43	18:19	19:50	20:20	20:50	21:08	20:59	20:23	19:32	18:45	17:14	17:14
24	07:51	07:17	07:33	06:45	06:13	06:07	06:25	06:54	07:24	07:55	07:30	07:55
	17:44	18:21	19:51	20:21	20:50	21:08	20:58	20:22	19:30	18:44	17:13	17:14
25	07:50	07:16	07:32	06:44	06:12	06:07	06:26	06:55	07:25	07:56	07:31	07:55
	17:45	18:22	19:52	20:22	20:51	21:08	20:57	20:20	19:28	18:42	17:13	17:15
26	07:50	07:14	07:30	06:42	06:12	06:07	06:27	06:56	07:26	07:57	07:32	07:56
	17:46	18:23	19:53	20:23	20:52	21:08	20:56	20:19	19:27	18:41	17:12	17:15
27	07:49	07:13	07:28	06:41	06:11	06:08	06:28	06:57	07:27	07:58	07:33	07:56
	17:47	18:24	19:54	20:24	20:53	21:08	20:56	20:17	19:25	18:40	17:12	17:16
28	07:48	07:11	07:27	06:40	06:10	06:08	06:29	06:58	07:28	07:59	07:34	07:56
	17:49	18:25	19:55	20:25	20:54	21:08	20:55	20:16	19:24	18:38	17:11	17:17
29	07:47		07:25	06:38	06:10	06:08	06:30	06:59	07:29	08:00	07:35	07:57
	17:50		19:56	20:26	20:55	21:08	20:54	20:14	19:22	18:37	17:11	17:17
30	07:46		07:24	06:37	06:09	06:09	06:31	07:00	07:30	08:01	07:36	07:57
	17:51		19:57	20:27	20:55	21:08	20:53	20:13	19:20	18:36	17:11	17:18
31	07:45		07:22		06:09		06:32	07:01		08:02		07:57
	17:52		19:58		20:56		20:52	20:11		18:35		17:19
Potential sun hours	300	299	370	397	446	449	456	426	374	346	300	291
Sum of minutes with flicker	0	0	0	0	0	0	0	0	0	0	0	0

Table layout: For each day in each month the following matrix apply

Day in month		
	Sun rise (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker
	Sun set (hh:mm)	First time (hh:mm) with flicker-Last time (hh:mm) with flicker/Minutes with flicker

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
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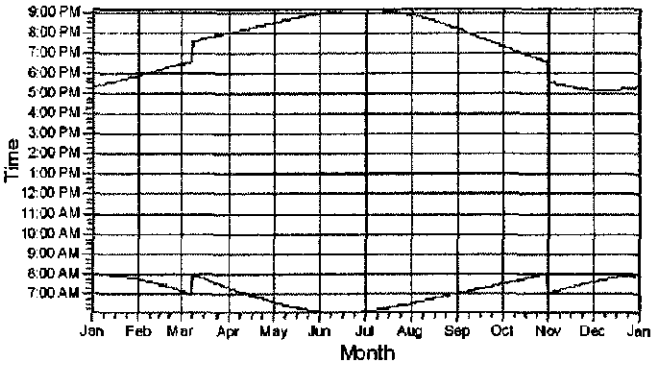
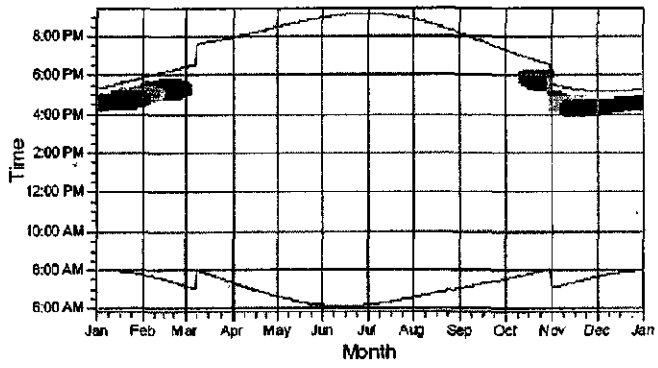
SHADOW - Calendar per WTG, graphical

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030

44: NORDEX N100 2500 100.0 !O! hub: 100.0 m (213)



48: NORDEX N100 2500 100.0 !O! hub: 100.0 m (217)



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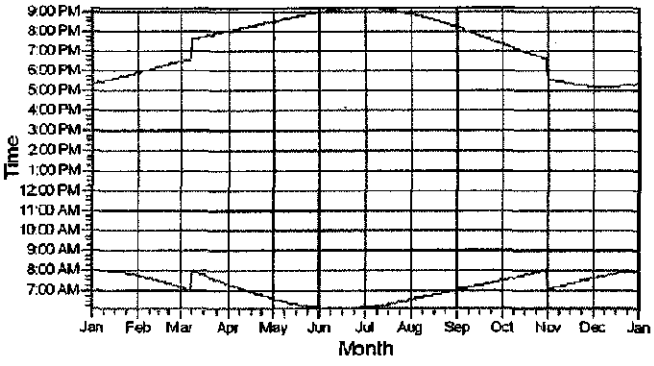
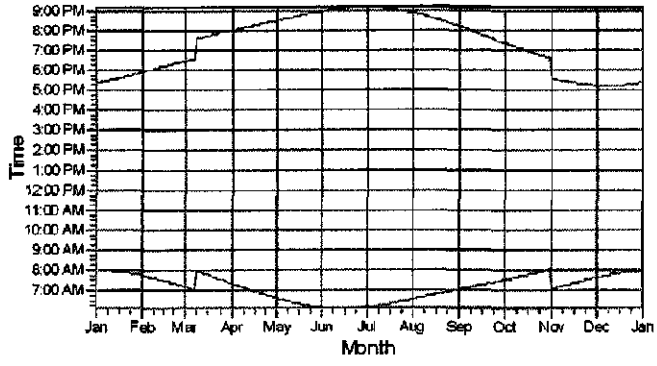
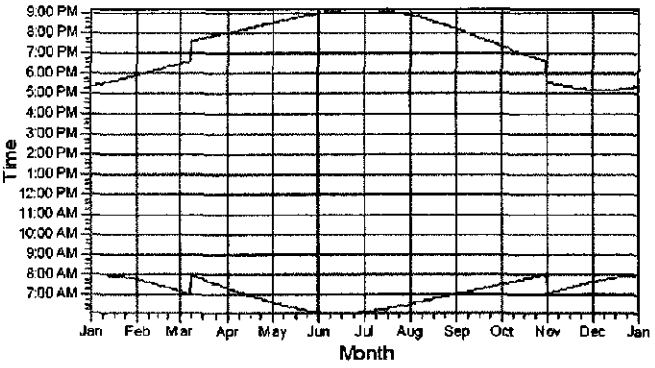


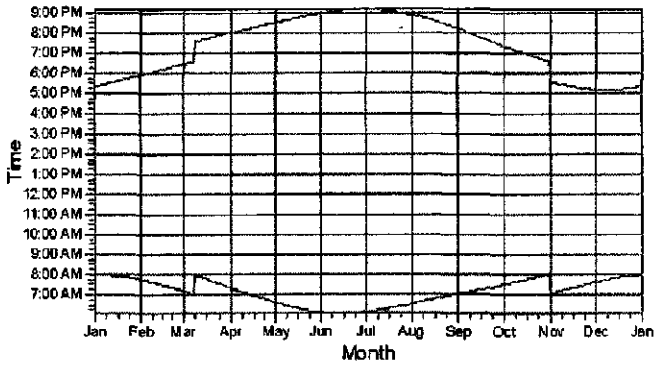
50: NORDEX N100 2500 100.0 !O! hub: 100.0 m (219)



52: NORDEX N100 2500 100.0 !O! hub: 100.0 m (221)



55: NORDEX N100 2500 100.0 !O! hub: 100.0 m (224)



Shadow receptor

- 1: Golf Course Receptor 1
- 2: Golf Course Receptor 2
- 3: Golf Course Receptor 3
- 4: Golf Course Receptor 4

Project:
Buckeye - Shadow Flicker

Environmental Design & Research
Ben Brazell
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Syracuse, New York 13202

Description:

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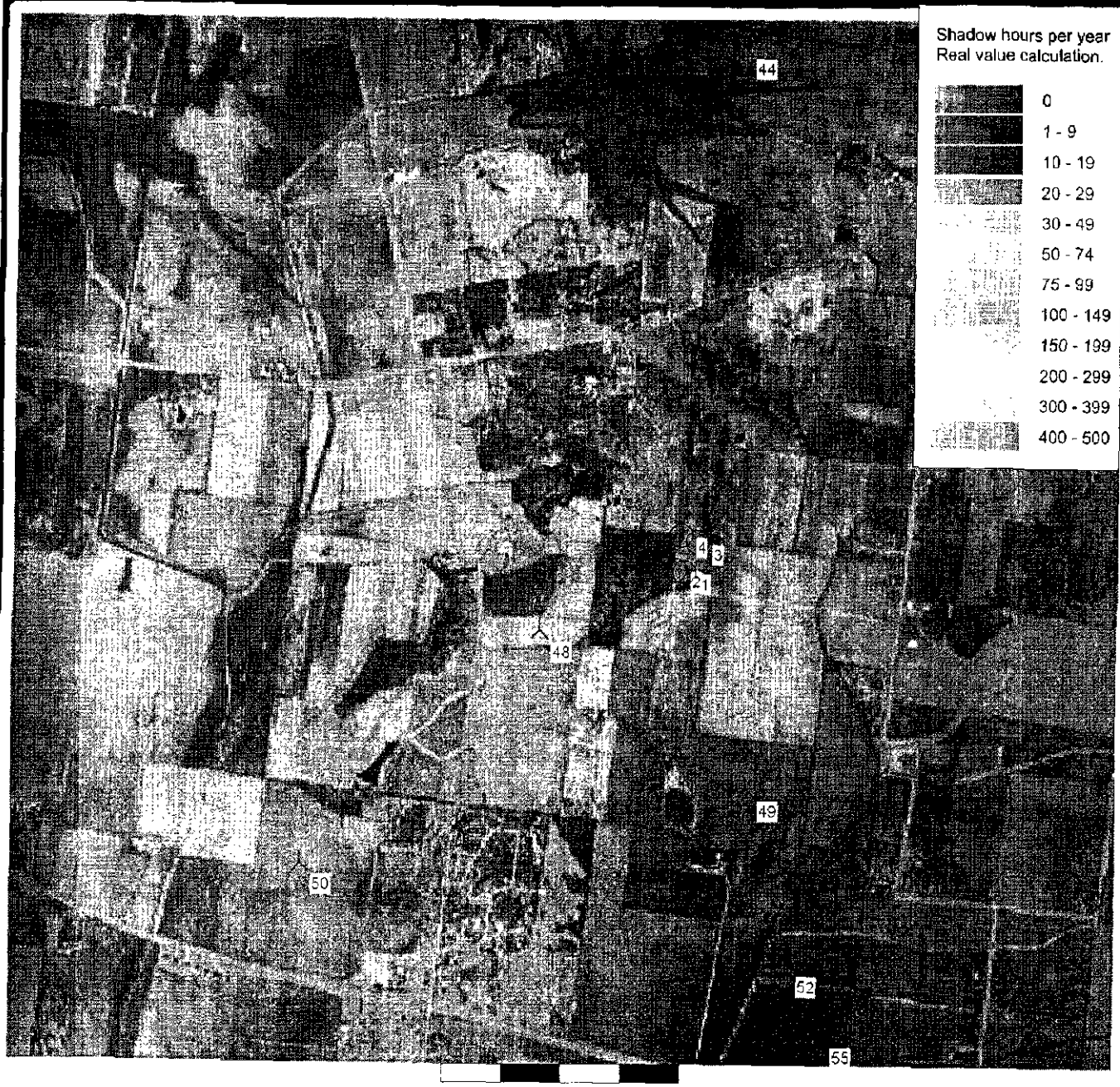
US-GRAND FORKS, ND 58201
+1 701 775 5507

Calculated:
10/30/2009 4:53 PM/2.6.1.252

SHADOW - Aerial Photo

Calculation: Shadow Flicker Point Calculation - 1700 m - Golf Course Sensors - 20091030 **File:** e254400n4505600z17b.jpg



Map. , Print scale 1:25,000, Map center UTM WGS 84 Zone: 17 East: 273,223.50 North: 4,442,395.00

New WTG
Shadow receptor

Isolines showing shadow in Shadow hours per year. Real value calculation.
0 10 25 50 100 200

Micrositing

Choosing the type of wind turbine (WTG) and its exact position are very important parts of the planning work of a wind park. This process is called *micrositing.*

During micrositing many aspects have to be regarded:

- wind conditions (statistic data concerning wind speed and wind direction)
- building requirements (e.g. distances to residences)
- ownership structure of the area
- accessibility (existing roads)
- influence of the WTG on the environment (e.g. shadow flickering, noise emission)
- distances between the individual turbines in a park

The knowledge of the wind conditions is very important for the decision about the development of a wind park. It is always the best to have measured data of the planned site for a period of at least two years. But this is not always possible. In case of a shorter measurement period wind consultants can find out the conditions by an interpolation of long-term measurements of near-by weather-stations.

Based on the information about the wind conditions it is possible to choose the type of turbine and the park layout which provides the highest energy production while keeping the external requirements. Based on a realistic forecast of the energy production it is possible to decide whether to invest in wind energy or not.

It is important to keep a distance to the next residences in order to not disturb the inhabitants by *noise emission* and *shadow flickering* of the turbine. Normally there have to be at least 500 m between the WTG and the next residence.

But it is also very important to keep the distance between the turbines in the park. A layout of a wind farm where the turbines are placed too close to each other could endanger the material and reduce the operating life of the turbines. A rotor of a WTG causes high turbulences that reduce the energy output of the next turbine. Compared with a single stand-alone turbine there are also higher loads on the following turbine because of increased turbulences in the wind park. Therefore the minimum distance between two turbines depends on the wind conditions and may be e.g. 6 rotor diameters (D) in the main wind direction and 4 diameters in other directions. As a matter of principle the turbulence intensities at the WTG should not exceed the certificated turbulence intensities.

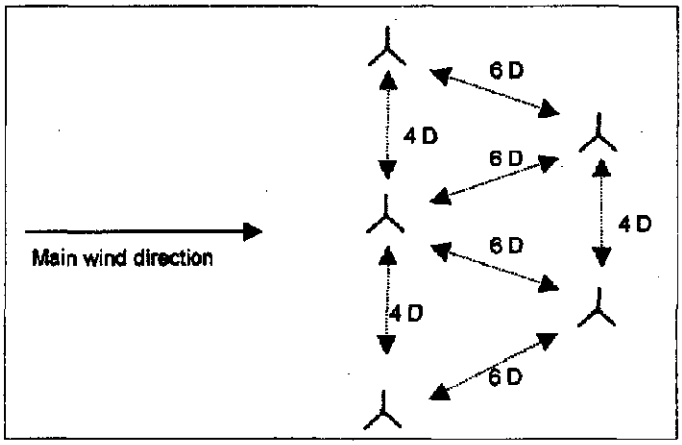


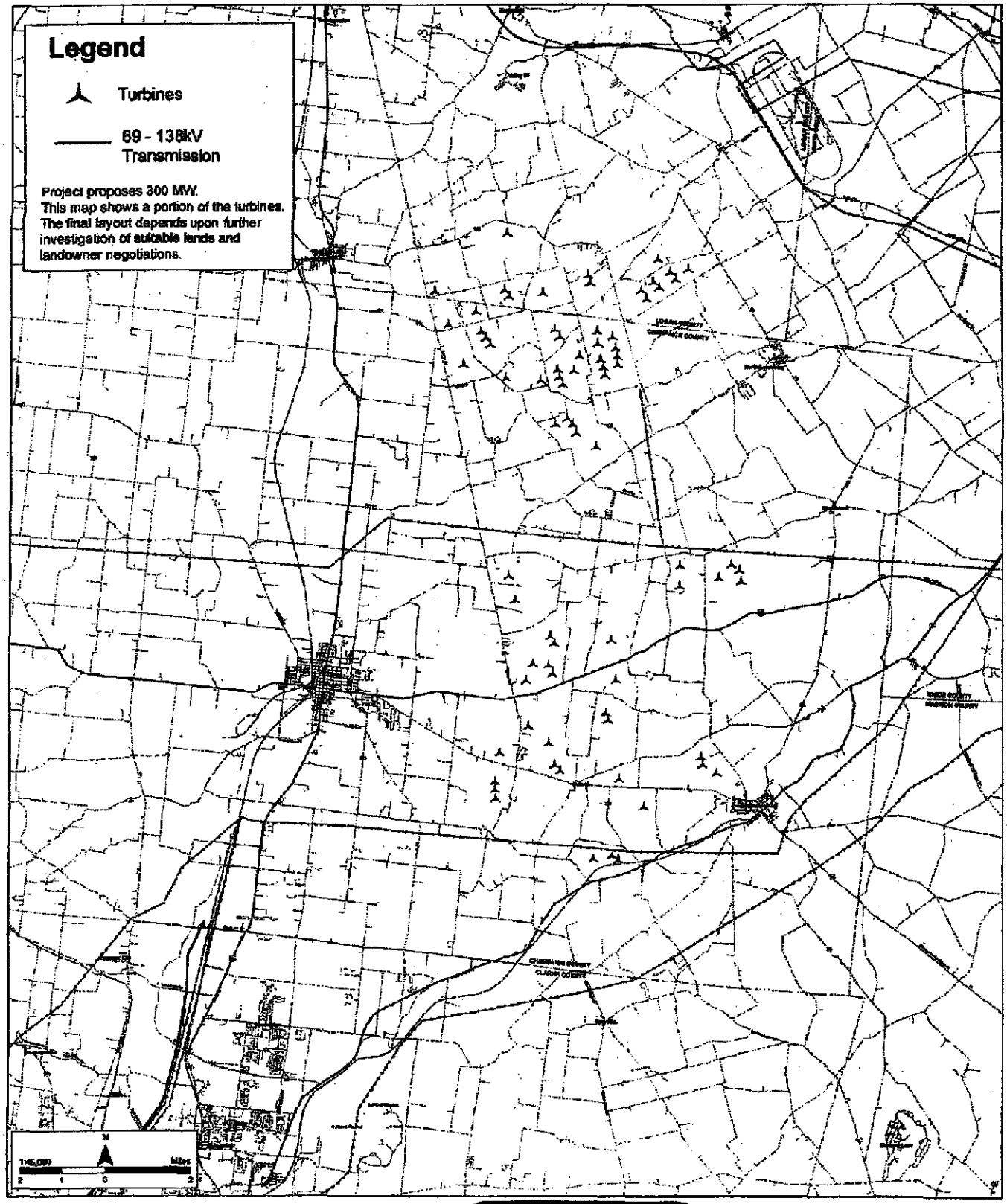
Figure 1: Distances between the turbines in a wind park

The distances between the turbines also have a strong effect on the energy output of the wind park. This effect is described by the park efficiency, the relation between the output of the park and the output of the same number of stand-alone turbines. Therefore the layout has to be planned carefully.

UNU Exhibit 12

BUCKEYE WIND PROJECT - OHIO

everpower RENEWABLES



Information on this map is provided for purposes of discussion and visualization only.

Created by Everpower Renewables on 06/05/2008
Projection: NAD83 UTM Zone 17N (m)
File: Buckeye_OpenHouse_Roads_Alt_20080605

UNU Exhibit
16

everpower

Buckeye Wind Project Fact Sheet

"...renewable sources such as wind offer us the opportunity to create jobs, support our farmers, reduce our dependence on foreign oil producers, and be responsible stewards of our environment."
– Governor Ted Strickland, March 14, 2007

Harvesting Ohio's Future

The Buckeye Wind Project, being developed by EverPower Renewables, is a wind project that will provide Ohio with one of the cleanest, most environmentally friendly energy sources available.

EverPower is one of the few companies that is developing and harvesting this natural energy source in Ohio. EverPower has reached agreements with a number of landowners in Champaign and Logan counties who are very excited about the potential the Buckeye Wind Project holds for Ohio's future.

Wind energy is the fastest growing source of energy in the world and is inexhaustible and non-polluting. Wind energy emits no greenhouse gases, uses no water or other natural resources, and is compatible with mixed land use such as grazing, agriculture, or forestry. Wind power can provide a stable pricing structure for decades because it is not subject to fuel price volatility, like energy produced from fossil fuels.

Wind Power Resources:

EverPower
www.everpower.com

Ohio Wind Working Group
www.ohiowind.org

Ohio Office of Energy Efficiency
www.odod.state.oh.us/cdd/oee

Green Energy Ohio
www.greenenergyohio.org

American Wind Energy Association
www.awea.org

EverPower Renewables Contacts:

Kevin Sheen
(866) 647-8111 (office)
(917) 679-6877 (mobile)
ksheen@everpower.com

Michael Speerschneider
(866) 647-8111 (office)
(617) 283-2226 (mobile)
mspeer@everpower.com

Wind Power in Ohio

Ohio is currently only using 1.8% of its total wind potential. Each turbine proposed for the Buckeye Wind Project could power 600-750 Ohio homes. In addition, wind turbine construction, operation, and maintenance will create new jobs, boosting the economy of the area. In fact, according to Environment Ohio, over 13,000 new manufacturing jobs could be created in Ohio with an investment in wind energy. Many of the materials, supplies, and services required during construction can be purchased locally.

Benefits to Landowners and the Community

The Ohio Department of Development cites renewable energy sources as a key to Ohio's competitiveness in recruiting and retaining businesses. Currently, the state is supporting the development of wind power through the Ohio Wind Production & Manufacturing Incentive Program of Ohio's Advanced Energy Fund.

Wind energy provides farming communities with a new source of long-term revenue with little impact to existing agricultural operations. A modern, utility-scale wind turbine provides about $10,000 to $12,000 in income to a landowner leasing his wind rights. Farmers can continue to grow crops up to the base of the turbines located on their land. This boost to Ohio's rural economies and the additional income for farmers will reinvigorate rural Ohio.

Finally, tax payments from wind projects to school districts, town, and county or state governments will improve local services and reduce tax burdens on local residents.

everpower RENEWABLES

Buckeye Wind Project: Agriculture, Hunting and Fishing Fact Sheet

Agricultural operations and woodlands, streams and other natural habitats exist within the project area. Many residents within the project area own or work on farms, and many like to hunt and fish.

Most of the wind turbines and access roads within the Buckeye Wind Power project area will be located in active agricultural fields. The choice of farm fields for placing wind turbines results from several criteria used in picking the locations, including maximizing the energy yield of each turbine, conforming to setbacks, and minimizing adverse impacts to forests, streams, wetlands and other natural areas.

How will agricultural operations be affected?

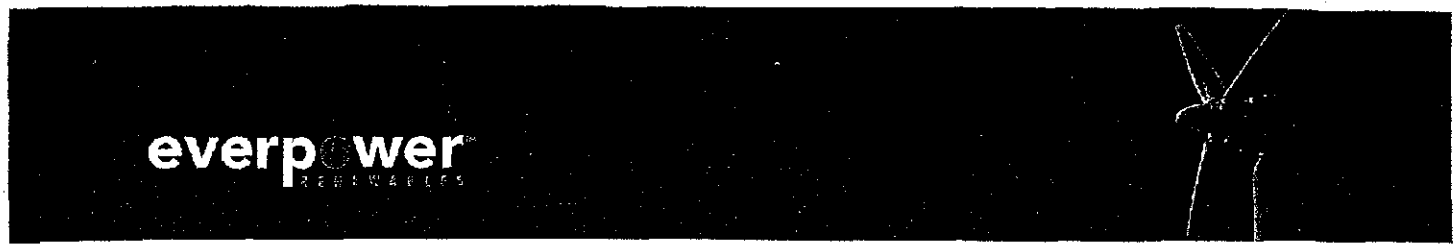
During construction, an area of approximately two to three acres will be cleared and graded in preparation for equipment delivery, foundation construction, and assembly. Once the turbine is in operation, the circular 'footprint' of the turbine and the access drive is approximately one-half acre. Agricultural activities can continue right up to the turbine footprint and the edge of the access road.

Wherever possible, construction access roads will be located on existing farm lanes, minimizing obstructions to row cropping. Where new access roads must be constructed, the landowners will be consulted so as to locate the roads in areas that will result in minimum disruption to the property.

How will hunting and fishing be affected?

Wind turbines are not known to affect game populations. In addition, because impacts to streams (e.g., from construction of stream crossings) will be avoided wherever possible and unavoidable impacts will be minimized, the project will have negligible impact on fishing opportunities.

75 Ninth Avenue, Suite 3G New York, NY 10011 Tel: 212.647.8111 Fax: 212.647.9433 www.everpower.com



Buckeye Wind Project: Ecological Survey Fact Sheet

EverPower will work with the Ohio Department of Natural Resources, the US Fish and Wildlife Service and other agencies to appropriately avoid and minimize impacts to natural habitats.

Avoiding Impacts to Wetlands, Streams and Other Habitats

EverPower's process for choosing turbine locations begins with a general understanding of the range of wetland, stream and other natural habitat types and their landscape positions in the project area.

The next step in avoidance planning involves using aerial photographs and maps to select preliminary turbine and access road locations that avoid prominent streams, wetlands, forests, ponds, and other natural features.

Next, field surveys are conducted to confirm each proposed location and to identify additional wetlands, streams or other habitats within or adjacent to the proposed project footprint. Wetlands and streams found during these field visits are carefully mapped, measured and evaluated. This information is then used to refine turbine and access road locations, which includes footprint relocation where possible, to further avoid habitat impacts.

Minimizing Unavoidable Impacts to Wetlands and Streams

Some impacts to wetlands and streams can not be avoided. In these cases, steps will be taken to minimize the impacts.

For example, an access road may need to cross a stream to support project construction and operation. Wherever possible, EverPower plans to use existing stream crossings, such as agricultural equipment crossing points. In some cases, these stream crossings may need to be strengthened or widened, which may involve rebuilding or extending the road crossing. In other cases, it may be possible to temporarily strengthen the crossing (e.g., using steel plates or wooden mats).

As another example, a buried electrical line may need to cross a wetland. In this case, impacts are temporary and generally limited to the width of the cable trencher, and the original wetland condition is restored according to state and federal guidelines and requirements.

Mitigation of Unavoidable Impacts to Wetlands and Streams

EverPower will mitigate all unavoidable impacts to wetlands and streams, and wetland and stream mitigation will be designed to meet current state and federal requirements.

Permitting

EverPower will obtain all necessary state and federal permits prior to construction.

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Buckeye Wind Project: Erosion and Sedimentation Control Fact Sheet

EverPower is committed to controlling soil erosion from turbine and access road construction sites within the project area and protecting streams from excess sediment.

What is Storm Water, Why Manage It and How Is It Protected?

Storm water is runoff from rainfall or snowmelt. Land clearing or development can intensify the velocity and decrease the quality of storm water. If not properly managed, exposed soils can erode away causing increased turbidity and sedimentation of nearby streams.

Developers must follow federal, state and local regulations that establish permit requirements and storm water management requirements to protect water quality. Storm water regulations require the development of a Storm Water Pollution Prevention Plan (SWPPP), which contains certain Best Management Practices (BMPs) for water quality protection.

Purpose of Storm Water Best Management Practices (BMPs)

BMPs are structural and non-structural techniques whose purpose is to prevent or reduce problems related to increased velocity or decreased quality of storm water. BMP design standards and planning concepts are used by local authorities, planners, land developers, engineers, contractors, and others involved with land development projects. EverPower will construct and maintain the most-effective BMPs to control soil erosion from construction sites within the Buckeye Wind Project area, and obtain all necessary permits.

Construction Storm Water BMPs Used to Protect Water Quality

Minimize Disturbance – Minimize ground disturbance by maintaining the natural vegetation buffers and limiting the amount of soil exposed.

Waterbars and Clean Water Diversion Swales – Protect water quality during construction through the use of temporary structural controls that disperse the energy of flowing water preventing the formation of gully erosion.

Silt Fence – Confine sediment to the area of soil disturbance through the use of fencing constructed of filtering material.

Revegetation – Reestablish native vegetation to areas temporarily disturbed during construction.

Maximize Infiltration – Ensure that soil surfaces at each completed construction site are fully stabilized with vegetation or permeable materials such as gravel, allowing storm water to infiltrate into the ground rather than run off as it would from an asphalt or concrete surface.

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Buckeye Wind Project: Geology and Ground Water

The Buckeye Wind Power Project is not expected to have any adverse impact on the availability or quality of water from household or other wells. This is because project-related activities should not alter the distribution, depth, flow or quality of groundwater in any way.

EverPower concluded that water wells should not be affected by the project after careful review of the geology and groundwater aquifers within the project area, and after reviewing the results of a water well survey distributed to some project area landowners.

Geology of the Project Area

The project area is characterized by gently rolling hills and moderate slopes. Elevations range from approximately 1100 feet along the stream valleys and major highways to approximately 1420 feet in the northern portion of the area.

The surface topography of the region consists of thick deposits (typically 100 to 200 feet) of glacial till (an unsorted mix of clay, silt, sand and/or gravel) intermixed with thin sand and gravel layers. The till is thicker in the southern project area and thins to the north where the bedrock is close to or at the surface.

The uppermost bedrock within most of the project area is limestone and dolomite. Shale with interbedded limestone is the uppermost bedrock near the border between Logan and Champaign Counties. The depth to bedrock is highly variable. Bedrock may be encountered at depths of just a few feet to depths of 345 feet or more.

Aquifers of the Project Area

Aquifers occur in the bedrock and in the glacial till. The limestone and dolomite bedrock aquifers yield the most water (up to 300 gpm), but are often too deep for domestic use and may have taste and odor issues. Instead, most households and farmsteads in the project area rely on wells driven into the sand and gravel aquifers within the glacial till layer to depths of 60 to 200 feet. Landowners report these shallower wells have sufficient yield (ranging from 5 to 35 gpm) for domestic and farm use.

Can wind turbines adversely affect water well yields or quality?

The foundations of the wind turbines planned for the project area will extend about 10 feet below the surface and will be located at least one thousand feet from any structure, and so impacts on water well yield will be completely avoided. In addition, it will probably not be necessary to blast in bedrock due to the thickness of the glacial till. If blasting is required in a few locations, there should be no adverse effect on well water quality.

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Landowner Frequently Asked Questions

EverPower Renewables and our contractors are committed to working with you and other landowners in the development of a wind power project. We realize that your family, land and community are very important to you and it is our goal to be a good corporate citizen in your area.

Based on our meetings with individuals and groups of farmers and landowners to discuss wind-generating projects, we have developed a list of frequently asked questions and answers.

We know that there may be individual situations and circumstances we will need to address with individual landowners, but we hope this document will answer some of the more common questions.

Q: ***I rent my land to a tenant farmer. Who will have the final say on what is done on the property?***

A: EverPower will work with the landowner unless the landowner authorizes in writing that the tenant farmer will make decisions. EverPower will encourage landowners and the tenant farmer to discuss issues and agree on the final decision.

Q: ***What contact can I expect from the company prior to actual work on my land?***

A: A lease option agreement will be in place during the study phase while EverPower assesses the feasibility of the project and determines the final project design. Once the project is nearing construction, a lease agreement will be in place that will have a site plan outlining the location of the access road and turbines. EverPower and the construction company will work with the landowner and community to make sure they are aware of what to anticipate prior to any major construction activity.

EverPower also will have a local liaison present to work with the landowner and construction company. There will be times when the landowner will be asked to approve an aspect of the construction (i.e., drainage tile replacement or repair) and the liaison will help the landowner understand the situation so they can comfortably provide approvals.

The construction company will have a project manager on site and will handle communications with the landowner during construction. The project manager will provide contact information to the landowner so they can be reached anytime in the event of a question.

Q; ***What type of disturbance can I expect to my land?***

A: If a wind turbine is to be constructed on your property you can expect there to be an access road to the turbine site, a disturbed area at the turbine construction site used to accommodate the crane and other construction equipment, an underground easement for running the electrical cable, and possibly a temporary 3-5 acre area for the equipment storage and lay-down area.

After construction there will be a permanent 10-15' diameter ring to accommodate the turbine tower base and a 12-15' wide access road.

EverPower will work with the landowner on constructing temporary fencing to restrict livestock from entering the construction area and access roads.

Q ***During construction, how close to the turbine can I farm?***

A: You will be able to farm or graze livestock up to the 10-15' clearing at the base of the turbine and to the edges of the 12-15' access road. Overall, each turbine will remove about one acre from farm production.

Q: ***How will you avoid impacts on drain tile?***

A: The construction company will work with the landowner to identify the location of all underground tile in the anticipated work area. If there is a need to disrupt existing tile it will be replaced, repaired or relocated to meet the satisfaction of the landowner prior to backfilling the trench. All tile lines will be repaired or replaced with materials of same or better quality as that which was damaged.

Q: ***Will topsoil be segregated from subsoil?***

A: In cases where topsoil will be removed, it will be segregated from the subsoils and when possible replaced on the area from which it was removed. In cases where it is not feasible to replace the topsoil, the topsoil will be spread on adjacent land in close proximity to where it was removed. No subsoil will be used to replace topsoil.

Q: ***What will happen to subsoil removed due to construction?***

A: Subsoil and rocks will be used as fill material and will not be placed over topsoil or spread on the land surface without permission of the landowner.

Q: ***How will soil be de-compacted after construction?***

A: The construction company will de-compact the topsoil layer in areas that have experienced compaction from construction activities using appropriate industrial equipment.

Q: ***Will I be compensated for crop damage or other damage to fencing or structures on my land?***

A: EverPower will work with each individual landowner to determine how damage to crops, fencing and other personal property can be avoided or minimized. The landowner will be compensated for 100 percent of the value of the crops destroyed plus $100 per acre. Any tile or fencing will be replaced to as good or better condition.

Q: ***Will the contractor have total access to my property?***

A: You will be contacted by the construction manager prior to any construction. The construction manager also will work with you to mutually agree upon access to the construction site. All construction employees will carry identification and the construction vehicles will be easily identified.

Q: ***What type of equipment will be used during construction?***

A: The construction contract will require both company-owned equipment and leased equipment for the construction phase of the project. The equipment will include pick-up trucks, bulldozers, cranes and chisels for burying the lines.

Q: ***What if I encounter a problem or have a question?***

A: Prior to construction you will receive EverPower's toll-free phone number, as well as contact information for the local representative and the construction manager. EverPower is committed to addressing any question or resolving any issues the landowner may have prior to, during and after construction.

Q: ***How will dust be controlled and will there be mud on the roads?***

A: We will use dust mitigation practices typically used in construction projects. During any construction project there will be a certain amount of dust, but we will take steps to keep it at a minimum. We also will work to keep an excessive amount of mud off the road.

Q: ***Will there be a need to modify the local roads to accommodate equipment used in construction or the erection of the turbine and tower?***

A: Modifications may be necessary depending on the specific road situation and condition. EverPower will obtain any required permits and coordinate any movement of special oversized equipment on the roads with the county engineer and law enforcement officials.

Q: ***Will soil and water conservation practices be adhered to?***

A: EverPower will work with the landowner and any appropriate state or federal agency to adhere standard construction practices and repair or replace any soil and water conservation structure.

Q: ***If problems arise after land has been restored, what should I do?***

A: EverPower will monitor the construction site and any disturbed areas that have been restored for up to two years after completion of the project. EverPower also will work with the landowner to remedy any problems that occur during the two-year transitional period on any restored areas.

Q: ***The towers will probably attract a lot of attention. Will the turbine towers have security? Will the public have access to the towers?***

A: The towers and surrounding area will not be open to the public. The towers and any outbuildings will be locked. If necessary, entry points and access roads will be gated. We hope that the landowner will report any suspicious activity to local law enforcement officials.

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Wind Energy: Myth vs. Fact

Myth: Wind energy is expensive.

Fact: From strictly a cost of energy perspective, wind power is competitive with conventional sources of energy in areas with moderate to good wind speed. Given that there is no fuel component to wind power, it is not subject to some of the price volatility that can be experienced by other sources of energy and, therefore, provides a stable price for utilities and consumers.

If external costs (those not included in the market price for energy), such as costs resulting from treatment of air pollution related health conditions and the cost of securing ample sources of fossil fuels, are considered in the evaluation of the relative price of wind power or other forms of renewable energy, these renewable energy sources are much less expensive than fossil fuel burning sources of energy.

Myth: Wind energy is unreliable and must be "backed up" by conventional generation.

Fact: Regional grid operators are responsible for maintaining electric supply reliability at the lowest cost. To achieve the level of reliability required in today's society, a wide range of management tools are incorporated. The fact is, grid operators must "back up" all sources of generation in case of sudden outages or spikes in electricity demand. Wind energy would not increase the need for "back up" generation and it would not require different management tools until it was responsible for a larger portion of electricity supply. The reality is that wind energy is naturally variable, but not unreliable. Wind farms are built in windy areas, and seasonal and daily wind generation patterns can be anticipated. And, in contrast to conventional power plants, wind farms need not shut down altogether for maintenance and repairs – a turbine fault, when it occurs, can be repaired while the other turbines continue to operate.

Myth: Wind turbines operate only a small fraction of the time.

Fact: Wind turbines generate electricity most (65-80%) of the time, although the output amount is variable. No power plant generates at 100% "nameplate capacity" 100% of the time. Nameplate capacity refers to the maximum generation potential of a power plant. A conventional power plant is occasionally closed for maintenance or repairs, or runs below full capacity to best match demand.

Wind farms are built in areas where the wind blows most of the time, but because of variations in speed, a wind farm will generate power at full rated capacity about 10% of the time. On average, throughout the year wind turbine power generation is 30% to 40% of its rated capacity.

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Myth: Wind energy provides hardly any electricity.

Fact: The U.S. Department of Energy estimates America's wind energy potential to be much larger than today's total U.S. electricity consumption. Tapping only a fraction of that potential would provide a significant part of America's electricity supply. While there will be challenges, it is possible that wind could supply up to 20% of the total electricity used in the United States within the next 20 to 25 years. Beyond that, advances in technology and in electric system management techniques could allow wind and other renewable energy technologies to become even more important. In the United States, wind energy currently produces approximately 17 billion kilowatt-hours of electricity, equivalent to powering about 1.6 million average American homes year-round. A typical two-megawatt turbine generates enough electricity for 600-800 homes.

Myth: Wind turbines are inefficient.

Fact: Wind turbines are efficient and that is part of their beauty. One of the simplest ways to measure overall efficiency is to look at the "energy payback" of an energy technology, i.e., the amount of time it takes to produce a given amount of energy. The energy payback time for wind is similar to or better than that of conventional power plants. A recent study by the University of Wisconsin-Madison calculated the average energy payback of Midwestern wind farms to be between 17 and 39 times as much energy as they consume (depending on the average wind speeds at the site), while nuclear power plants generate only about 16 times and coal plants 11 times as much energy as they consume.

Wind turbines are also highly efficient in a larger sense: they generate electricity from a natural, renewable resource, without any hidden social or environmental costs – there is no need to mine for fuel or transport it, no global warming pollutants created, and no need to store, treat, or dispose of wastes.

Myth: Wind farms are ugly.

Fact: Beauty is in the eye of the beholder, and many people throughout the world find wind turbines on the landscape to be a graceful addition to the view. While larger than their predecessors, modern wind turbines have sleeker lines and fewer rotations per minute, which also adds to their visual appeal.

Myth: Wind farms are noisy.

Fact: Advances in system designs and appropriate use of setbacks from residences have helped to reduce sound issues associated with wind turbines. Aerodynamic noise has been reduced by adjusting the thickness of the blades' trailing edges and by orienting blades upwind of the turbine tower. To put this into perspective, the sound generated from a wind turbine 250 meters from a residence is no noisier than a kitchen refrigerator.

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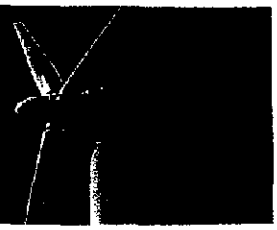


Myth: Wind projects decrease property values.

Fact: There are numerous factors that affect property values. Publicly available studies have shown that there is little or no statistical evidence that property values decrease in the immediate vicinity of wind turbine facilities. Everpower believes that proper planning and constructive community involvement will result in a project that adds value to the area.

Myth: Wind projects don't contribute to the local tax base.

Fact: Wind farms support the local tax base, helping to pay for schools and roads. Economic development associated with a new wind farm extends far beyond taxes. Wind energy offers new employment opportunities both directly from the wind farm operation and construction and indirectly from the companies that will support the development, construction, manufacturing and operation of wind turbine projects throughout the state and the country. In addition, money for services needed to support a large construction project, including increased hotel stays and restaurant revenues, will be pumped into the local economy.

Myth: Turbine shadow flicker is harmful.

Fact: Shadow flicker is the term used to describe what happens when rotating turbine blades come between the viewer and the sun, causing a moving shadow. Shadow flicker is almost never a problem for residences near new wind farms and, in the few cases where it could be, it is easily avoided. For some who have homes close to wind turbines, shadow flicker can occur under certain circumstances and can be annoying when trying to read or watch television.

However, the effect can be precisely calculated to determine whether a flickering shadow will fall on a given location near a wind farm, and how many hours in a year it will do so. Potential problems can be easily identified and solutions range from providing an appropriate setback from the turbines to planting trees to disrupt the effect.

For more information, please contact Everpower Renewables at info@everpower.com.

Survey Methods to Monitor Bird and Bat Activity During Pre- and Post-Construction of Wind Energy Facilities

C.W. Meinke, S. K. Pelletier; Stantec Consulting - Topsham, Maine

Stantec

Introduction

The eastern United States has recently seen a large increase in the number of wind power projects being proposed in a variety of landscape settings. Impacts to bird and bat populations have been identified as a potential concern. Natural resource agencies commonly request that the risk to these resources be assessed while siting a project. A variety of survey methods have been developed to characterize bird and bat activity patterns. We present a review of these methods and the utility of the results that they provide.

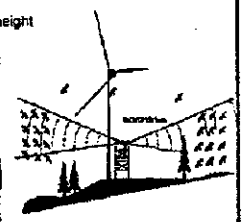
Documenting bird and bat migration and activity provides important information to understand species occurrence and potential risk.

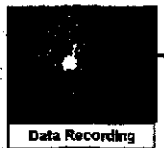
~ WILDLIFE SURVEY OBJECTIVES AND METHODS ~

Radar Surveys

Marine radar (X-band) operated in vertical and horizontal (surveillance) modes, from mobile platforms and stationary platforms

- Nightly traffic rates (#/km/hr)
- Full season traffic rates (#/km/hr)
- Mean flight direction
- Average flight height
- % below max turbine height

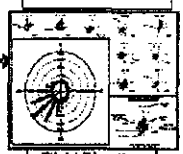




Backup live data to portable hard disk array

Permanent digital record

Data Recording



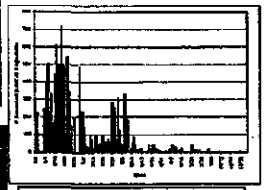
Analyze

Flight Direction

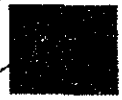
Bat Acoustic and Mist-net Surveys

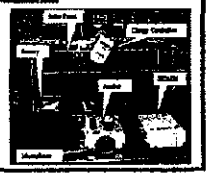
Bat activity and species occurrence is monitored using mist-nets and acoustic detectors that passively record bat echolocation calls at multiple heights above ground.

- Bat activity level (# recorded files)
- Species composition
- Nightly timing of activity
- Seasonal timing of activity



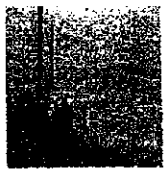
Long-term bat acoustic monitoring shows trends in seasonal activity



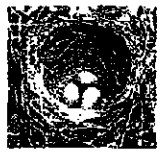


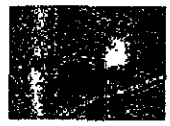
Raptor and Breeding Bird Surveys

Visual and auditory documentation of bird migration and breeding activity of diurnally-migrating raptors (hawks, falcons, harriers, vultures, and eagles) and breeding passerines (songbirds).

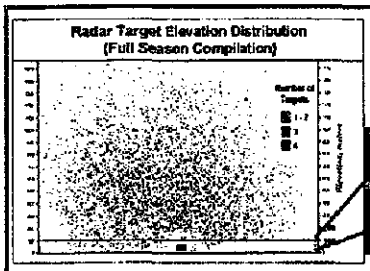


- Species diversity
- Species abundance
- Flight patterns
- Flight height
- Flight direction
- Breeding activity

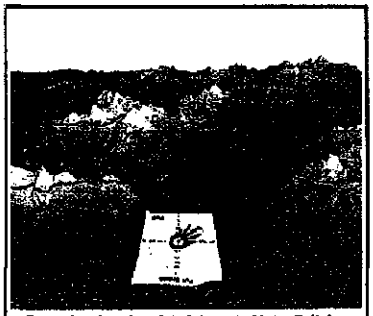




~ EXAMPLE SURVEY RESULTS ~



Example of total seasonal avian counts displayed in 10-meter cells of airspace (left). Further statistical evaluation of data can yield quantitative assessments of collision risk within rotor zone elevations (right).



Example migration data integrated into digital elevation terrain models

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Class II
Item no.: 964106.R00
2007-06-29

Mechanical Operating and Maintenance Manual

V90 – 3.0 MW, VCRS 60 Hz

Onshore/Offshore (Mk 7)

Vestas Wind Systems A/S · Alsvej 21 · 8900 Randers · Denmark · www.vestas.com

History of this Document

Rev. no.	Date	Description of changes
00	2007-06-29	First edition

Table of Contents

Please see Mechanical Drawings & Parts List

1 Preface

This manual applies to the wind turbine **V90 - 3.0MW, VCRS 60 Hz, Mk-7.**

It is the turbine owner's responsibility that only qualified persons operate the turbine.

Do not operate the turbine before, as a minimum, having studied the following carefully:

- ✓ 960314 Safety Regulations for Operators and Technicians
- ✓ 950173 User Guide

Do not hesitate to contact your plant manager or Vestas' Service Department if you need more detailed explanations.

Vestas Wind Systems A/S

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2 Updating of the Manual

The manual will continuously be brought up to date. Corrections to each specific chapter are listed for the past year under the heading of "History of this Document".

3 The Header

The latest revision date of a specific chapter is stated in the header of the chapter. Class II indicates that the document is only handed out according to agreement with Vestas' Technology Department.

Each specific chapter has its own item number followed by a revision number (Rx).

First editions have revision number R0.

Contents

Supplier Drawings

Safety Regulations for Operators and Technicians, V90-3MW/V100-2.75MW

History of this Document

Rev. no.:	Date:	Description of change
0	2005-06-23	First edition
1	2005-09-19	947554 replaced by 959055; Chap. 9: "However, the capacitors in the converter and AGO2 section might be energized." inserted Chapter 10 Converter and AGO2 Sections Figure numbers updated
2	2006-01-17	Reference to 947554 added again page 12
3	2006-03-03	Chapter 18.1.1. New wind speed limit 23m/s
4	2006-05-08	Language revision. Inserted: section 14.2 Access to roof, text and picture.
5	2006-09-11	Reference to V100 added Section 19 updated with new pictures and new text.

Contents ..... Page

1. Introduction

A turbine connected to the grid implies certain elements of danger if it is handled without exercising proper caution.

For safety reasons, at least two persons have to be present during a work procedure.

The work must be properly carried out in accordance with this manual and other related manuals. This implies, among other things that personnel must be instructed in and familiar with relevant parts of this manual.

Furthermore, personnel must be familiar with the contents of the "Substances and Materials" regulations.

Caution must especially be exerted in situations where measurement and work is done in junction boxes that can be connected to power.

Consequently the following safety regulations must be observed.

2. Stay and Traffic by the Turbine

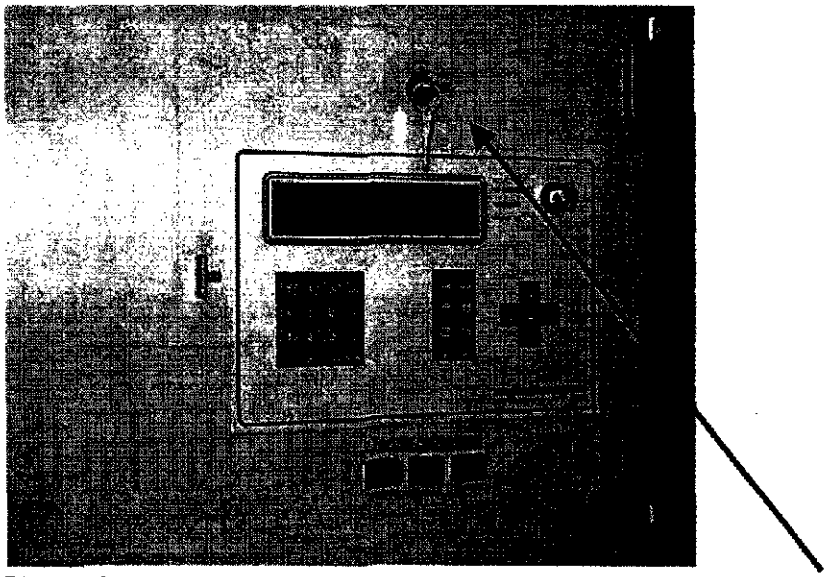
Do not stay within a radius of 400m (1300ft) from the turbine unless it is necessary. If you have to inspect an operating turbine from the ground, do not stay under the rotor plane but observe the rotor from the front.
Make sure that children do not stay by or play nearby the turbine. If necessary, fence the foundation.
The access door to the turbine must be locked in order to prevent unauthorised persons from stopping or damaging the turbine due to mal-operation of the controller.

3. Address and Phone Number of the Turbine

Note the address and the access road of the turbine in case an emergency situation should arise. The address of the turbine can often be found in the service reports in the ring binders next to the ground controller. Find the phone number of the local life-saving service.

4. Controller and Operating Panel

Only authorised or instructed persons are allowed to open the doors of the controller cabinet.



Picture 1

Before inspecting or working on the turbine, the remote control MUST be deactivated. Use the breaker-key and set it in position "local".
Remember to activate the remote control when the inspection or the work has been completed.

5. Emergency Stop Buttons

For safety reasons please note the location of the 4 emergency stop buttons. The buttons are located (Figure 1 Locations of emergency stop buttons and trip F60 in nacelle) at:

- Ground controller (at the bottom of the turbine).
- Gearbox (pos. 1).
- Yaw ring (pos. 2).
- Nose cone (pos. 3, only local stopping function)
- Nacelle controller (pos. 4).
- Trip F60 (pos. 5).

The emergency stop buttons are red with a yellow background. An emergency stop is activated by pressing one of the red buttons. When an emergency stop is activated, the controller switches to "EMERGENCY STOP" mode meaning that no power will be supplied to the contactor solenoids, the blades will pitch (full feathering), the brake will be applied and the turbine will stop. The yaw system, the hydraulic pump, the gear oil pump and the nacelle ventilator will also stop. Consequently, all moving parts will be brought to a standstill.
However, the power supply to the light, the nacelle, the hub and the ground controllers will still be on. The stop button in pos. 3 is not an emergency stop button but a local stopping function.

Remember: The hydraulic system is still under pressure. Due to the accumulators, up to 6 litres of hot oil will pour out, if the hydraulic system is intervened.

Please note: When the emergency stop buttons are activated, the brake is activated.

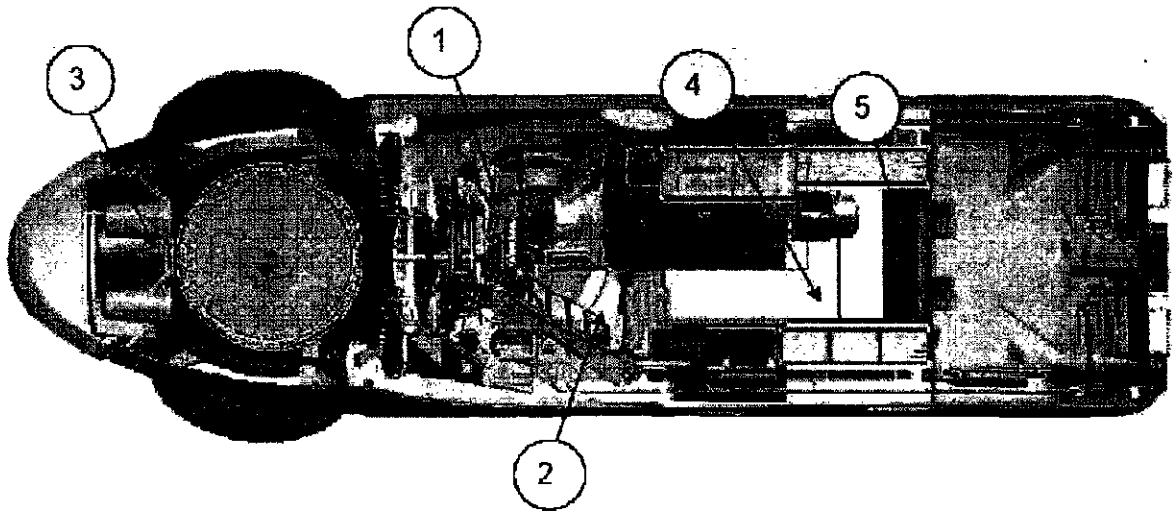
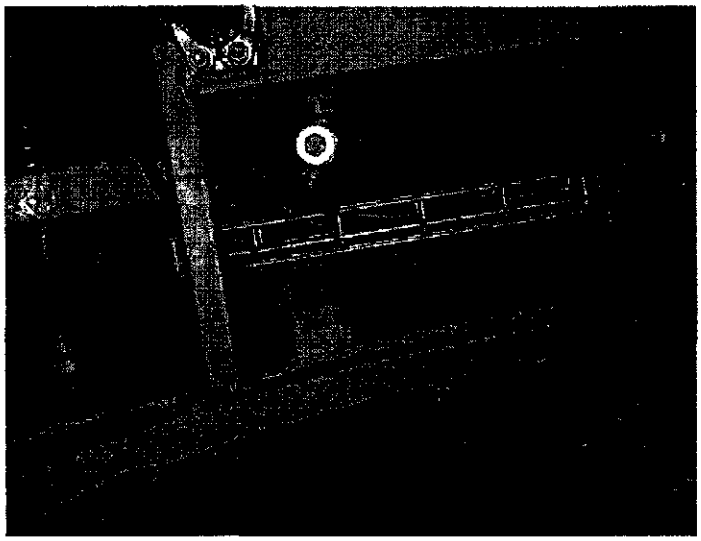
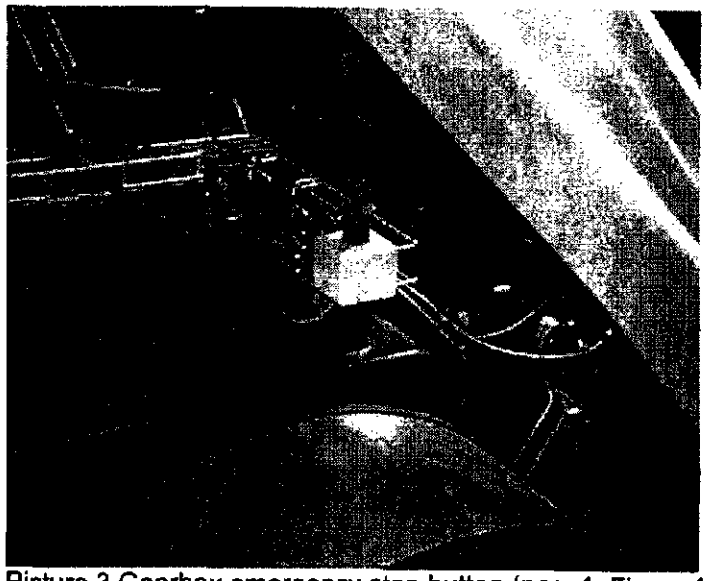


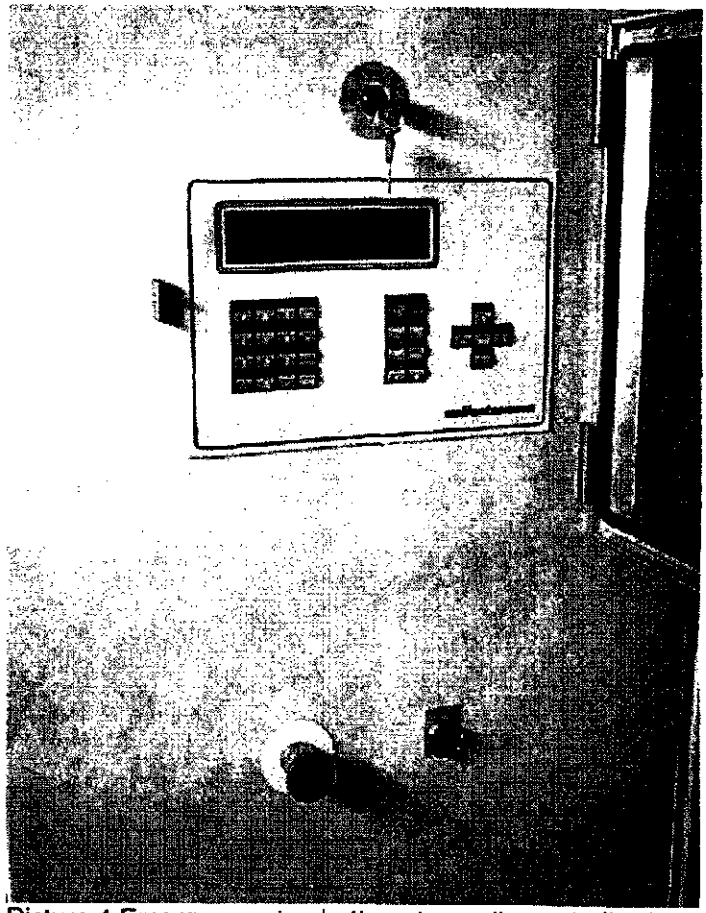
Figure 1 Locations of emergency stop buttons and trip F60 in nacelle



Picture 2 Yaw ring emergency stop button (pos. 2, Figure 1)

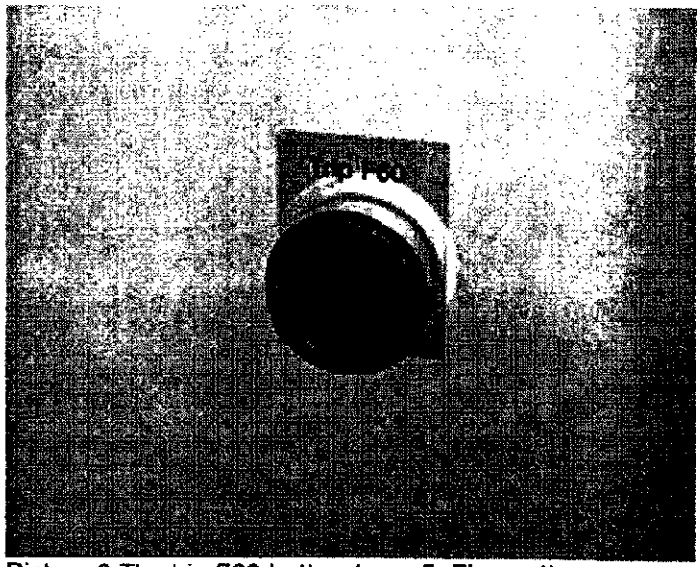


Picture 3 Gearbox emergency stop button (pos. 1, Figure 1)



Picture 4 Emergency stop button at nacelle controller (pos. 4, Figure 1)

Picture 5 Emergency stop button in hub (pos. 3, Figure 1)



Picture 6 The trip F60 button (pos. 5, Figure 1)

5.1 Trip F60

Trip F60 is situated on the nacelle controller (pos. 4). Trip F60 disconnects the high voltage supply for the turbine. When disconnected, only the control system in the turbine is supplied from the UPS for approx. 6 hours. Usually, the local power station must take part when the turbine is connected to the grid.

5.2 Lift (Optional)

If a lift is installed, it has several emergency stop buttons.
Note: These buttons only stop the lift; emergency stop buttons for turbine do not apply to the lift.

5.3 Internal Crane

The crane is equipped with an emergency stop button. This only applies to the crane and otherwise the emergency stop buttons in the turbine do not apply to the crane.

6. Practical Advice at Inspection

When inspecting the machinery, always look very closely for oil spills and loose bolts. Dirt must be wiped off, otherwise it can be difficult to determine whether there is a significant leak.
Loose bolts in the structure mean danger. They must be tightened immediately. If it is a matter of several bolts or repetitions, please contact Vestas Wind Systems A/S service department.

7. Influence by Lubricants

The lubricants used in the turbine can be aggressive. Lubricants must not get in contact with skin or clothes.
At inspection of a gearbox if removing a cap while the oil is still hot, be careful not to breathe in the hot oil vapours.

8. High Voltage Installations

As a basic rule it is not allowed to dismount cover or open locked doors to the high voltage installations.
An operator/service technician is only allowed to move around behind the covering when the high voltage is disconnected, locked and visibly earthed. The work must be carried out and approved by authorised personnel only (power station or selected coupling leader). One of these persons must give permission to access the HV installation.
Work done on high voltage installations must be carried out in accordance with national regulations and related Vestas Wind Systems A/S manuals.

9. Grid Drop-Out

A grid drop-out causes an EMERGENCY STOP. The blades pitch out of the wind (full feathering); the yaw system, the hydraulic pump and the nacelle ventilator stop. Consequently, all moving parts will be brought to a standstill except for emergency lubrication system for the gearbox. The power supply for the light and the nacelle, hub and ground controllers is partly off. However, the capacitors in the converter and AGO2 section might be energized.

10. Converter and AGO2 Sections

WARNING:
***If working* on the converter section or AGO2 section, note that the capacitors inside can be charged to 800 V and those in the filters can be charged to 690 V. The capacitors are discharged to below 50 V in 5 minutes after disconnection from the grid. Switch Q7 and Q8 must be turned off.**
Before opening the cabinet, check the DC-link-voltage in picture 17.
Before working on the converter/AGO2, check the DC-link-voltage with a Fluke multimeter.

11. Turbine Standstill

After a period of maximum 14 days without grid connection, necessary equipment for humidity- and temperature control must be installed in the turbine in order to fulfil the following requirements:

- For 90 % of the shutdown period, the relative humidity (RH) must not exceed 45 %.
- The RH must be between 45% and 60% for max. 10% of the shutdown period only.
- Within a period of 12 hours, the temperature in the turbine must not drop more than 10° C.
- The temperature and humidity must be logged.

During a period without grid connection, the following inspections must be carried out on a monthly basis:

- Check the functionality of the equipment as regards humidity and temperature.
- Check the RH and temperature logging in *accordance* with the requirements mentioned above.
- Check the emergency lubrication.
- Recharge emergency lubrication batteries (only every 3 months).
- Check the blade locking system.
- Check that the brake is released and without pressure.

12. Overspeed Guard

If the turbine rotation exceeds its limit, the overspeed guard (VOG) is activated, and the turbine will go into EMERGENCY STOP mode. The state of failure cannot be reset until the VOG has been de-energized.

13. Inspection of the Turbine

At inspection of the turbine, the following procedure must be followed.

When inspecting the turbine there must always be at least two persons present.
Full feathering of the blades is done by pressing <PAUSE>. When the rotor comes to a standstill or rotates slowly, activate the <Emergency stop button> to stop the turbine.

It is now possible to climb the turbine but remember as a minimum to wear:

- Safety footwear suitable for climbing towers.
- H-belt with fall protection device fastened directly to the H-belts D-ring on your chest.
- Safety helmet.

Always make sure that there is nobody above you in the turbine when you start the ascent.
If you bring tools, lubricants etc. with you, keep these in a rucksack or a bag which is attached to the safety belt.

During the ascent the fall protection and the supporting strap **MUST** be mounted. Do not mount the fall protection hook on the aluminium ladder rungs or on the fittings for the ladder, as they might brake in case of falling. Instead the swivel eye plate (yellow) must be used.
Close the trap doors of the landings when passing them.
Please notice the location of the emergency stop buttons and Trip F60 in the nacelle.

When working on the electrical part of the controller, the controller must be disconnected by the circuit breaker (marked Q7, Q26 and Q27) in the board arrangement and locked by means of a padlock. Only authorised personnel must have access to the key/keys.
When working on the terminal of the generator, inspecting the generator cables or the controlling as such, the generator must be disconnected by the circuit breaker (Q8 and Q23) in the board arrangement and locked by means of a padlock. Only authorised personnel must have access to the key/keys.

When working on the yaw system, the yaw motors must be disconnected in the control panel at the contactors F35.1 and F35.2.

Always make sure that there is nobody below the turbine while you are working in the nacelle. Even a small screw is highly dangerous when falling from a height of 60m or more.
Unauthorised persons must under no circumstances move the covering plates which cover rotating or electrical parts, especially the high voltage installation. Be cautious that safety straps are not caught on any rotating shafts during stay in the nacelle while the turbine is in operation.

Before entering the hub or working on rotating parts in the nacelle, make sure that the rotor is locked and that the blades are fully feathered. See section "Operating the Rotor Locking System" on how to activate the rotor locking system.
Before descent, close the nacelle skylights and the service hatch. Make sure that you have gathered all tools and remember that the red emergency stop buttons must be off.
If the blades are iced up, it is highly dangerous to stay below or close to the rotor. If the turbine is to be restarted with iced up blades, the operator must be very careful and make sure that no persons are nearby because of the risk of falling pieces of ice.

Do not stay in the nacelle while the turbine is in operation, unless if checking for gear and generator noise.

Any oil or grease spills must be cleaned up because of the risk of slipping.
Make sure that the covering and the locking of the high voltage installations are undamaged.
Make sure that the high voltage cable between the high voltage installations in the nacelle and the bottom are undamaged and do not have any visible mechanical damages, such as having been squeezed/cut by cable binders, mechanical parts etc.

When working in the nacelle, spinner or roof, please pay attention to safety hooking points. See figure 3.

When working on the roof of the nacelle, secure a safety line on the roof rail. See Picture 11 Hooking points on the roof.

Special caution must be taken when climbing lattice towers when it is wet or icy. Moreover special cautions must be taken when climbing on the outside of the lattice tower, since the back of the blade is close to the lattice tower when the blade is turning around its longitudinal axis. This happens if anyone pushes <PAUSE> or <EMERGENCY STOP> and also at an unintended EMERGENCY STOP.

14. Safety Equipment

See Figure 2 Safety Equipment

1. Safety helmet.
2. H-belt (delivered by Vestas).
3. Lanyards: one line with a fall damper device, one line with a shortening device (delivered by Vestas).
4. Fall protection device (delivered by Vestas).
5. Rubber-soled footwear properly tightened.

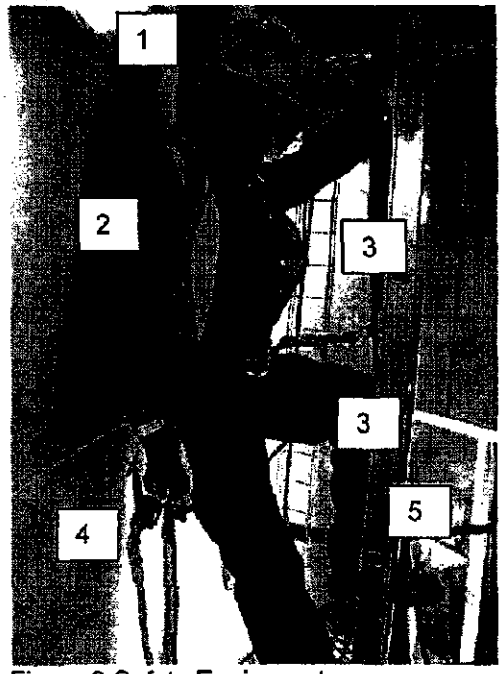


Figure 2 Safety Equipment

When climbing the tower, fasten the fall protection device directly to the H-belt's D-ring. Only one person is allowed on each ladder section at a time.

If a service lift is installed in the turbine, bring along the safety equipment in it.

14.1 ResQ Emergency Rescue Equipment

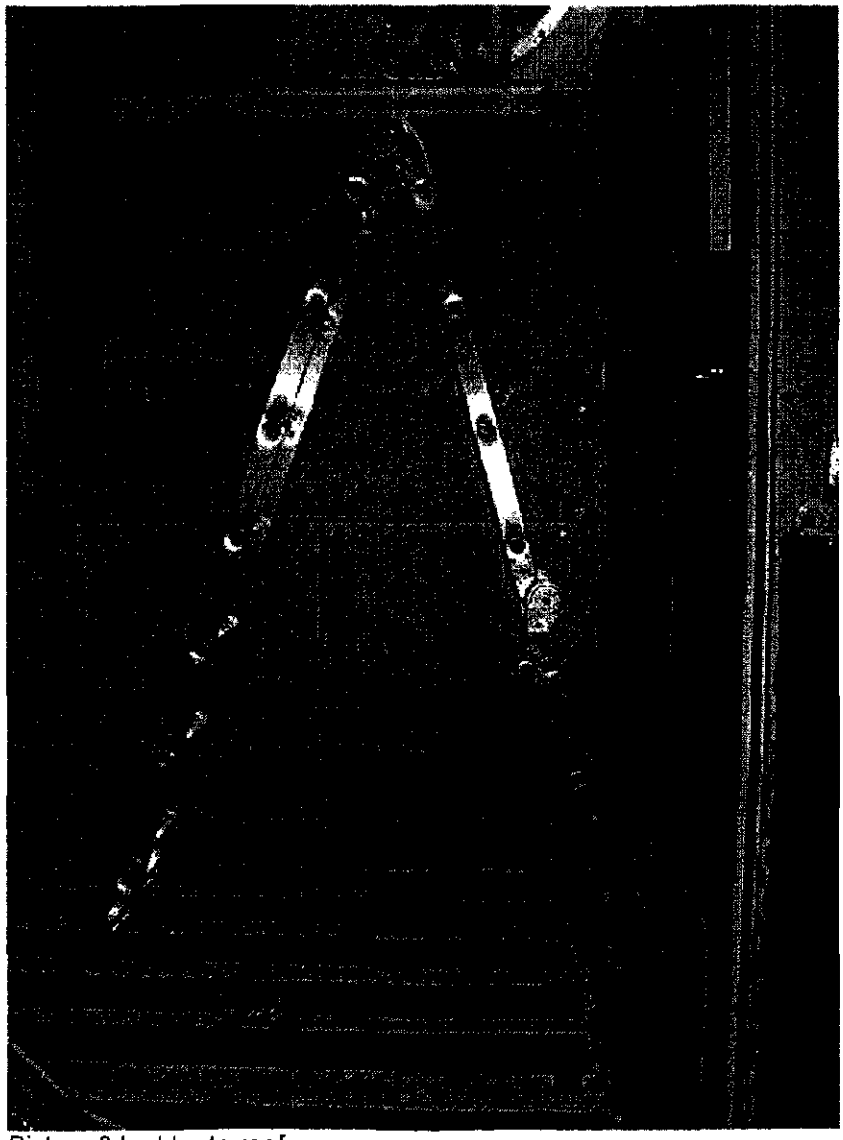
In case the escape route via the tower should be cut off by fire or other unforeseen events, a rescue and descent device is located in the nacelle behind the main controller section in an aluminium box. Please see user manual for rescue equipment, item number 959055 (VCS, 50 Hz turbines) or 947554 (VCRS, 60 Hz turbines).

Picture 7 Fixing Point for ResQ descent device

- Fixing point for ResQ descent device.
- Open the left service hatch.
- Lift the arm above the opening.
- Fasten the ResQ descent device to the arm.
- Ready for lowering, SWL 2000kg.

14.2 Access to Roof

Place the ladder on machine foundation at the rear of the nacelle to gain access to nacelle roof as shown in the picture below.



Picture 8 Ladder to roof

15. Hooking Points and Safety Chains

A number of hooking points is installed at different locations in the nacelle. A hooking point is shown in Picture 9 Hooking point.

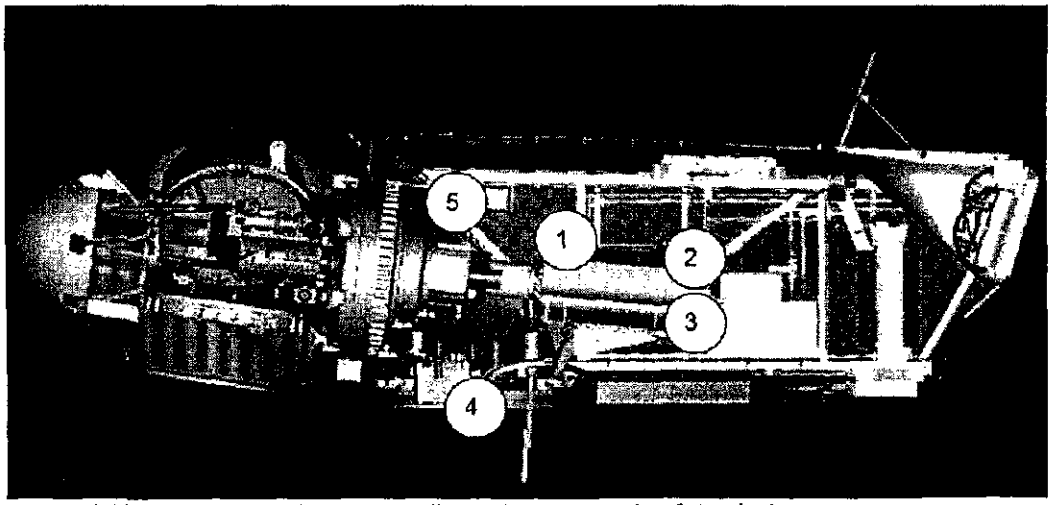
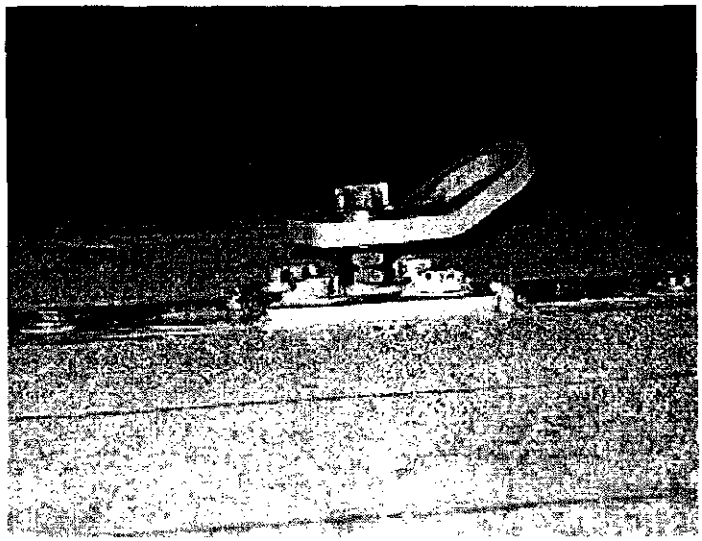
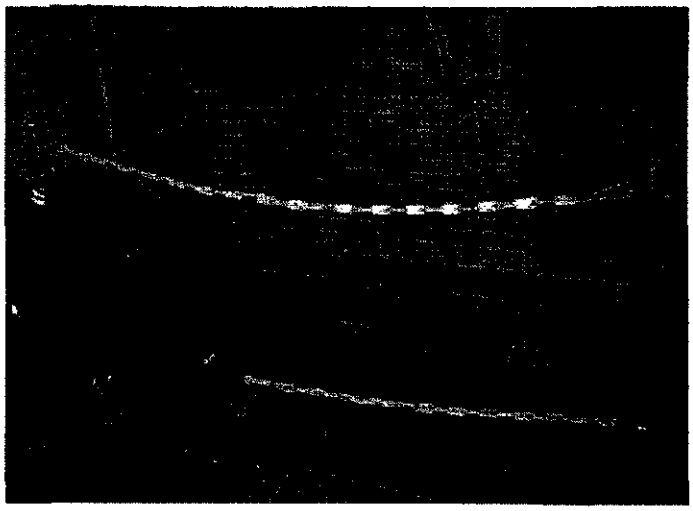


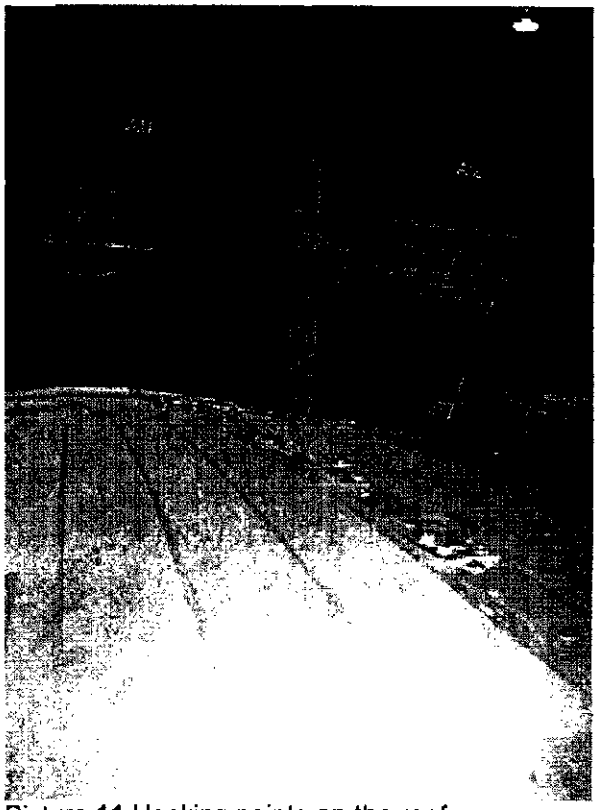
Figure 3 Hooking points in the nacelle and position of safety chains



Picture 9 Hooking point



Picture 10 Safety chains must be mounted when the bottom hatch is open (Figure 3)



Picture 11 Hooking points on the roof

16. Precautions in Case of Fire

At any type of fire in or near a turbine, the power to the turbine must always be disconnected at the main high voltage circuit breaker. To disconnect supply, switch off by pushing the red button (marked TRIP F60) on the nacelle controller in the nacelle. In the tower bottom the power supply is switched off by pushing the red button situated on the breaker in the high voltage section. If it is impossible to get to the main circuit breaker, contact the power station for a disconnection of the grid.

In case of a fire during an uncontrolled operation, do under no circumstances approach the turbine. Evacuate and rope off the turbine in a radius of minimum 400m (1300ft). In case of a fire in a non-operating turbine, the fire can be put out by means of a powder extinguisher.

⚠ CAUTION **Use of a CO_2 extinguisher in a closed room can result in lack of oxygen.**

17. Directions for Use of Rotor Lock

To avoid accidents and near-accidents, which can be prevented via mechanical locking of the rotor, the following guidelines must be followed:

IN GENERAL:
Besides following the requirements listed in this document, it is important also to use ones common sense and assess the specific situations.

When the wind speed exceeds the values of the mechanical design of the locking system, it is not allowed to work in a turbine as listed below.

A technical solution must be prepared before starting work on a turbine that cannot be locked mechanically.

The work listed below must not be carried out before the turbine has been mechanically locked.

Mechanical rotor locking must be used in connection with:

1. Hub and blades:
   a. stay in hub and nose cone
   b. stay on/near the blade is not allowed unless both the rotor and the blade has been locked

2. Work on gearbox and gear oil system if this involves:
   a. disassembly and adjustment of mechanical parts
   b. tensioning
   c. activation of shrink disc
   d. internal inspection – unless it is a visual inspection

3. Work on coupling and braking system if this involves:
   a. disassembly and adjustment of mechanical parts

b. tensioning
c. inspection of coupling
d. lubrication

4. Work on generator if this involves:
   a. disassembly and adjustment of mechanical parts
   b. tensioning
   c. work on slip ring systems/units

5. Work on yaw system
   In addition to rotor locking, the turbine must be secured against unintentional yawing, if this involves:
   a. disassembly of mechanical parts
   b. yaw brakes cannot be activated

6. Work on electricity in the nacelle, if this involves:
   a. that the turbine controller is switched off and work at rotating parts of the drive train has to be carried out.

7. Work on hydraulics for pitch as well as brake system, if this involves
   a. disassembly of mechanical parts
   b. that the pumps are out of operation

8. Work on the turbine's exterior
   In addition to rotor locking, the turbine must be secured against yawing, if this involves:
   a. use of crane
   b. use of front lift
   c. use of other lifts or scaffold systems

9. Replacement of components, if this involves:
   a. replacement of components, sensors, etc. close to unshielded rotating parts of the drive train.

18. Operating the Rotor Locking System

The rotor must not be locked unless it is necessary, however always when servicing the hub and it must be unlocked as soon as possible after the service operation, which caused the locking.

If the rotor has to be locked for more than 48 hours, it must be bolted to the main foundation, following the procedure description in section 18.2.

18.1.1 Operating the hydraulic rotor locking system for normal service

The rotor locking system must not be set or used at wind speeds exceeding 23 m/s.

The rotor locking system must not be used while the rotor is rotating.

Pitching of blades is not allowed while the rotor is locked, except at wind speeds below 15 m/s. In this case only one blade may be pitched at a time.

The rotor locking system is located at the upper right hand side of the main gear, see Picture 12 Rotor locking system.

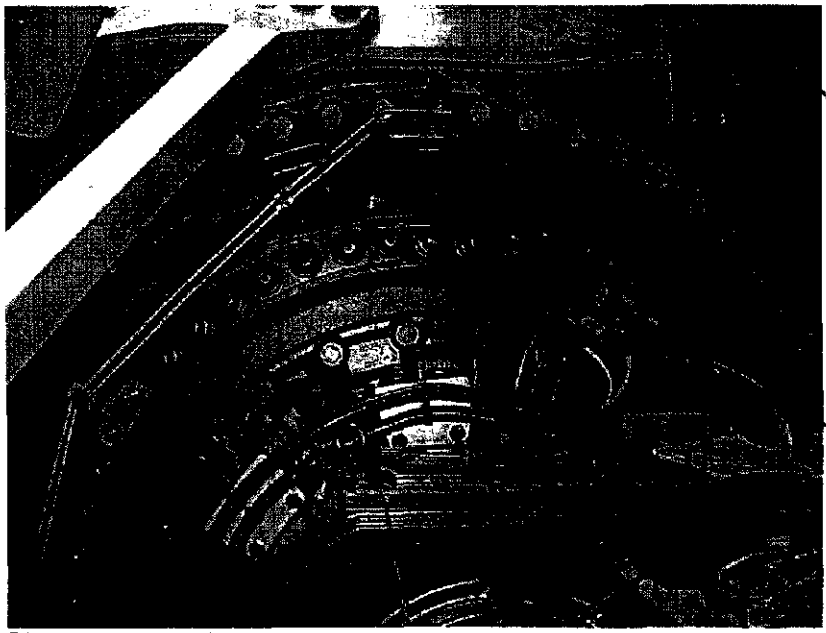
1. Set the turbine to PAUSE mode and select test picture 11.7 (Manual Pitch and Brake), where the brake can be activated.

2. Align the locking system position holes in the hub with the locking system mandrels by "manoeuvring" the brake (press [*]) until the V-notch marking (pos. 1) on the hub is aligned with pointer on machine foundation (see pos. 2). See Picture 13.

3. At the correct position set the handle in "+" position and pump the locking system mandrels out. Observe at the right side during the pumping! See Figure 4.

4. The locking takes place with the hydraulic hand pump located above the main gear on right hand side. The locked position of the handle is 45°. When locking set the handle in "+" position (the handle perpendicular to the gearbox centre shaft). When unlocking set the handle in "-" position and pump in the locking system mandrels.

5. When the mandrels are fully out or in, set the handle in "lock" position, see Figure 4. Verify the fully in or out position by looking at picture 11.7.B at the operator panel.



Picture 12 Rotor locking system

Picture 13 Alignment markings seen from machine foundation side

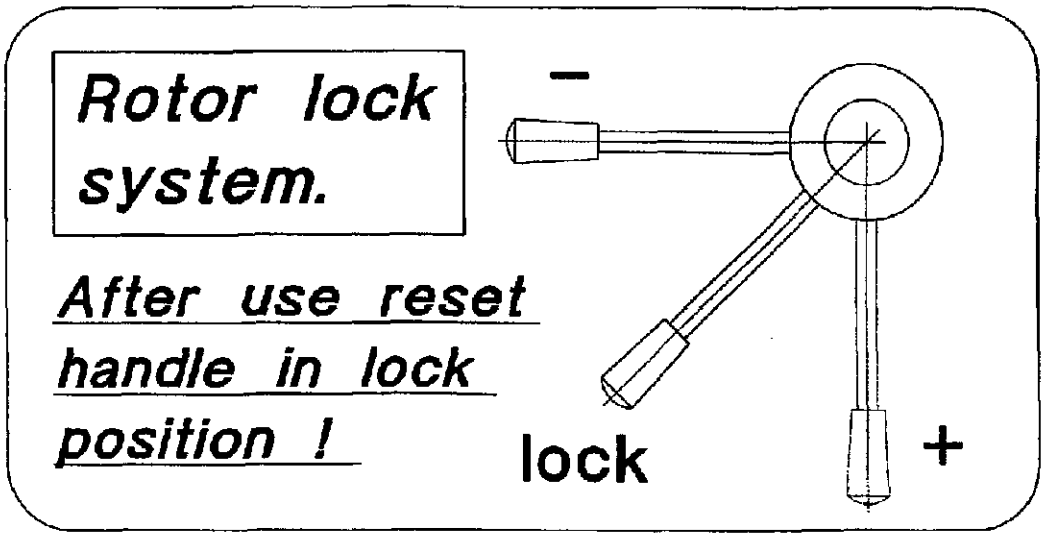


Figure 4 Handle positions

18.2 Operating the Manual Rotor Locking System with Bolts

The manual rotor locking system is used in case of servicing:

- Gearbox repairs
- Gearbox replacements
- Transport of nacelle
- Turbine standstill for long period of time: > 48 hours

The manual rotor lock must be used as an alternative to the hydraulic rotor lock
The following components must be used when operating the manual rotor lock.

Item number	Description	Quantity
950461	Centering mandrels	3
782137	M42 special nut	16
782138	Washer	16
782139	M42 special bolt	16
782142	Shim for rotor lock	16
782141	Hex.soc.h.scr.M16x60 yellow	16x8 = 128

Prior to mounting the manual rotor lock:

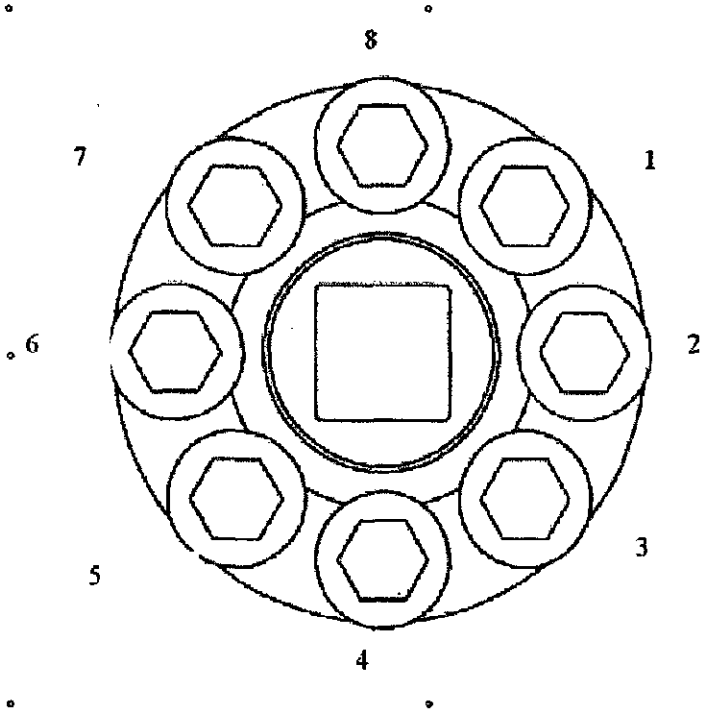
- Set the turbine in PAUSE mode and activate the <emergency stop button> to activate the disc brake.

18.2.1 Mounting the manual rotor lock

1. Turn the hub until the highest point points up and one of the blade bearings points downwards.
2. Lock the rotor with the hydraulic rotor lock or mount the three centering mandrels using 3 x 2 M20x40 from in front of the hub flange and into the locking holes of the main foundation.
3. Place 16 x M42 bolts (782139) 5 on each side and 6 in the top.
4. Insert 16 shims (782142) so the bolt is placed in the slot and the shims. Use a small hammer for mounting to ensure there is no space between the shim and the hub/main foundation.
5. Screw on the special nut, with washer underneath so it hits the hub flange.
6. Tighten the yellow M16 special bolts (782141) following this procedure:
   Tighten the 8 M16 bolts to 70Nm. Then tighten the 8 M16 bolts to 140Nm in a circular way and proceed with this operation with the first 3 bolts again, so you at the end have tightened 11 bolts to 140Nm.
   (see figure on the following page)

NOTE **Do not at any time remove the centering mandrels when the M 16 bolts are not tightened.**

Tightening force sequence, the full sequence has to be used.



Bolt nr.	Torque Nm
1	70
2	70
3	70
4	70
5	70
6	70
7	70
8	70
1	140
2	140
3	140
4	140
5	140
6	140
7	140
8	140
1	140
2	140
3	140

Figure 5

18.2.2 Dismantling the manual rotor lock after service work

1. Loosen all the M16 special bolts.
2. Loosen and remove all M42 special nuts.
3. Remove all the M42 special pin bolts
4. Remove the centering mandrels or pull back the hydraulic rotor lock.

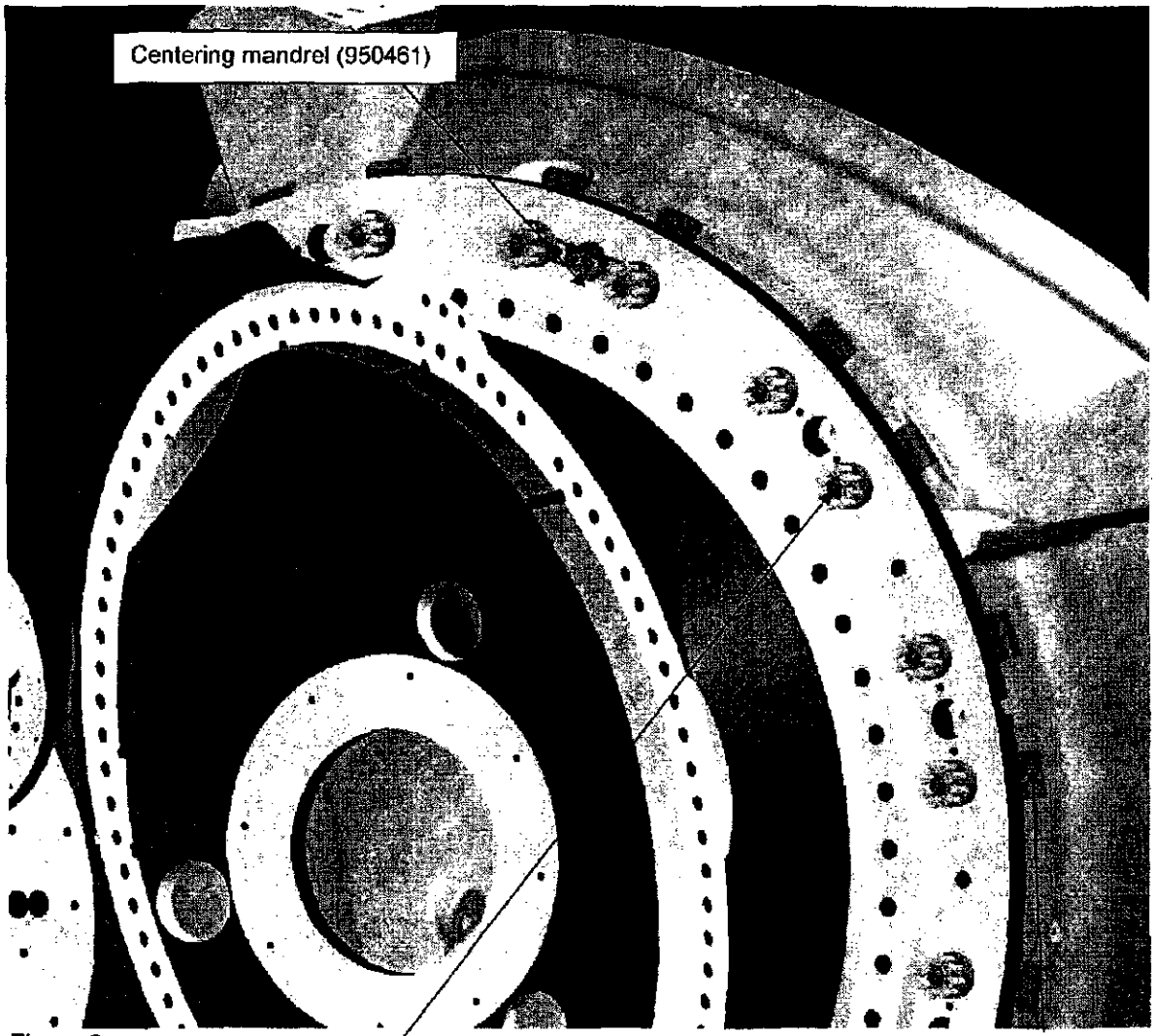


Figure 6

950084.R1

All these components are shown in an additional document 958627.

19. Operating the Internal Crane

Limitations on use:

- Lift or landing to floating vessels is not permitted for any crane constellation.
- Lift or lowering of personnel is not permitted for any crane constellation.
- Do not use any of the crane constellations for external operation above wind speed 15 m/sec 10 min.
- Do not operate the crane without correct authorization.

After 50 lifts with 12000 kg load the crane must be recertified:

- Inspect all welding on both trolleys for cracks. Repair or replace damaged items.
- Inspect all welding on lattice construction for cracks. In case of cracks Vestas Technology must be contacted.
- Replace all bolts, nuts and washers on bridge and trolley.
- Check rollers for free rotation, replace if malfunction.
- Perform overload test.

Attach chain to prevent accidental access to hazardous area.
Open the service hatch and secure it to transformer partition wall.
Keep the service hatch closed after hoisting operation is completed.
The internal crane and the traverse must be fastened in parked position when turbine in operation.

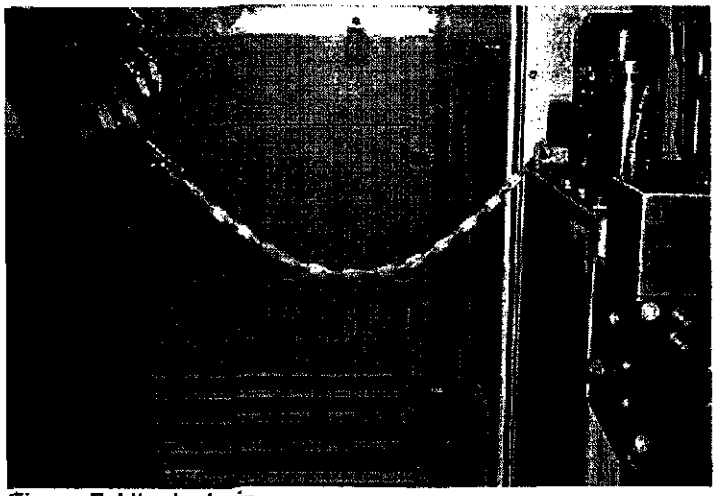


Figure 7 Attach chain

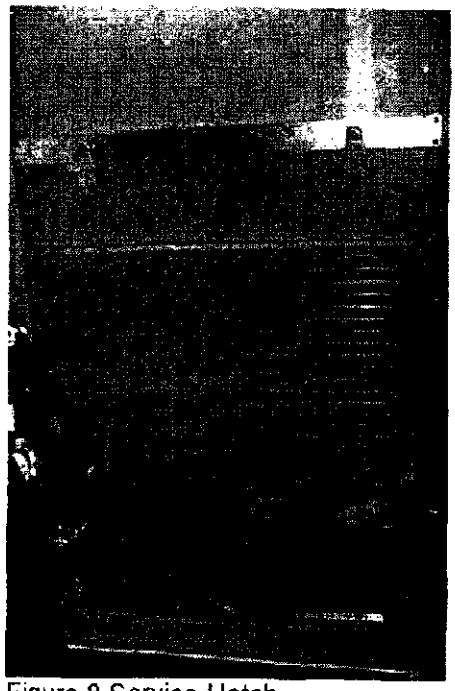


Figure 8 Service Hatch

Release the chain from the chain box.

Figure 9 The chain box

The crane can be moved longitudinally by a winch mounted on the machine foundation.

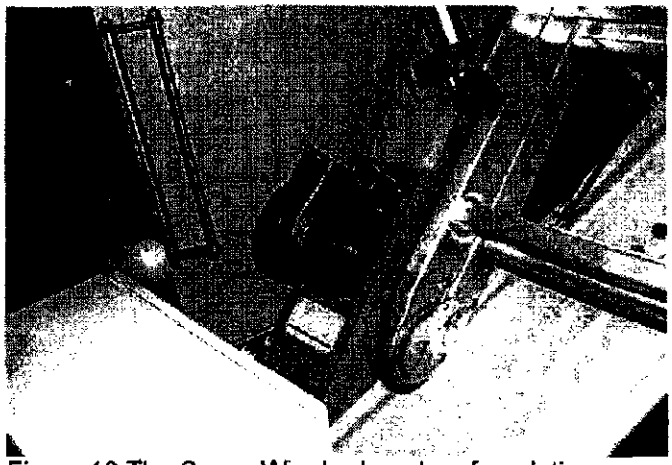


Figure 10 The Crane Winch placed on foundation.

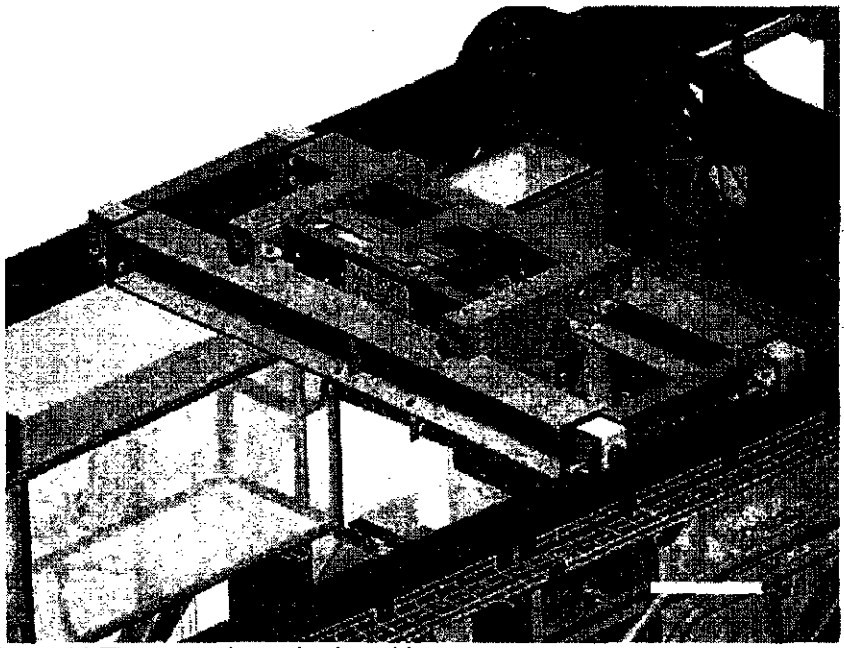


Figure 11 The crane in parked position

General crane functions:

The internal nacelle overhead traverse trolley support 4 lifting functions, each with specific manual.

- Normal service operation. Max. Work load is 800 kg.

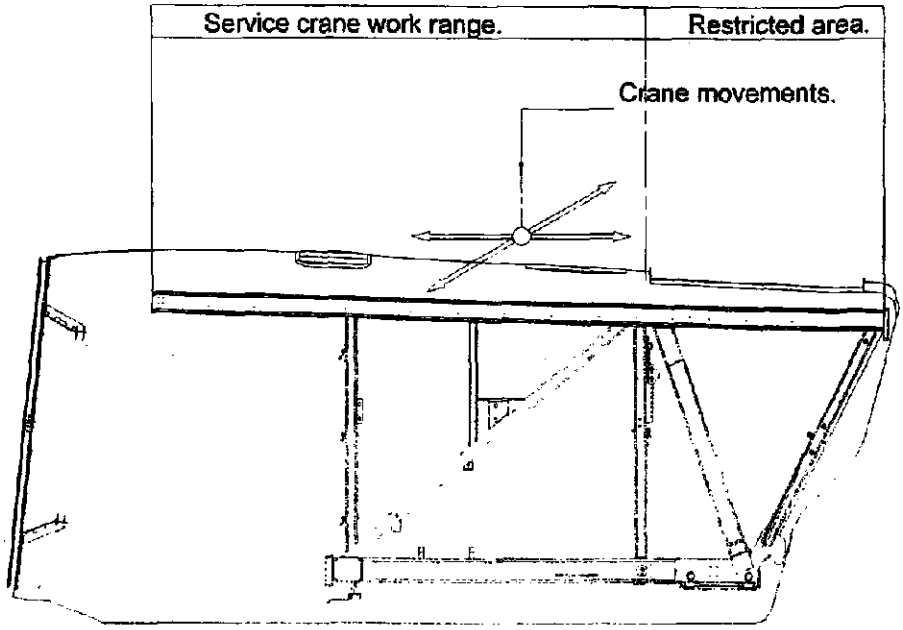
Prior to lowering the trolley must be locked in sideways direction by tightening lock screws ¼ extra turn after contact and in longitudinally direction locked by keeping the steel wire tensioned and tightening lock screw for longitudinally direction by tightening lock screws ¼ extra turn after contact .

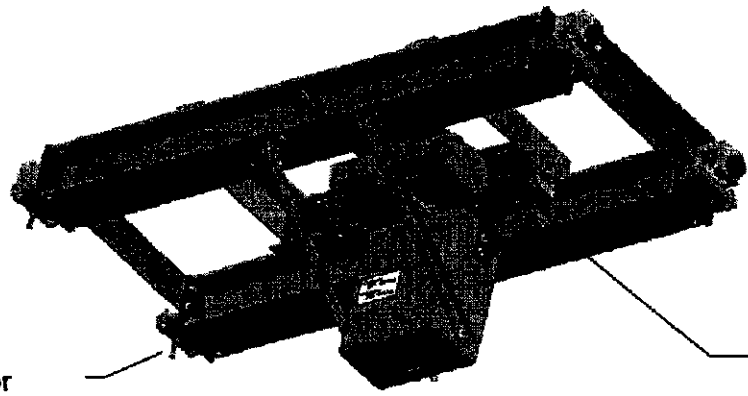
Warning:

Visual inspect:

- The bridge and trolley for corrosion, wear, defect bolts and connections before using the crane.
- Winch for oil/grease leaks and corrosion.

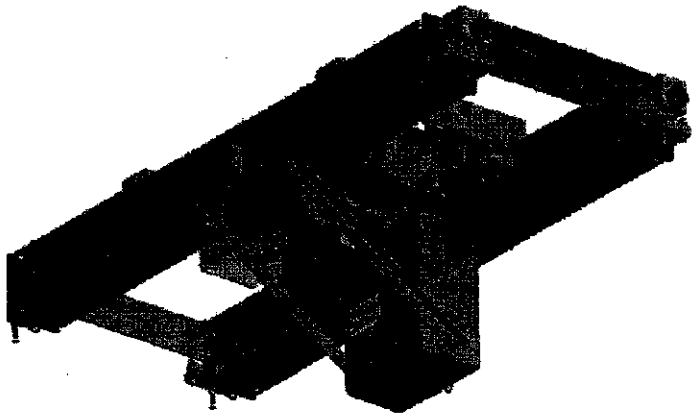
The crane must not be used before defects are repaired.





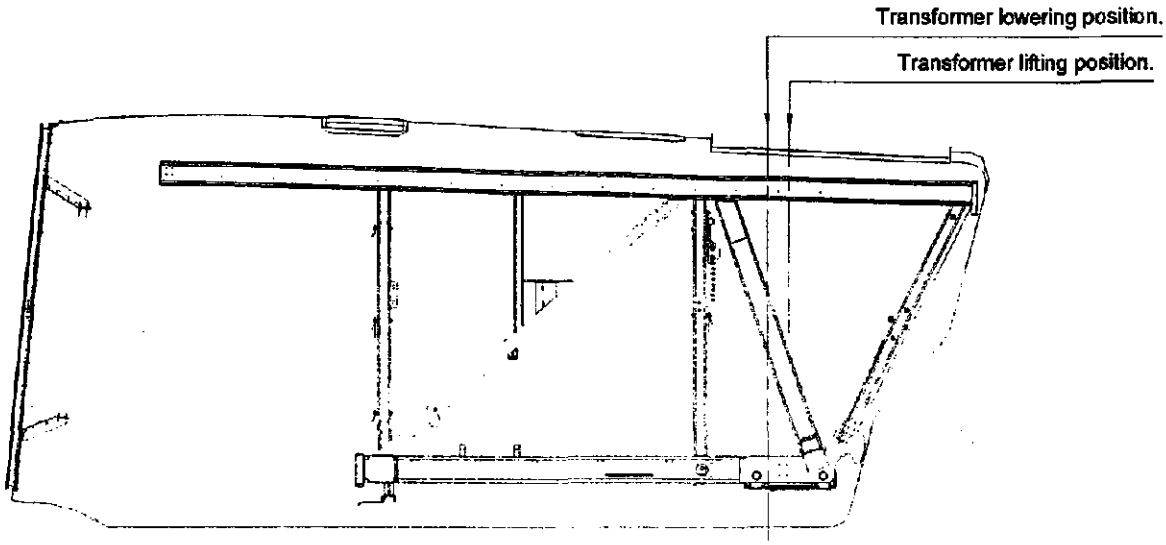
Lock screws for longitudinally direction.

Lock screws for sideways directions.



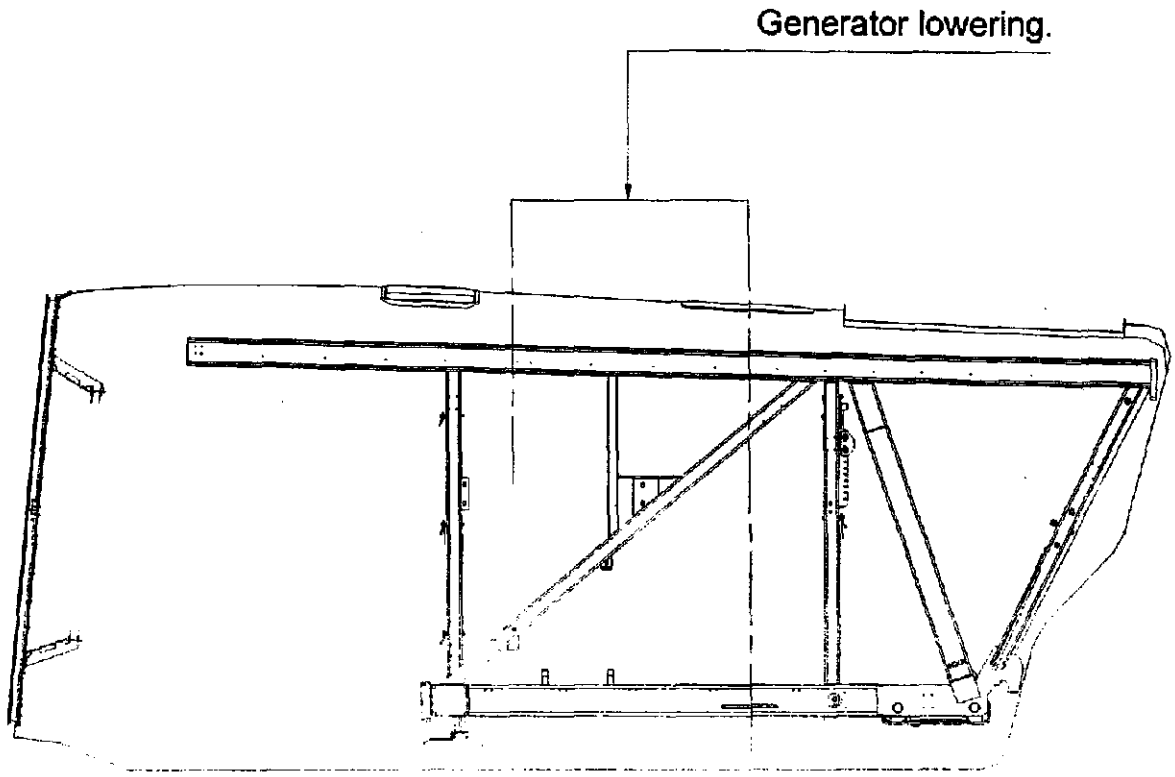
- Lifting transformer. Max. work load is 12000 kg.

This operation is only to be done by authorized personnel.



- Lifting generator. Max. Work load is 12000 kg.

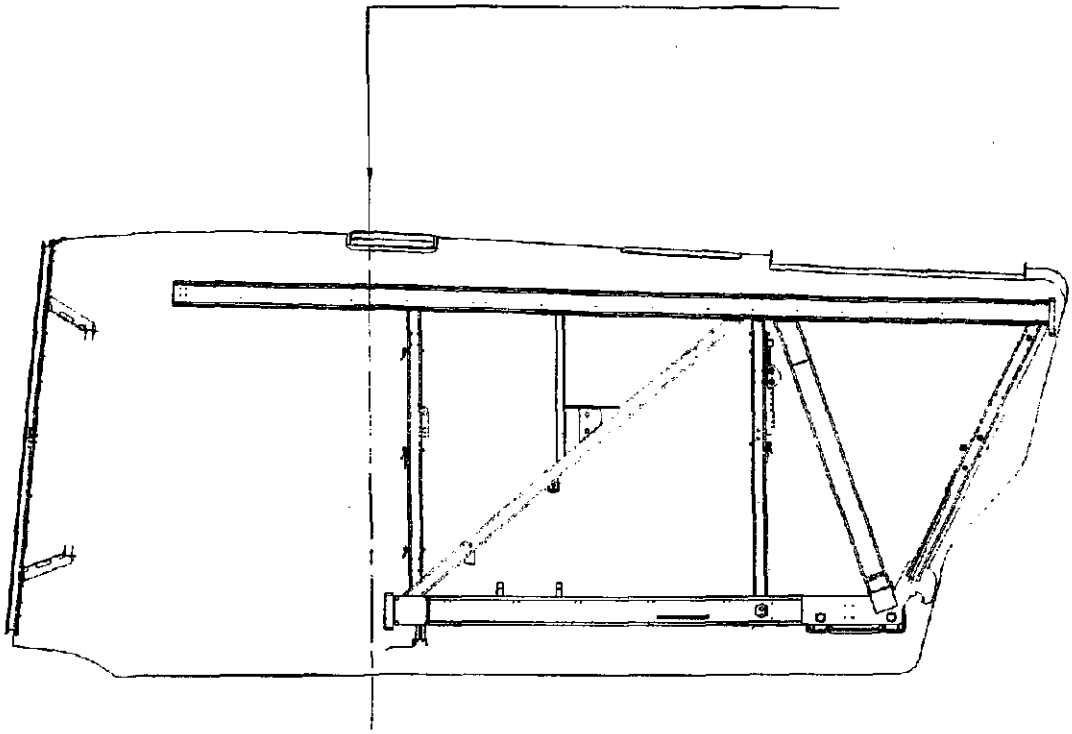
This operation is only to be done by authorized personnel.



Internal crane for lifting components in the hub:

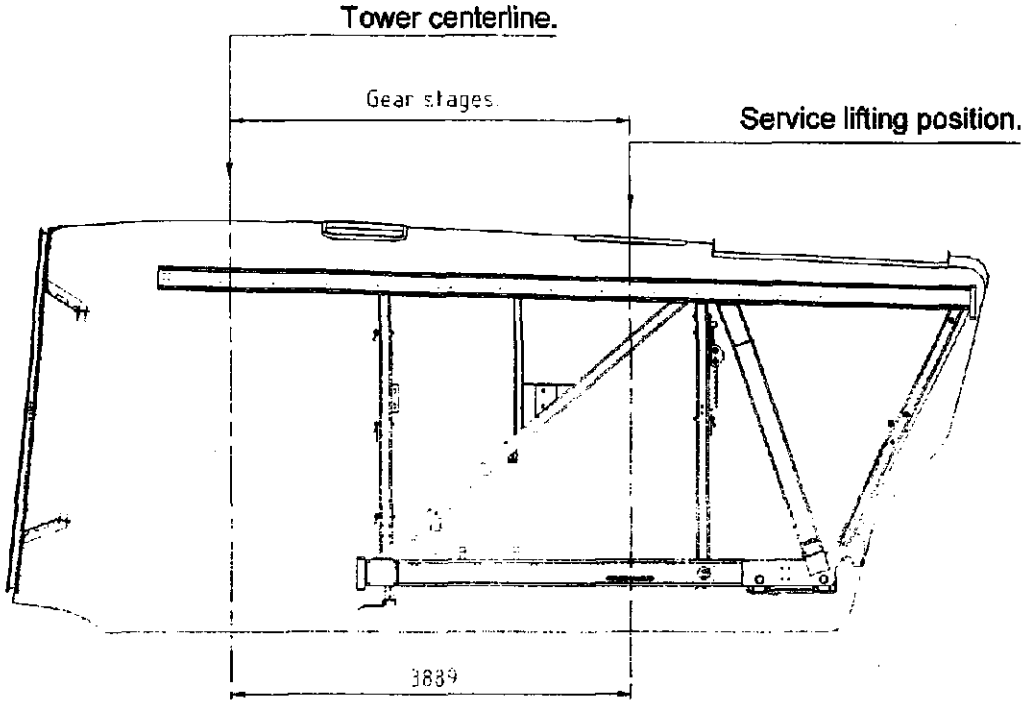
This operation is only to be done by authorized personnel.

Hub components position.



Internal crane for lifting gear stages, Max. work load is 12000 kg:

This operation is only to be done by authorized personnel.



Onshore wind
Offshore wind
Wave & tidal
Small wind systems
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Cymru
Wind farms in the UK
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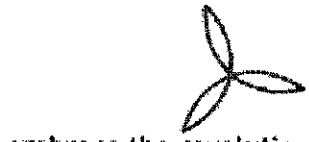


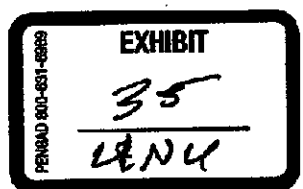
News

Wind industry to agree new CO2 reduction figures with Advertising Standards Authority

Tuesday 15 October 2007

BWEA, the UK's leading renewable energy body is taking steps to agree national standards for the wind industry's carbon offset figures. This follows a ruling last week from the Advertising Standards Authority (ASA) which overturned figures that had been previously agreed between the industry and the Authority.

BWEA Chief Executive Maria McCaffery said "The industry has been pro-actively working with the ASA since the Summer to agree a robust and verifiable set of figures, as well as an agreed methodology so that the new figures can be



regularly updated in future."

The ASA found that BWEA member company npower had breached its rules by using a figure of 860 g/kWh for CO2 displacement for its proposed new Batsworthy Cross wind farm. This figure had previously been agreed between the ASA and BWEA, and previous ASA adjudications had accepted the figure. In overturning the figure the ASA found that the company had acted in good faith in producing its publicity material.

For more information please contact:

Charles Anglin, Director of Communications BWEA, on 020 7689 1966 / 0797 348 1907 or c.anglin@bwea.com

Notes to Editors

BWEA is the trade and professional body for the UK wind and marine renewables industries. Formed in 1978, and with over 350 corporate members, BWEA is the leading renewable energy trade association in the UK.

Wind has been the world's fastest growing renewable energy source for the last seven years, and this trend is expected to continue with falling costs of wind energy and the urgent international need to tackle CO2 emissions to prevent climate change.

The ASA ruling stated "We noted that Npower had followed previously accepted advice and used the 860 g CO2/kWh figure. Although we welcomed their efforts to ensure that their claim was based on an established figure, we nonetheless considered that that figure was no longer representative of the UK

electricity generating mix."

BWEA

Delivering the UK's wind, wave and tidal energy

Education and Careers

Calculations for wind energy statistics

Examines emissions reductions, electricity produced, homes equivalent, energy balance and carbon footprint

See also:
Calculating the energy in the wind
Extracting energy from the wind

A typical turbine generates 5.3 million units of electricity each year, sufficient to:

- Meet the average annual electricity needs of 1,000 homes

- Make 170 million cups of tea

- Run a computer for 1,620 years

- Prevent the emission of 2,000 tonnes of the greenhouse gas carbon dioxide – equivalent to taking 667 cars off the road.

Emissions Reductions

Every unit (kWh) of electricity produced by the wind displaces a unit of electricity which would otherwise have been produced by a power station burning fossil fuel. This is a generally accepted fact used by many organisations including Government in their environmental calculations. Wind-generated electricity does not replace electricity from nuclear power stations because these operate at 'base load', that is they will be working for the whole time that they are available.

Electricity from wind turbines replaces the output of coal and gas fired power stations as these are the most flexible plant on the system.

Nuclear plant operates at base-load. It is the output from coal-fired and gas plants which is adjusted to meet the electricity demand on the system. In other words, most 'load following' is carried out by coal and gas fired plant.

It is easy to calculate how much carbon dioxide (CO_2) is emitted during the production of electricity from coal-fired, oil-fired or gas-fired power stations as this information is available from the main generators in their annual Environmental Performance Reviews.

BWEA calculations use a static figure representing the energy mix in the UK:

- **430g CO_2/kWh**

Emissions reductions can be calculated using the following formulae:

- **CO_2 (in tonnes)= (A x 0.3 x 8760 x 430)/1000**

where A = the rated capacity of the wind energy development in MW

UNU Exhibit 36

(note this is not the same as its declared net capacity or dnc)

0.3 is a constant, the capacity factor, which takes into account the intermittent nature of the wind, the availability of the wind turbines and array losses

8760 is the number of hours in a year

A typical turbine being installed onshore in the UK currently has a rated capacity of 2 MW and will therefore contribute emission reductions of

- **2260 tonnes of CO_2** each year

Electricity Produced

The amount of electricity produced by a wind energy development can be estimated by

Electricity produced = B x 0.3 x 8760

where B = the rated capacity of the wind energy development in kW
and constants 0.3 and 8760 have the same meaning as above

This is only an average estimation given that in many places, particularly Scotland and offshore, the wind speeds are higher leading to a greater electricity production per turbine, as power output is a cube of the wind speed.

On average then, a typical onshore turbine in the UK, rated at 2 MW, produces **5.3 million units of electricity each year**. This is equivalent to 5,256 MWh or 5.3 GWh.

Homes Equivalent

A more realistic measure of the amount of electricity a wind project generates is to calculate how many households this will supply

Number of households = B x 0.3 x 8760/4700

where 4,700 is the average UK household electricity consumption in kW hours.[2]

A typical turbine therefore produces enough electricity each year to meet the needs of **1,000 homes**.

Energy Balance

The comparison of energy used in manufacture with the energy produced by a power station is known as the 'energy balance'. It can be expressed in terms of energy 'pay back' time, that is the time needed to generate the equivalent amount of energy used in manufacturing the wind turbine or power station.

The average wind farm in the UK will pay back the energy used in its manufacture within three to ten months, and over its lifetime a wind turbine will produce over 30 times more energy than was used in its manufacture.

This compares favourably with coal or nuclear power stations, which deliver only a third of the total energy used in construction and fuel supply. So, if fuel is included in the calculation, fossil fuel or nuclear power stations never achieve an energy pay back. Wind energy not only achieves pay back within a few months of installation but does so from a fuel that is free and inexhaustible.

Carbon footprint

All electricity generation technologies emit CO_2 at some point during their lifecycle, whether from extraction and refining of raw materials, or during manufacture, transport and construction, and fossil-fired power plants will also emit CO2 during combustion of their fuel.

The Parliamentary Office of Science and Technology has published a report on the carbon footprint of electricity, which compares the lifecycle CO_2 emissions of different electricity generation systems currently used in the UK, including fossil-fuelled and 'low carbon' technologies. The note concludes that while all electricity generation technologies emit CO2 at some point during their lifecycle, CO2 from renewables is non-operational.

Wind power therefore ranks with one of the lowest carbon footprints at 4.64-5.25g CO2eq/kWh for onshore and offshore development respectively.

References

1. Parliamentary Office of Science and Technology, 1994. Select Committee Briefing: Environmental Aspects of Wind Generation.
2. Digest of UK Energy Statistics, 2005. BWEA regularly updates 'annual homes equivalent' figures based on the latest data for domestic electricity consumption divided by number of households.
3. Parliamentary Office of Science and Technology, October 2006, postnote 268, Carbon footprint of electricity generation, www.parliament.uk/documents/upload/postpn268.pdf

UNU Exhibit 37

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Adjudications
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Advertising Codes
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Advertising 101
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Visit the CAP web site.

ASA Adjudications

RWE npower plc t/a Npower Renewables
Oak House
1 Bridgewater Road
Worcester
WR4 9FP
Number of complaints: 1

Date: 10 October 2007
Media: Direct mail
Sector: Utilities

Ad
A newsletter, that promoted an Npower Renewables development, was entitled "Wind Power News Keeping you informed". The text stated "The scheme will also help prevent the release of some 33,000 tonnes of carbon dioxide, the main greenhouse gas contributing to climate change, as every unit of electricity produced using wind power will displace one that would otherwise be generated using fossil fuels." The text was linked to a foot note, which stated "National Grid Transcos Seven Year Statement 2004 supported the theory that wind power currently displaced high-emitting coal and indicated that an appropriate CO2 emissions factor for electricity generated by wind should be higher than that of the average UK mix of generating fuels in the region of 860g CO2/kWh. Over the life of the project emission savings may change due to variations in the generating plant mix.

Issue
The Two Moors Campaign challenged Npower Renewables to substantiate the claim that the scheme would prevent the release of some 33,000 tonnes of CO2. They believed the data upon which Npower Renewables based the figure was out of date because lower emitting gas, rather than coal, was the fuel currently being replaced by wind energy.

The CAP Code: 3.1;7.1;49.3

Response
Npower Renewables (Npower) said they submitted a planning application for a wind farm with a capacity of between 13.5 and 22.5 MW. They said it was likely that the proposed wind farm would have a specific capacity of 18 MW and they had based the claim about CO2 on that figure. They said the calculation used a carbon emissions factor of 860 g CO2/kWh, which, they pointed out, was recommended by the British Wind Energy Association (BWEA). They sent a document by the BWEA entitled, Blowing Away the Myths, which stated, "In practice, the BWEA figure is robust, and founded on what is actually happening in the real world. It is about 10% lower than the figure quoted by the Parliamentary Office of Science and Technology, and is therefore conservative ... [The] emission savings from wind energy would be around 860g/kWh, a figure that was quite different from the emissions associated with the forecast generating mix.

Npower pointed out that the ad referenced the Seven Year Statement (SYS) issued by the National Grid in 2004, but acknowledged that there had been two subsequent reports. They said the subsequent statements both included an installed capacity utilization ranking order. They said the ranking order was intended to inform the energy industry as to which plants allowed the greatest flexibility. They pointed out, for instance, that nuclear, wind, hydro and gas power were less flexible than high-emitting coal and oil. Npower maintained that both the 2005 and 2006 SYS showed that wind power was again higher up the utilisation ranking order and, therefore, more flexible than high-emitting coal and oil. Consequently, they believed there had been no change in how wind power offset carbon dioxide by displacing coal and oil fired

electricity generation.

Assessment

Upheld

The ASA noted the claim related to the yearly reduction in CO2 emissions caused by the displacement of coal-fired generation by wind power. We noted the carbon savings claim was based on the electricity generation mix outlined in the National Grid SYS 2004 and the BWEA's recommended carbon emissions factor of 860 g CO2/kWh. We noted the figure was representative of the emissions of a coal fired power station. We also noted a previous ASA adjudication in 2005 had examined the issue of emissions factors and concluded, on the available evidence, that 860 g CO2/kWh was an appropriate emissions factor for wind power. However, we also noted the complainant's assertion that the situation had now changed. We therefore consulted the National Grid, which produced the SYS, for their view.

The National Grid said the marginal plant (i.e. the fuel likely to be displaced by wind power coming online) depended on the relative prices of coal and gas. They pointed out that, historically, there were some seasonal variations, with prices tending to favour coal-fired generation throughout the winter months and gas-fired generation throughout the summer. The National Grid pointed out that when coal fired generation was favoured, wind power was likely to displace gas and vice versa. They said the SYS contained a ranking order based on generation in December and January for the previous two winters and considered that, given the seasonal pattern of generation, it was perhaps an inappropriate basis for identifying the marginal plant over a full year and, although they said the estimate of 33,000 tonnes was realistic assuming wind power displaced coal for a full year, the National Grid considered that the assumption that coal would be the marginal plant consistently over the course of a year was inappropriate. They also considered, however, that for the same reasons, the complainant's point that gas was now consistently the marginal plant (with a typical emission factor of around 400 g CO2/kWh) was also inappropriate. They concluded that a more accurate emissions factor for wind power lay between the two figures taking account of the variations throughout the year.

We noted previous ASA adjudications had accepted that the figure of 860 g/kWh as an appropriate carbon emissions factor for wind power. We noted, however, that the recent fluctuations in wholesale energy prices, in particular, the large increases in the price of gas, had affected the market for electricity supply. We understood from the National Grid, however, that the SYS was not the most appropriate source on which to base carbon offsetting claims. Although we did not accept the complainant's assertion that gas fired generation had replaced coal fired generation as the marginal plant, we did consider that the electricity generating mix was, over a year, highly complicated and was not accurately reflected by the either the coal or gas carbon displacement figures.

We noted that Npower had followed previously accepted advice and used the 860 g CO2/kWh figure. Although we welcomed their efforts to ensure that their claim was based on an established figure, we nonetheless considered that that figure was no longer representative of the UK electricity generating mix. We therefore concluded that the carbon offset claim was inaccurate and likely to mislead.

The ad breached CAP Code clauses 3.1 (Substantiation), 7.1 (Truthfulness) and 49.3 (Environmental claims).

Action

We told Npower to ensure that future carbon savings claims were based on a more representative and rigorous carbon emissions factor.

Adjudication of the ASA Council (Non-broadcast)

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Advertising Standards Authority.

RWE npower plc

Mid City Place, 71 High Holborn, London. WC1V 6QT. United Kingdom

NOTICE OF PROPOSED MAJOR UTILITY FACILITY

Buckeye Wind LLC, a wholly owned subsidiary of EverPower Wind Holdings, Inc., is proposing to construct a wind-powered electric generation facility located in Champaign County. The energy generated at the wind farm (hereafter referred to as the "Facility") will collect to an electric substation in Union Township, Champaign County (Ohio Power Siting Board Case No. 08-666-EL-BGN). The proposed Facility will consist of 70 wind turbine generators, along with access roads, electrical interconnect, construction staging areas, and operations and maintenance facilities, and the substation. The "Project Area" is defined as the Facility including the area 914 feet from the turbines.

The general purpose of the Facility is to produce wind-powered electricity that will maximize energy production from wind resources in order to deliver clean, renewable, low cost electricity to the Ohio bulk power transmission system. The electricity generated by the Facility will be transferred to the transmission grid operated by PJM Interconnection for sale at wholesale.

The proposed Facility is located within approximately 9,000 acres of leased private land in the townships of Goshen, Rush, Salem, Union, Urbana, and Wayne. Each of the 70 turbines will have a nameplate capacity rating of 1.8 to 2.5 MW, depending on the final turbine model selected. This will result in a total generating capacity of 126 to 175 MW. The Facility is expected to operate at an average annual capacity factor greater than 30%, and therefore the 70 turbines will collectively generate approximately 331,000 to 460,000 megawatt hours (MWh) of electricity each year.

Champaign County Commissioners Coates, Corbett, and Hess as well as the LUC Regional Planning Commission, 9676 E. Foundry Street, P.O. Box 219, East Liberty, Ohio 43319 each have received copies of the accepted application pursuant to Rule 4906-5-06 of the Ohio Administrative Code. A single copy of the accepted application was sent to the Goshen Township Trustees (Cooper, Cassidy, and Topp); the Rush Township Trustees (Bailey, Westfall, and Williams); the Salem Township Trustees (Clyburn, Smith, and Wilkins); the Union Township Trustees (Hurst, Peters, and Virts); the Urbana Township Trustees (Coon, Koerner, and Terry); and the Wayne Township Trustees (Doty, Gregg, and Johnson). Notice of the availability of such application have been sent to the Champaign County Library, 1060 Scioto Street, Urbana, Ohio 43078; the Mechanicsburg Public Library, 60 S. Main Street, Mechanicsburg, Ohio 43044; and to the North Lewisburg Branch Library, 161 Winders Street, North Lewisburg, Ohio 43060. Buckeye Wind LLC has filed with the Ohio Power Siting Board an application for a certificate to construct, operate, and maintain a wind-powered electric generation facility in Case No. 08-666-EL-BGN, which is now pending before the board.

The following eight criteria are set forth in section 4906.10(A) of the Revised Code and used by the Board in reviewing an application for a certificate to construct, operate and maintain such a facility:

(1) The basis of the need for the facility if the facility is an electric transmission line or a natural gas transmission line;

(2) The nature of the probable environmental impact;

(3) That the facility represents the minimum adverse environmental impact, considering the state of available technology and the nature and economics of the various alternatives, and other pertinent considerations;

(4) In the case of an electric transmission line or generating facility, that the facility is consistent with the regional plans for expansion of the electric power grid of the electric systems serving this state and interconnected utility systems and that the facility will serve the interests of electric system economy and reliability;

(5) That the facility will comply with Chapters 3704, 3734 and 6111 of the Revised Code and all rules and standard adopted under those chapters and under sections 1501.33, 1501.34, and 4561.32 of the Revised Code. In determining whether the facility will comply with all rules and standards adopted under section 4561.32 of the Revised Code, the board shall consult with the offices of aviation of the division of multi-modal planning and programs of the department of transportation under section 4561.341 [4561.34.1] of the Revised Code.

(6) That the facility will serve the public interest, convenience, and necessity;

(7) In addition to the provisions contained in divisions (A)(1) to (6) of this section and rules adopted under those divisions, what its impact will be on the viability as agricultural land of any land in an existing agricultural district established under Chapter 929 of the Revised Code that is located within the site and alternative site of the proposed major utility facility. Rules adopted to evaluate impact under division (A)(7) of this section shall not require the compilation, creation, submission or production of any information, document, or other data pertaining to land not located within the site and alternative site.

(8) That the facility incorporates maximum feasible water conservation practices as determined by the board, considering available technology and the nature and economics of the various alternatives.

Section 4906.07 of the Revised Code provides;

(A) Upon the receipt of an application complying with section 4906.06 of the Revised Code, the Power Siting Board shall promptly fix a date for a public hearing thereon, not less than sixty nor more than ninety days after such receipt and shall conclude the proceeding as expeditiously as practicable.

(B) On an application for an amendment of a certificate the board shall hold a hearing in the same manner as a hearing is held on an application for a certificate if the proposed change in the facility would result in a material increase in any environmental impact of the facility or a substantial change in the location of all or a portion of such facility other than as provided in the alternates set forth in the application.

(C) The chairman of the Power Siting Board shall cause each application filed with the board to be investigated and shall, not less than fifteen days prior to the date of any application is set for hearing submit a written report to the board and to the applicant. A copy of such report shall be made available to any person upon request. Such report shall set forth the nature of the investigation, and shall contain recommended findings with regard to division (A) of section 4906.10 of the Revised Code and shall become part of the record and served upon all parties in the proceeding.

The public hearing shall consist of two parts:

(a) a local public hearing, pursuant to Section 4906.08(C), Revised Code, where the Board shall accept written or oral testimony from any person on October 26, 2009 at 6:00 PM at the Triad High School Auditeria, 8099 Brush Lake Road, North Lewisburg, Ohio 43060 and

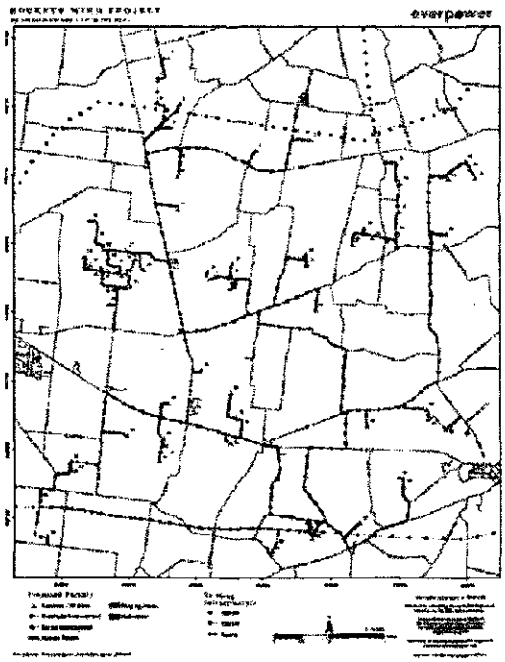
(b) An adjudicatory hearing commencing on October 27 at 10:00 AM at the offices of the Public Utilities Commission of Ohio, 180 East Broad Street, Hearing Room 11-F, Columbus, Ohio 43215-3793.

Section 4906.08(C) of the Revised Code provides:

(C) The board shall accept written or oral testimony from any person at the public hearing but right to call and examine witnesses shall be reserved for parties. However, the board may adopt rules to exclude repetitive, immaterial, or irrelevant testimony.

Petitions to intervene in the adjudicatory hearing will be accepted by the Board up to 30 days following publication of the notice required by Rule 4906-5-08(C)(1), OAC, or later if good cause is shown. However, the Board strongly encourages interested persons who wish to intervene in the adjudicatory hearing to file their petitions as soon as possible. Petitions should be addressed to the Public Utilities Commission of Ohio, 180 E. Broad Street, Columbus, Ohio 43215-3793, and cite the above-listed case number.

The attached map shows the proposed layout of the facility.



September 10, 2009
ID# 1220710

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Exhibit
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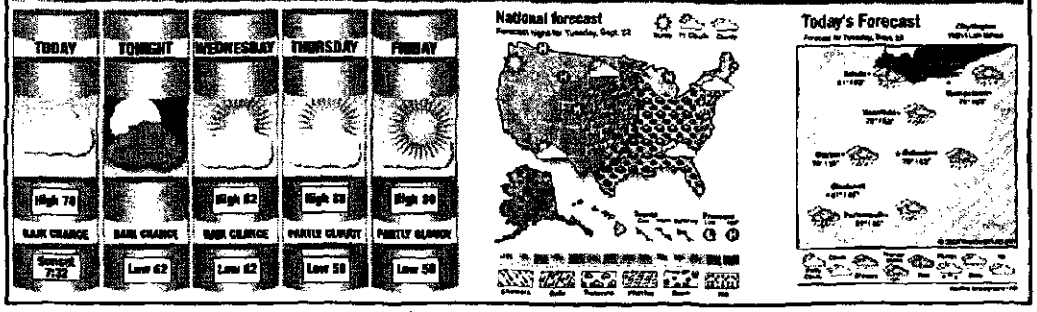
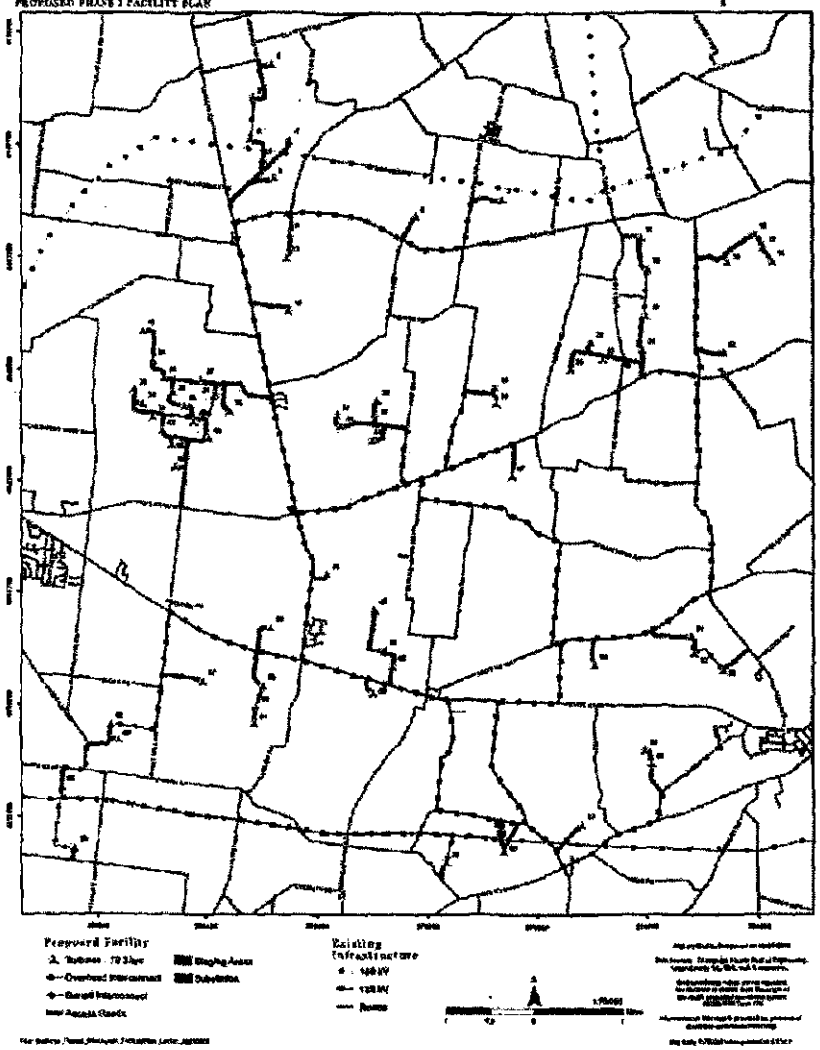
Weather



Wind

BUCKEYE WIND PROJECT
PROPOSED PHASE 1 FACILITY PLAN

everpower



This map was submitted by Buckeye Wind as part of the legal advertisement mandated by the Ohio Power Siting Board earlier this month.

Continued from Page 1

adjudicatory hearing will be more formal, with testimony from Buckeye Wind representatives along with parties that have been granted "intervenor" status by the OPSB. Petitions to intervene should be addressed to the OPSB, 180 E. Broad St., Columbus, Ohio 43215-3793, and cite the Buckeye Wind case number, 08-0666-EL-BGN.

To date, the OPSB has granted intervenor status to the Union Neighbors United group, the Champaign County Commission, the Urbana Country Club, the Union Township trustees and the Ohio Farm Bureau Federation.

In notices of determination issued earlier this month, the Federal Aviation Administration issued notices of presumed hazard for 38 proposed turbine locations near Grimes Field on the north side of Urbana. An FAA spokesman said that most of the notices were for sites between two to five miles from the airport, but said the FAA most likely won't become involved as an intervenor to the OPSB application process.

Doug Crabill, assistant to Urbana's director of administration, said that the information from the FAA has been turned over to the city's airport consultant for further review, but the city has not taken action to become involved as an intervenor, even though the project could negatively impact airport operations based on the FAA data.

On Sept. 16, staff with the OPSB filed an 11-page list of interrogatories related to the project and a request for production of other documents. Buckeye Wind representatives have not yet responded to the inquiry, which includes questions such as the turbines' proximity to radio, cellular and water towers, possible interference with television, radar and cellular phone signals, and the potential effect on microwave transmissions.

The request also requires Buckeye Wind to provide notification to the Ohio Department of Transportation's Office of Aviation and addresses the filing status of the FAA determinations. It also raises questions about shadow flicker on neighboring "non-participating" properties as well as safety concerns such as fire, ice throw and blade shear and seeks detailed engineering specifications for the proposed turbine models.

Brendane Parcell can be reached at bparcell@urbanacitizen.com

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Wind Energy Siting Handbook

FEBRUARY 2008

Prepared by:
Tetra Tech EC, Inc.
& Nixon Peabody LLP

Contributors:
Aviation Systems Inc
& Comsearch

3.2 Constraints Map

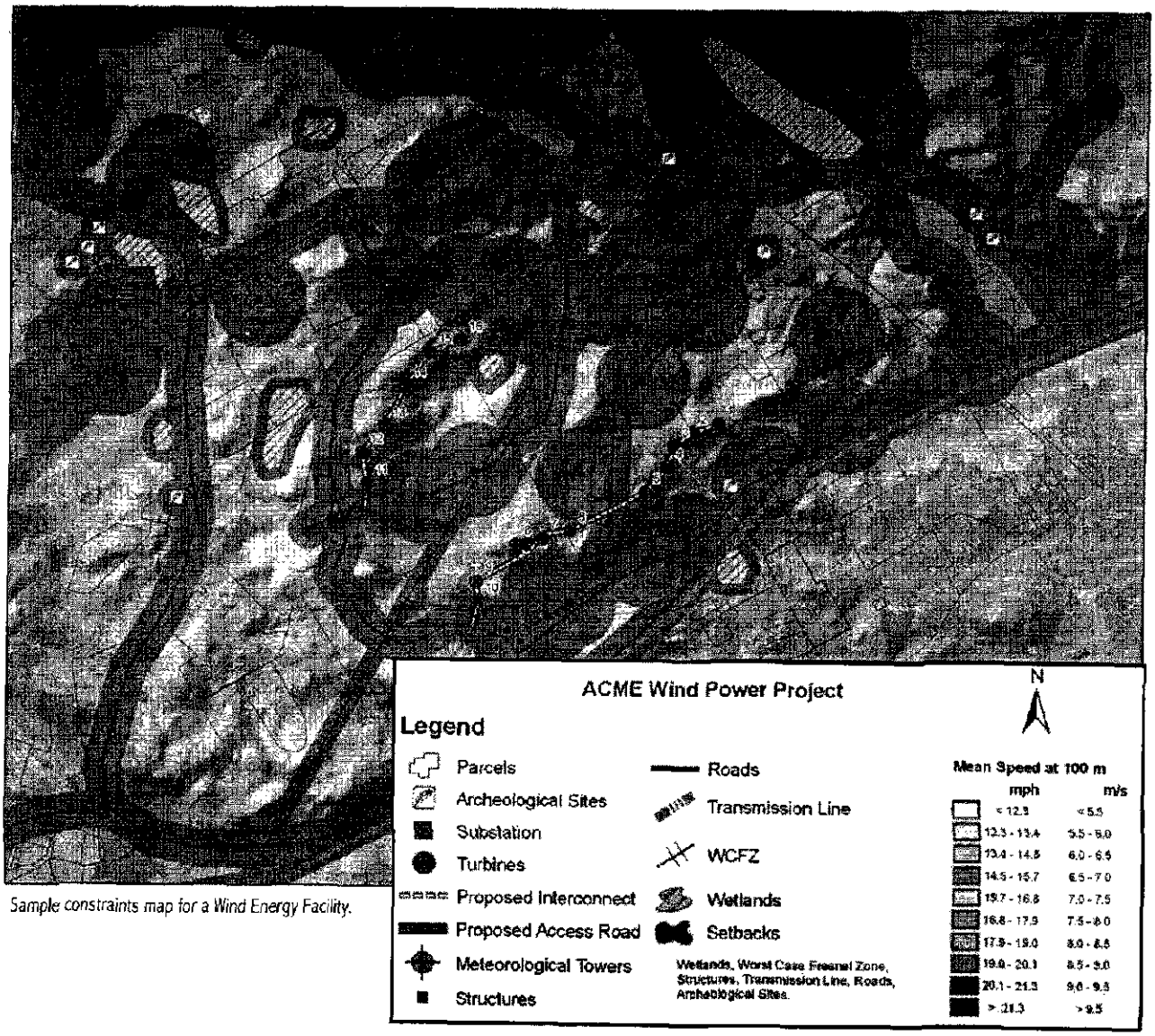
A constraints map graphically depicts environmental and land use constraints that limit the desirable area for development at a site.

A constraints map is a useful tool for graphically depicting the environmental and land use constraints that limit the desirable area for development at a site. The constraints map enables the developer to ascertain the number of turbines that can be located on the site. It also identifies features that may present challenges for siting ancillary facilities. The constraints map uses a base map that shows the wind resource and parcel information. Mandatory or other appropriate setbacks can be overlaid on the map. An example map is provided at the end of this section.

These setback constraints may include:

- Setbacks from sensitive buildings such as residences, schools, hospitals, and churches
- Setbacks from outbuildings such as barns, garages, and hunting camps
- Setbacks from roads, trails, and recreational areas
- Setbacks from electric transmission lines; oil and gas wells; oil and gas transmission, gathering, and service lines; sub-surface mining operations; and other such infrastructure/facilities
- Setbacks from non-participating parcel boundaries
- Wetlands, surface waters, drinking water supplies, and any regulatory buffers surrounding them
- Sensitive cultural resources and any regulatory boundaries surrounding them
- Locations of special-status wildlife or vegetation species and/or critical habitat
- Areas of known geotechnical instability
- Fresnel zones and other communication/radar-related constraints
- Areas impacted by air traffic (both civilian and military)
- Any other environmental and land use constraints identified for the site

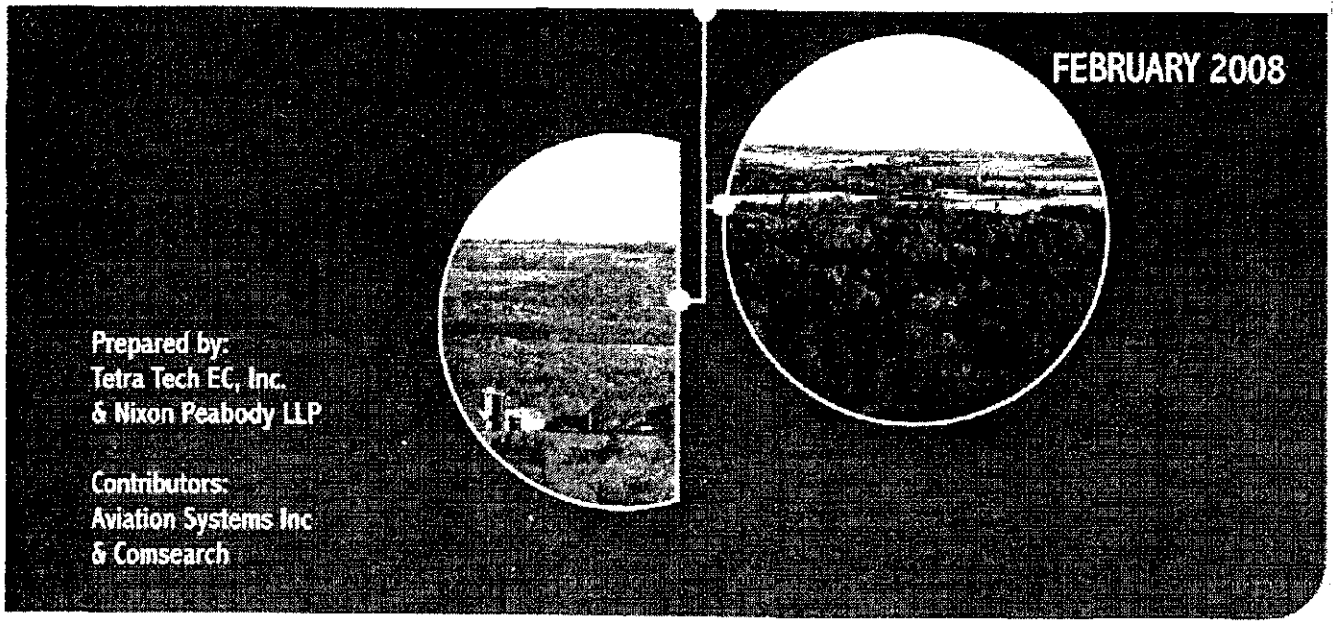
The map may include additional constraints that can create development challenges. For example, constraint maps often indicate parcels that cannot be developed, such as conservation easements, and residences close to the site. Engineering constraints, such as steep slopes and areas of geotechnical instability, are also often depicted on the constraints map.



Sample constraints map for a Wind Energy Facility.

American Wind Energy Association®

Wind Energy Siting Handbook



FEBRUARY 2008

Prepared by:
Tetra Tech EC, Inc.
& Nixon Peabody LLP

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impacts be understood locally. Researching and developing information on the type and extent of such potential impacts would assist the wind developer to develop appropriate mitigation measures to incorporate in the local permitting process. In most cases, developers can reach out to the local community early in the process to discuss mitigation measures.

The potential for the host community to be compensated in some manner by the developer is often an important factor in reaching agreement with local officials. Virtually all wind project facilities will be subject to property taxes. Alternatively, developers may seek to negotiate an agreement with the local taxing entities, often called a PILOT agreement (*Section 4.3.6*). By establishing a fixed set of payments over a specified period of time, the developer (and the project financers) will be able to better forecast long-term expenses, and the taxing authority will have a guaranteed level of income.

Many factors contribute to changes in the local economy. Employment from development, construction, and operations can stimulate local businesses and provide personal income in the county. Local cities and governments may receive additional tax revenues, while individual landowners may receive additional income from royalty/lease payments. In either case, the community benefits from the increased income.

Agreements between the wind developer and the local community, including police, fire, medical, and other, similar services, not only promote good will, but also establish protocols to handle potential events and maintain the lines of communication between the wind project and the host community.

5.7.2.2 Property Values

Many variables can affect property values in the vicinity of a wind farm, and these must be reviewed on a case-by-case basis. Typically, wind farms do not impact properties in a uniform manner, and the circumstances of each development can be different. Developers should work with individual landowners to discuss mitigation measures, if any, to protect property values and preserve the integrity of the property. Public outreach is a key component in addressing and mitigating any impacts to socioeconomic resources. *Chapter 7* provides more information regarding public outreach.

5.8 Public Health and Safety

Potential risks to public health and safety should be identified and addressed early in the development process. This section describes key health and safety issues and mitigation techniques to be considered.

House of Lords

Session 2003-04
Publications on the internet
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Science and Technology - Minutes of Evidence

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WEDNESDAY 11 FEBRUARY 2004

Present

Flowers, L	Sutherland of Houndwood, L
Methuen, L	Tombs, L
Oxburgh, L (Chairman)	Turnberg, L
Perry of Southwark, B	Wade of Chorlton, L
Platt of Writtle, B	Winston, L
Sharp of Guildford, B	Young of Graffham, L

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UNU Exhibit 42

Select Committee on Science and Technology Minutes of Evidence

Examination of Witnesses (Questions 167-179)

11 FEBRUARY 2004

Mr Alan Moore, Mr Chris Shears, Mr Rob Hastings and Mr Alan Mortimer

Q167 Chairman: Good afternoon. Thank you very much for coming along to speak to us. At the beginning may I remind you that these are public proceedings and that this afternoon we are being broadcast live as a web cast, only for sound. Could we begin, please, working from one end to the other, perhaps from the left, by asking you to identify yourselves, say who you are and what you do and then we will go into the questions.

Mr Hastings: My name is Rob Hastings. I work for Shell Wind Energy, Vice President of Shell Wind Energy UK. I am also a Director of BWEA and a member of the Renewables Advisory Board.

Mr Mortimer: Alan Mortimer, Head of Wind Development for ScottishPower in charge of developing new wind business for the company and also Director of BWEA responsible specifically for Scottish issues.

Mr Moore: My name is Alan Moore. I am Chairman of the BWEA. I am Managing Director of National Wind Power, which is the UK's largest wind farm owner-operator. I am a member of the Renewables Advisory Board and a member of the Distributor Generation Co-ordination Group.

Mr Shears: I am Chris Shears. I am Development Manager with Renewable Energy Systems, who are one of the main developers in the UK and internationally and part of the Sir Robert McAlpine Group. I am also Vice Chairman of the British Wind Energy Association.

Q168 Chairman: Could I just emphasise the point that the acoustics in this room are extremely bad. If you see me doing that it means please speak up because we cannot hear you properly. May I kick off and ask you whether you think that the Government's targets for the contribution from renewables to electricity, namely 10 per cent for 2010 and, indeed, 20 per cent for 2020, are likely to be met? In your view, how will the present rate of construction of wind farms contribute to this? What are the main obstacles that those are encountering?

Mr Moore: We had a little warning of that particular question so in the last week or so we have undertaken a survey amongst the leading players within the wind industry to make sure that we have a consensus view on how much wind could get built. I have to say the time horizon we looked at was up to 2010, we did not look past that, but that is far enough into the crystal ball, if you like. When we take a consensus view across the industry, recognising that this is a cautious view, and I am sure we can talk later on about the Renewables Obligation review that is due in 2005-06, if we did not expect a lot of change out of that review then I think the consensus is that we could be pretty sure about delivering between six and six and a half gigawatts of wind capacity before 2010. You may be interested to know how much of that is onshore and offshore. Once again, the consensus view is very slightly more onshore but roughly 50/50 is the view. Clearly everybody has to take a different view of the market but there is a surprising degree of unanimity amongst us.

Q169 Lord Sutherland of Houndwood: I want to follow up in relation to that prediction, whether you thought the bulk of the development would be in large scale projects, perhaps in Scotland, because clearly different forms of latching into the consumer is very important there?

Mr Moore: Offshore, in Round One, we have been building projects which are typically in the 60 megawatt to 100 megawatt range. In Round Two the size of the projects is much larger than that, typically 300 megawatts and greater. My own company has announced a project of 1,200 megawatts. Projects will get very large when we get to the back end of the decade in Round Two. Onshore I expect there to be a mixture of projects in terms of size. The average size of projects which have been coming through in the last few months has been about 25 megawatts. That is ten or more turbines. I think there is space for some of what we tend to call wind clusters, two or three turbines, in particular locations. I have to say I think there will be a tendency towards larger capacities in general, onshore as well as off.

Q170 Lord Sutherland of Houndwood: To meet the six to six and a half gigawatts? That will be a larger capacity rather than small.

Mr Shears: That is right. If I could just add to that. I think that part of the process we see onshore is a spread of projects around the whole of the UK and inevitably some areas are more populous than others and, therefore, there is a physical constraint on the size of the project which is appropriate. Perhaps you will see in an area such as the West Midlands or the South East, for example, which both have a reasonable wind resource which should be utilised, we believe smaller projects may be appropriate for a number of reasons.

Q171 Lord Sutherland of Houndwood: Can I just follow up on that. Is the cost of the connection hugely variable? Supposing you have a lot of small projects, does that put up the connection costs very dramatically?

Mr Shears: An individual turbine, for example, may be two megawatts and you may be able to connect that at the 11KV voltage which should be viable for that particular project. As the schemes go up to perhaps ten megawatts a 33KV connection and the costs go up proportionately to a 132KV connection. Probably as a rule of thumb if you can keep your grid costs at somewhere within five to ten per cent of total project costs then you should have a fighting chance.

Q172 Chairman: Your six and a half gigawatts prediction was as a result of your usefully taking soundings from the industry. Did you get any feeling for what the regulating factors were in all this? Was this the ability to have monies available for capital, planning permission? How did these things trade off?

Mr Moore: I think the answer to that is a yes.

Q173 Chairman: All of those?

Mr Moore: All of those things have historically been constraints and will continue to be constraints to a certain extent, although some of the changes that have been made in recent months and the last couple of years may not have demolished those barriers, but they have certainly lowered those barriers. As a result of that we are expecting between 400 and 600 megawatts of wind farms to be built in 2004. That compares with what we have achieved in the last 13/14 years, which is 650 megawatts. So we are achieving almost as much in one year as we have achieved in the previous decade. Clearly those barriers are falling, if not fallen. Let me develop the issues of the Renewables Obligation and ask my colleagues to join me if they wish. The Renewables Obligation has been an enormous incentive to renewables and wind power in particular. As I say, we have seen an enormous increase in activity in wind farming since its introduction. The extension of the Renewables Obligation out to 2015 I think it is fair to say was as a result of lobbying from the renewables industry in terms of giving us an extended period, ten years or more, when we could actually do our economic sums and see if we were making a decent return. The problem when the Obligation only went out to 2010 was the period between now and 2010 was getting shorter and shorter and, therefore, the certainty with which we could estimate the value of the Renewables Obligation Certificates and the value of our electricity was getting shorter and shorter and was reducing to a point where it was shorter than the simple payback period of the investment. The extension to 2015 was a major breakthrough. For that same reason the outcome of the Review of the Obligation in 2005-06 that was announced in the Energy White Paper will be equally important because once again we will be getting to a period when we will have less than ten years of relative certainty in terms of how the Obligation will work, the value of Renewables Obligation Certificates, and we will be looking as an outcome of that Review to see where we go in terms of 2020.

Mr Shears: If I can just add to that. We are pretty certain that we have quite a good build rate for the next two or three years. Beyond that, the 2005-06 review and the 20 per cent target we think is very important. In canvassing our members there is clearly a view that towards the back end of the decade, 2009-10, we will have a significant ramping up of offshore development and for many reasons we believe that is wholly possible. The one potential thorn in that is if the RO target is not extended because that will not give the financial security to allow those projects to proceed. Certainly at this moment in time a lot of investment is going into those projects on that basis.

Q174 Chairman: Can I just be clear that we understand the figures you are giving us. The six and a half gigawatts is installed capacity.

Mr Moore: Yes.

Q175 Chairman: So working on, say, a 30 per cent load factor or something like that, we are looking at about a third of that as a contribution to the grid?

Mr Moore: It is 8,760 times 6,500 times about 30 per cent in terms of megawatt hours.

Mr Shears: You need to bear in mind that obviously all technologies have different load factors.

Q176 Chairman: The answer is we are not going to get ten per cent.

Mr Moore: I was doing some rough sums in terms of—

Q177 Chairman: That is what I was trying to do as well but I am only about half way through.

Mr Moore: The six and a half gigawatts is a number we felt confident we could deliver and it is a minimum. Let us take that number for a while. That six and a half gigawatts delivers about five and a half per cent of the ten per cent, roughly.

Q178 Chairman: That is what I thought.

Mr Moore: We have got the co-firing of biomass which has been announced and that will be around one per cent.

Q179 Chairman: That is absolutely fine. I think our back of the envelope arithmetic agrees in that case. It is about five per cent of the ten and if the ten is to be met it is going to have to be met from other sources.

Mr Moore: Yes.

Mr Shears: Just to caveat that, the key period is this back end of the decade when offshore really comes to the fore. If we had an extension of the target beyond the 2005-06 review it is wholly within reason that we could achieve a lot more with wind. I think we are quite conservative in these estimations.

Select Committee on Science and Technology Minutes of Evidence

Examination of Witnesses (Questions 180-199)

11 FEBRUARY 2004

Mr Alan Moore, Mr Chris Shears, Mr Rob Hastings and Mr Alan Mortimer

Q180 Lord Turnberg: I would like to come to a point you talked about in your memorandum about the obligations of operators and regulators. Do you agree that the primary obligation of operators and regulators must be to ensure safe and secure power supply and the suggestion that technologies, particular technologies, should be the primary obligation should be secondary to that? Is that not the case?

Mr Moore: As someone who has worked in the electricity generating industry for 37 years I would agree that safe and secure supplies are, and always will be, the prime concern of all of us.

Q181 Lord Turnberg: I thought you might.

Mr Moore: Let us not read into that that what we are representing here is necessarily something that works to our detriment. Wind power itself brings a number of advantages in terms of security, both in terms of being an embedded distributed generation system that can supply local networks, and clearly whilst the wind does not blow all the time it does not cost anything and, therefore, is not subject to price variations and it certainly is not subject to problems with importing fuels from abroad. Yes, we are intermittent but we bring some advantage to that security as well.

Q182 Lord Turnberg: I want to come to this intermittency business because if you do have a primary role to guarantee supply how do you get round the intermittency issue?

Mr Moore: I do not think "get round" is necessarily the right term. The intermittency of wind is a fact of life but system operators will tell us quite rightly that that does not necessarily mean that it is an enormous problem. There are other factors in the system which in terms of the contribution that wind is making today are having much greater effects in terms of variability on the system. Yes, as the penetration of wind increases the way that the system operator has to operate the system will have to change to accommodate that. I think in one of the questions we had prior notice of, you acknowledged David Millborrow's contribution to this in terms of the natural reserve where he said that for a ten per cent contribution from wind we would need reserves from thermal plant of about 750 megawatts which is not large, it is just over one large coal fired generator. One of the questions you asked was what would happen if it got to 20 per cent. I have spoken to David and, in fact, he has published a paper which gives us the figure for a 20 per cent penetration of wind and that is in the range of two to three gigawatts. That two to three gigawatts could well be coal fired plant which is unable to operate at a higher load factor because of its emissions and the LCPD regulations, but it would be perfectly acceptable within those regulations to operate at a lower load factor, which is what you require in order to provide a reserve. In fact, oil fired power stations, I am sure you are aware, are fulfilling that role right now and run for a relatively few hours a year but provide reserve for the intermittency of other technologies. When a large nuclear power station drops off, as they have a tendency to, that is a much bigger shock to the system than we are ever likely to produce from wind.

Q183 Lord Turnberg: You see the intermittency problem being obviated by conventional carbon fuel?

Mr Moore: By thermal plant, yes.

Mr Shears: It is important to make the point that it is not a substitution issue. For example, for ten per cent of wind on the grid you take away almost ten per cent, apart from this few hundred megawatts we are talking about which is required from conventional plant, so we are not having to keep all of that plant in operation. The one statistic I have here is that to get to eight gigawatts of wind, which is our industry thoughts for 2010 perhaps, would require 300 to 500 megawatts of conventional plant in the system. The grid is a very complicated animal, as you will appreciate. It is a question of being fit for purpose. The Dinorwig pump hydro scheme operates at about a two per cent load factor because it serves a specific purpose on the grid to deal with those very high peaks in demand and similarly we can be incorporated into that complex mechanism.

Q184 Baroness Perry of Southwark: I want to turn to what some of the critics of wind energy have thrown out. First of all, I am sure you will have seen the report in the *Sunday Telegraph* saying there were certain deleterious health effects from wind farms. What is your response to that report and are you undertaking any research in that area?

Mr Moore: I should answer that since the article in the *Telegraph*, which I think came originally from the *Western Morning News*, referred to a wind farm that I own. The study that was done on a Cornish wind farm was of very few people and we sought from the author of the newspaper article, because that is what it is, it is not a serious piece of research, to find out the basis of the results and we have not been able to do that.

Q185 Baroness Perry of Southwark: You mean the author has not responded to you or you have not been able to find him?

Mr Moore: The response has been that she has given her evidence to the local newspaper and that is sufficient.

Q186 Lord Winston: What is claimed? Dizziness?

Mr Moore: Dizziness, sleeplessness, a whole range of things.

Mr Shears: Headaches.

Mr Moore: Those sorts of things. The author has then linked the results of this survey to what is called infrasound, very low frequency sound. The basis for that link is certainly unclear.

Q187 Baroness Perry of Southwark: I have not seen the article. Can you give us an idea of the numbers that she is claiming are affected?

Mr Moore: Our understanding is she spoke to 14 people living around the wind farm.

Q188 Baroness Perry of Southwark: Right. Can we go on from that then, do you think?

Mr Moore: Regarding infrasound, low frequency sound, in some circumstances that can cause problems but there are many tens of thousands of wind turbines around the world and this is the first time the issue has arisen. There was a study done, my colleagues remind me.

Mr Shears: A 1997 ETSU study, a DTI sponsored study undertaken to look at this issue. That concluded that it is difficult to measure but levels ten times below the most stringent international health standards was the conclusion. There is a context issue here. We have got 50,000 turbines operating globally and this issue has cropped up in one or two small instances. The industry is trying to get to the bottom of those studies, as we have heard, and will do a thorough review, but it is within that context.

Q189 Baroness Perry of Southwark: Do you have any thoughts on commissioning research or doing it yourselves?

Mr Moore: At the moment there is very little to do a study on but if there is some real evidence produced from a reputable source then clearly we will work with them and do a study if necessary.

Q190 Baroness Perry of Southwark: Presumably some people do have ultra sensitivity to sound and there is a huge variation.

Mr Moore: I am not a doctor but—

Chairman: We have a doctor here.

Q191 Lord Winston: I am just wondering whether you consulted the National Radiation Protection Board who looked at the power lines. There have been a number of vague issues with public health risks of power lines which have not been substantiated and I wonder if this is the same kind of problem.

Mr Moore: I am reasonably familiar with the power line studies, but that is to do with electromagnetic radiation rather than noise.

Q192 Lord Winston: Sometimes you do have power lines at wind farms.

Mr Moore: But at relatively low voltages.

Q193 Baroness Perry of Southwark: The article was claiming it was sound.

Mr Shears: Low frequency sound going through the ground effectively.

Q194 Lord Winston: I do not think anyone is suggesting there is a serious risk, it is whether or not it is the same kind of problem in people's minds.

Mr Moore: What I would say is we are not dismissing it. If some serious evidence could be produced then we would be very happy to join in a survey and even initiate it.

Q195 Baroness Perry of Southwark: The second on the list is the bird hazard. People are claiming there is a hazard to bird life.

Mr Shears: Yes. This is an issue the industry takes very seriously. The fact that we now have over 80 wind farms operating in the UK means that a lot of studies have been done and there are very small bird strike issues in any of them. Even the RSPB acknowledge that the issue is not bird strike as such, it is more the scarecrow effect, if you like, the possible disturbance of breeding birds. That is where the debate is rather than bird strike. It is a very emotive issue and if there is a strike it tends to get publicity. The particular example recently was one from Wales with a Red Kite. A lot of this has come from the two examples internationally where there have been problems. One was the Altamont Pass turbines, 6,500 of them in California, which are very old, very close together lattice towers. The raptors tend to nest in the towers, perch on them, and occasionally fly through and get clobbered unfortunately. As I understand it, even in that situation there are several hundred killed every year, which tends to show in terms of the significance and impact on the population, which I suppose is the most important thing overall, that there is not a significant issue even in that extreme situation. We clearly do not want that to happen in the UK and we do a lot of consultation with RSPB, English Nature and the like very early on in designing the projects. I think overall the projects which have been built have been very well placed. There is a lot more potential as long as we avoid key migratory routes and SSSIs designated for bird issues and these kinds of things. There is an awful lot of work that goes into the siting of projects.

Q196 Baroness Perry of Southwark: There is, of course, a more general criticism which is the visual impact on the landscape of the design. I am sure you have thought a great deal about that.

Mr Shears: Yes, you are dead right, it is the most important issue for us. It is probably the one issue that as an industry we cannot design away, if you like. We can deal with noise, we can deal with bird issues and various other things, but the visual impact of turbines is an intrinsic part of what they are and basic physics will not dictate otherwise. We have to be careful about how we design projects. I suppose the big picture is that a lot of public attitude studies have been done by the industry, but more importantly by Government and independent bodies, and without fault they always show 80-90 per cent support for the technology. Clearly there are some who are opposed and they do tend to make their voice heard, quite rightly, as they should. It is against that background that we have to be careful about where we put them. Clearly there are some very treasured landscapes and the public do not want to see too much change, but we should bear in mind that the landscape has been changing forever and in the last 30 or 40 years we have become very preservationist in some ways about our landscapes. They are an ever changing thing and I think we need to bear that in mind against the backdrop that we do not need to cover the whole of the UK with wind turbines in order to achieve the penetrations that we need to, say up to 20 per cent. It is a question of balancing and spreading them around the whole of the UK.

Q197 Baroness Perry of Southwark: There is quite a bit of NIMBYism about it anyway.

Mr Shears: I cannot say I have a particular problem with NIMBYism, if it is right next to you then you are going to fight your corner. I think it is for the planning system and the developers to address those issues and come to the right compromise.

Q198 Baroness Perry of Southwark: Briefly, and finally, your own memorandum refers to some of the difficulties with regard to aviation—objections from the MoD to development within Tactical Training Areas, and from civil and military aviation stakeholders to development in the "line of sight" of radar and so on. Have there been any developments or progress made?

Mr Shears: I guess a cautious yes is my answer to that. There has been some progress. We have the Aviation Steering Group which has been operational now for a couple of years, which has 30 people sitting around a table, so nothing is going to happen that quickly I guess, but there has been some progress made through that. For example, on the issue of low flying areas, just last week at that meeting the MoD did say that they were undertaking a review of the Southern Scotland low fly zone to see what more could be accommodated. They have already released the biggest project onshore in the UK in our sector, 150 megawatts or thereabouts, just recently. We are encouraged by the MoD's

project offshore in the UK in our sector, 150 megawatts or thereabouts, just recently. We are encouraged by the MoD's progress as of late. Having said that, it is still taking them six months to respond to an inquiry "Is this area acceptable" and they are still objecting to every other project. We still think there is an awful long way to go. Some of that is technical but we believe a lot of it is institutional and about getting it up the order of priorities. We have got some evidence that this is beginning to occur and some extra resources are being brought to bear. On the civil aviation side, which is in many areas equally as big an issue which is stalling an awful lot of projects, we have no dispute that if a turbine is in line of sight with the radar, you may well see a twinkling on the radar screen. The question then becomes how significant is that in terms of the operational capabilities of that radar. There are many thousands of turbines operating in Europe very successfully around projects.

Q199 Lord Winston: The impression we got last week from the Met Office from a visit in Exeter was that with regard to Doppler radar—which they use of course—this was a serious problem.

Mr Shears: It is a serious issue and I think as an industry we have moved forward in our understanding from the simple "Well, it is a wind turbine, it is not an aeroplane, that cannot really be an issue" to the fact that they are moving objects and there are issues to be addressed. I think where we are struggling at the moment is to get more enthusiasm, particularly from the civil side now because they are a disparate bunch. With privatisation of National Air Traffic Services these days, to get funding for them to do bits of work is difficult and so on and so forth. So, again, it is getting the profile raised in order to come up with mitigation measures. There are possible solutions out there which the BWEA are encouraging which are software fixes, filtering fixes which can be added to radars which effectively process out the wind turbine returns. Now there is still a way to go in proving those sorts of technologies, and they are not cheap, so we have been pushing very strongly that it should be a two pronged attack. One is to look at those sorts of technical issues but also then look at the operational issues and see what compromises can be reached in terms of the day-to-day operations as well.

Select Committee on Science and Technology Minutes of Evidence

Examination of Witnesses (Questions 200-219)

11 FEBRUARY 2004

Mr Alan Moore, Mr Chris Shears, Mr Rob Hastings and Mr Alan Mortimer

Q200 Lord Young of Graffham: In addition to the problem of sight, of course, a real obstacle to achieving a ten per cent, let alone a 20 per cent market is finance, finding institutions which are prepared to invest or help to fund the investment. Have you noticed any change in the attitude of institutions, in particular the 2015 target for Renewable Obligations, has that helped?

Mr Moore: Yes. Perhaps I could take that one. As I said in my first answer, I think the 2015 Obligation was extremely useful, not only as a signal in terms of the Government's intentions. Whether I am talking to my in-house investors or outside banks and equity players, political risk is always the one risk that is quite difficult to mitigate. The 2015 target was a powerful signal about political intent but also, as I was explaining earlier, it gives us the ability to do our economic spread sheets over a period where we can make our own predictions about Renewables Obligations Certificate values. Whilst we were looking at a short period that was not so easy. I think it is fair to say, and I am not being in any way rude, it takes finance houses a couple of years after any major change to get comfortable with the risks that are involved. I am told, although I was not involved at the time, that was the case when the old fashioned NFFO contracts came into place in the early 1990s. I think we have seen that in the last couple of years since the RO was first announced. What I can say is my own company announced only last week the closure of a £400 million financing deal involving private equity and a consortium of 13 banks. I think that is a very good sign that the finance houses in the city are getting comfortable with the risks. Inevitably there will be tension between who takes the risk on the off-take contract, on the long term contract for the electricity and the Renewables Obligation Certificates. There are some pretty interesting negotiations going on between the electricity supply companies, who have the Obligation, and the finance houses about who takes that long term risk. I think that is a debate which is going on right now and I think there will be a compromise somewhere in the middle with both sides taking some of that risk. Very powerful signs are that in only the last few weeks things are moving on that front.

Q201 Lord Young of Graffham: Obviously your company has made progress but are you aware of other potential investors who cannot get finance or will be looking to finance?

Mr Moore: Certainly if you went and talked to some of our colleagues in the industry they would say they have been having problems, but equally I am aware that what I would like to think of as a bit of a pioneering deal that we have done, I already know that others are riding on the wave of that.

Q202 Lord Tombs: Could you give us a ballpark figure of the capital cost of six gigawatts of wind power?

Mr Moore: If you take onshore and offshore as a mixture—

Q203 Lord Tombs: 50/50 you said.

Mr Moore: It is around £900 a kilowatt at today's prices.

Q204 Lord Tombs: £900?

Mr Moore: Yes, £900 a kilowatt, £900,000 a megawatt.

Q205 Lord Tombs: That is rather a lot of money, is it not?

Mr Moore: It is quite a lot of money but the running costs are very low once you have built it.

Q206 Lord Tombs: I am thinking about capital resources. It makes your £400 million deal look quite small.

Mr Moore: Yes, it will deliver something like approximately 400 megawatts and a lot of money has to be raised.

Q207 Lord Tombs: I have two questions on your press release which I found very interesting. It is to finance your existing 13 wind farms and new development. What is the split between that?

Mr Moore: There are about 150 megawatts of existing wind farms.

Q208 Lord Tombs: How much of the £400 million is taken up financing those?

Mr Moore: That is commercially confidential, if you do not mind me not answering that.

Q209 Lord Tombs: I can do my sums.

Mr Moore: There are about 150 megawatts of existing wind farms and the total fund will be for about 430 megawatts.

Q210 Lord Tombs: You said in that same statement that the principal aim was to get the existing wind farms off your balance sheet to allow breathing space. I can understand that. Is that a situation widely existing in the industry? You are a big operator.

Mr Hastings: Maybe I could come in? The way in which financing is approached in the projects is it is maybe driven in some cases by a corporate target. We have a return on equity investment hurdles to reach. It can be that you can structure a capital investment with financing which can improve some of your returns on equity and so it really depends on what sort of corporate targets we have. Yes, going for structured project finance which may be non recourse and, therefore, off balance sheet, can be beneficial to the economic performance of the project when it is consolidated within the corporate targets.

Q211 Lord Tombs: It is a bit of a problem essentially because of the size of operators?

Mr Hastings: Yes.

Q212 Chairman: If we turn to the specifics of offshore briefly at the moment. What do you see as the main risks associated with offshore development? There are questions of health and safety associated with the maintenance of offshore turbines. There is the question of reliability of turbines working for long periods in very hostile environments. There is the question of appropriate foundation structures to stop these things falling over. The first one which falls over will be quite a blow for the confidence in the industry. Comments, please?

Mr Hastings: If we are taking risks in general of course you have to get the project in the first case so there is a consenting risk. There is a process you have to get it through in terms of converting an idea into something which is operating so that is one part of it. Of course there is a lot of work going on at that stage to identify what is appropriate and that is appropriate in the sense of the environment it is working in and that can be an extended period of time, typically something in the region of maybe three years. There is an awful lot of work going into identifying what the actual environmental considerations are and the issues like we mentioned in terms of the suitability of the foundation designed for the location would be worked through extensively and effectively what will be delivered will work in terms of the engineers' design. There are other risks. There is the financial risk of making this thing perform financially and return for the investors and there are other risks like making sure you have a distribution system which is going to operate. If I may pick up specifically on the points you raised which are the safety related risks. Is the asset going to be safe? Once we have constructed it will it stay there, will it operate and will it function as it was intended to function? I think inevitably as you go through the process of making a decision to invest, for example, £500 million in building an offshore wind farm, clearly there is a rigorous process of investigation which goes on to determine whether it is an appropriate design and whether it will operate appropriately for its application. If you look at who is doing this work I think typically these are large household name engineering type companies who are doing the design. For example, if you take specifically foundation design, there is a wealth of experience in terms of constructing offshore foundations and that largely comes from the oil and gas industry.

Q213 Chairman: Can you tell me what industry has experience of building structures in situ in which wind farms are placed because I believe very little of the oil and gas industry experience is relevant?

Mr Hastings: I am not sure that is the case. I think there is a lot of work that has gone on in marine engineering, marine structural engineering, if you like, which is applicable. For example, the environmental loading conditions which

are encountered in these locations are quite similar. There are slightly different parameters you may have, because of the shallower water conditions there may be slightly different parameters that they have to design to. Effectively the engineering models that are used, the design concepts which are used and applied, for example piled foundations, are in effect very similar to what you find in an offshore area.

Q214 Lord Flowers: At first sight an oil rig is one thing, a wind turbine is a very different proposition.

Mr Hastings: It is relatively easy to design for a wind turbine compared with an offshore oil and gas structure. If you imagine the difference in scale, offshore oil and gas structure could weigh something in the region of 10,000 tonnes. A wind turbine could weigh something like maybe 200 tonnes, a large offshore wind turbine. It is an order of magnitude of difference in terms of weight. The dynamic loadings are probably different but, again, in terms of relative loadings a wind turbine, even a large wind turbine, maybe a three or four megawatt wind turbine, which would be applied offshore, still does not approach anything like the kind of loadings you would encounter on an oil and gas structure.

Q215 Chairman: Has anybody, for example, modelled the effects of the vibrations—which we have been discussing already—associated with the operation of the turbine and unconsolidated sound? These vibrations would be transmitted down the structure.

Mr Hastings: There has been quite a lot of research done on this already. Probably going back over the last maybe five or six years, there was a lot of research undertaken by, strangely, the Danish engineering organisations and universities and, in fact, some of the Germans have been doing that as well.

Q216 Lord Sutherland of Houndwood: May I ask an additional question? This is on the ScottishPower piece. I was looking particularly at the paragraphs dealing with the predicted price rises to end users and then you have a very significant paragraph seven in which you say there is a real concern when Government actually come to face these they will be tempted to—meddle is the word I would use—intervene is the word you use. Have you drawn this very clearly to the attention of the relevant departments and has it registered? This will clearly have an impact on the long term planning?

Mr Mortimer: In terms of prices?

Q217 Lord Sutherland of Houndwood: Yes. Is Government aware that these are your predictions and are they nonetheless giving you encouraging noises to go ahead?

Mr Mortimer: Yes, I think they are. We have made it clear, certainly in our responses to various consultations, that there will be implications for consumer prices and that it is in our interest to be up front and honest about what they are and recognise that is the cost of a lower carbon economy.

Q218 Baroness Platt of Writtle: I am struck by the difference in David Milborrow's papers, on intermittency from Scottish Power's views. Has he seen the paper that we have had from ScottishPower which is very much more doubtful about the practicality of their being able to operate in a sensible, efficient, economic, secure way? We have had this paper and ScottishPower seems extremely doubtful.

Mr Mortimer: Certainly we are flagging up some issues which do need to be tackled in the early term. There are some particularly Scottish issues as well which are maybe driving that concern.

Q219 Baroness Platt of Writtle: Yes, but that is going to be a major source, is it not?

Mr Mortimer: It could be and it should be. It should be a substantial contribution towards the national targets. We can see, for example, that the grid could become a significant constraint. It is already a constraint, I know, to areas, for example the North West of Scotland and South West Scotland where there just is not any grid capacity at the moment. That has been recognised and studies have been done to show how it can be expanded to deliver the capacity but that will take time. To take new grid infrastructure through the planning process and invest in it and construct it will take time and our experience, for example, with the Northern Ireland interconnector was that it took seven years to go through that process. Now when you bear in mind that by 2010 the achievement of targets could start to be compromised by lack of grid then really we need to be acting now. Work is underway on environmental aspects, environmental assessment of new grid lines in Scotland, and that is good, but as yet there is no agreement on a funding mechanism which will allow investment in this grid infrastructure to go ahead. That is very urgently required and Ofgem are working on it but it is not in place yet.

Examination of Witnesses (Questions 220-231)

11 FEBRUARY 2004

Mr Alan Moore, Mr Chris Shears, Mr Rob Hastings and Mr Alan Mortimer

Q220 Lord Flowers: You refer in paragraph 2.2, Nature of Grid Codes, to the desirability of a fundamental review of the grid industry being more appropriate instead of just tinkering. How serious is the problem and is there any sign of such a review taking place?

Mr Moore: Perhaps I could answer that because it is an issue that is being addressed through the Distributed Generation Co-ordination Group, which is a joint DTI/Ofgem group. It is being taken very seriously. There is a great deal of work. At the last count there were about 51 different projects working in this area. If I deal, firstly, with the distribution systems. At its simplest, and this is not just wind, this is distributed generation in general, small scale generation which is expected to be a large part of the future, the distribution systems were originally designed to take electricity radially outwards from the bulk transmission system and deliver it to the consumer, but if you put generation on to that distribution system electricity is perhaps, flowing both ways, as I am sure you know. You need to think about how you control that system. Now the technology exists, and it is already being used on the transmission system where it is an everyday occurrence, but what are missing at the moment are the commercial and financial incentives to the Distribution Network Operators to take this seriously and make it happen. There is a great deal of work going on, as I say, within DTI and various working groups within Ofgem to ensure that those incentives are built into the Distribution Price Control Review which is taking place next year, 2005. I am repeatedly assured, and I repeatedly ask the question of both Ofgem and DTI, that that Distribution Price Control Review will contain the commercial incentives to get the attention of the DNOs to invest in those changes to the distribution systems. If I move to the transmission system, the bulk transmission system, then that is going to be important for large scale offshore generation and there is work going on in terms of extending the transmission system out to sea. There is talk about a hub in such areas as the outer Wash where you could extend the transmission system out to a substation, perhaps 20 kilometres out to sea, and then a number of different offshore wind farm developments could connect into that radially. There is an issue about who pays for that transmission link and do you treat it as part of the developers' costs or as an extension of the National Grid which in other circumstances would be paid for by all users of the National Grid. There is a lot of work going on on that. Also there is work going on in the Scottish context about how we get the large quantities of wind power that we would like to see from Scotland down into the South where the consumers are but, yes, once again, there are working groups within the Government and within Ofgem looking at that on an urgent timescale.

Q221 Lord Flowers: Thank you for that. The other question I wanted to ask you is that we have been told that one of the problems with wind turbines is they have a habit of tripping when the network voltage drops in quite a short period. What steps are manufacturers taking to respond to these concerns?

Mr Moore: I think that there were a number of issues. As I say, we were responsible for building North Hoyle, a large offshore wind farm, and slightly to our surprise half way through the process of building that wind farm we were asked to comply with changes to the Grid Code in terms of how we connect and the services we could provide for that. There was a great deal of discussion, as you might imagine, between us (and Powergen who were in a similar position with their offshore wind farm) and National Grid on how we could accommodate that. My reading of the situation was that National Grid were anticipating a large influx of large wind farms and were effectively getting the changed rules in early. I believe we have been successful in persuading them that we can see a time when the penetration of wind has got to

a point where they need to get serious about these things. When we are generating less than one per cent of electricity the problem is relatively minor and, therefore, the Grid Code changes will be phased in with time working in conjunction with the wind turbine manufacturers to allow them to change the technology, if you like, meeting half way and eventually complying with the genuine requirements of the grid. The manufacturers are confident that they can do it, in fact in all but the single issue that you raise there the technology already exists and they are confident that they can solve the problem which you raise.

Q222 Lord Flowers: Can I lead on from that to my standard question. If there was a duty of supply in the electricity industry as a whole, how would it impact on you?

Mr Moore: You mean a duty of supply as there was under the CEGB?

Q223 Lord Flowers: I want it to be guaranteed I have a supply of need within reason.

Mr Moore: I think it comes back to this question of how much reserve you need to accommodate the inherent intermittency of wind power. Dave Milborrow's paper and other papers which are endorsed by the system operator, National Grid, make it clear that for quite high penetrations of wind the system can be managed perfectly well in order to guarantee to you the customer, as best they can, that the security of supply can be ensured: that we will not be compromising the security standards that have been in the industry for as long as I have been in the industry, which is a long time.

Q224 Lord Flowers: You are pushing it back on to the suppliers.

Mr Moore: I think the solution lies with the network operator and that is inevitable. As I said earlier, we are not the only intermittent supplier out there, almost every form of generation is intermittent to some extent. The cross Channel link falls over on a regular basis; the nuclear power stations seem to fall over on a regular basis and the system accommodates that.

Q225 Lord Tombs: That is stretching it a bit, is it not?

Mr Moore: I do not think it is.

Q226 Lord Tombs: It is systematically intermittent. You are talking about Acts of God in other cases.

Mr Moore: I think we are very much talking about Acts of God in our case.

Q227 Lord Tombs: I think you have a good case. Don't exaggerate it.

Mr Shears: Just one final point on that. It is not an on and off situation like it is with an interconnector. We are going to have wind farms all over the country so generation is going to be spread around. It is not like 5,000 megawatts of wind will suddenly disappear, it is not that sort of a problem.

Q228 Lord Tombs: The ability to guarantee security of supply varies across the industry. It varies from a secure supply to one that could not accept such an obligation without purchasing standby power.

Mr Moore: If they were only purchasing wind?

Lord Tombs: It varies enormously.

Q229 Chairman: In that connection, it looks to me as if ScottishPower have essentially a vertically integrated system by which they have both conventional and wind and presumably with the company playing one off against the other?

Mr Mortimer: The grid operator is responsible for that but you have flagged up certainly the value of flexible plant and the need to retain that. The backdrop against that is the fact that the variability of wind is very often overplayed and when you look at the diversity of plants and the fact that there are many of them, as Alan has said, you do not on an hour by hour basis get very large changes in output. It is in the short term that these changes in output,are the most difficult thing for operators to deal with and it is not anything like as large a problem as it is sometimes made out to be.

Q230 Baroness Platt of Writtle: In paragraph 15 of David Milborrow's paper it says as you are dealing with larger amounts of power the back up seems to reduce. Is there a reason for that?

Mr Moore: I do not think it reduces, the percentage increases. As I say, David Milborrow's paper says that the amount of reserve you need for 10 per cent of electricity is about 750 megawatts and 20 per cent electricity is in the range of 2,000 to 3,000 megawatts.

Q231 Chairman: Thank you very much indeed. I am sorry we kept you rather a long time but we are grateful to you for coming to talk to us. We may have questions that we have not been able to pursue today but we would like to send

BEFORE THE
OHIO POWER SITING BOARD

In the Matter of the Application of Buckeye Wind LLC for a Certificate to Construct Wind-Powered Electric Generation Facilities in Champaign County, Ohio.	:	Case No. 08-666-EL-BGN

BUCKEYE WIND LCC'S RESPONSES TO DISCOVERY REQUESTS 1 AND 2 OF STAFF'S FIRST SET OF INTERROGATORIES AND REQUEST FOR PRODUCTION OF DOCUMENTS

Pursuant to Ohio Admin. Code § 4906-7-07, Buckeye Wind LLC ("Buckeye Wind") responds to the Ohio Power Siting Board Staff's interrogatories and document requests.

CULTURAL RESOURCES

1. Q. On Map Figure 6 - Please add the locations (as known) of existing radio, cellular and water towers within the 5 mile study area. Separately, please provide an approximate height for each structure.

   A. Please see the attached disc labeled "Response to Staff Discovery Request #1." Mapped tower locations were identified through a Federal Communications Commission (FCC) database, or located through field investigation (indicated in the map key). Towers not available through the FCC are not known to be available from any other public source. Approximate heights for each identified structure are indicated in the document included in the disc labeled "Response to Staff Discovery Request #1."

2. Q. On Map Figure 6 - Under the OAI (archeological) and NRHP symbol categories, please differentiate mounds with a separate symbol. Since most of the OAI "site names" in Exhibit U, Table 4 (other than mounds) are left blank, it is difficult to determine the composition or nature of each site. Are there other categories or subgroups that might help differentiate archeological sites (*i.e.* mounds, settled areas, foundations, individual finds, etc.), or is that information not known, or confidential?

A. **Please see the maps on the attached disc labeled "Response to Staff Discovery Request #1" which utilize a different symbol for known mound features as tabulated by the Ohio Archaeological Inventory (Exhibit U, Table 4) and the National Registry of Historic Places (Exhibit U, Table 1). The Ohio Historic Preservation Office's (OHPO) GIS does not differentiate archaeological site type by using different symbols; one symbol is used for all types of archaeological sites recorded in the Ohio Archaeological Inventory regardless of the type of archaeological site. Most prehistoric archaeological sites are classified as having an "unknown" site type because few artifacts identified and the level of investigation conducted was insufficient to make a reasonable determination of the site type.**

The only differentiation of archaeological site type is embedded in the OAI table (Exhibit U, Table 4). The OAI table contains the complete description of each archaeological site. Mounds and other archaeological site types, if known, are indicated in the tables.

3. Q. How current are the records retrieved for the literature review performed by the Applicant as depicted in Exhibit U-Cultural Resources Report?

A. The records are current as of January 12, 2009, when the records were received from the Ohio Historic Preservation Office. The OHPO updates the information on their online GIS every month, therefore the records used for the literature review were last updated in December 2008. No new data regarding archaeological sites in Champaign County has been added to the online GIS since November 2007, and there is no new information on archaeological sites in Champaign County pending.

4. Q. Aside from the literature review, was any additional, independent archaeological or architectural survey work performed in the project area by the Applicant or its representative (windshield survey, field observations, resident survey, shovel test, etc)? If yes, please provide this information to Staff. If no, does the Applicant or its representative intend on doing further archeological or architectural resource survey work for the project area?

A. Yes. In March 2009, investigators for ASC Group conducted a windshield survey to determine whether all of the National Register of Historic Places (NRHP)-listed or eligible sites identified in the OHPO literature review of January 12, 2009 were extant or whether any had been demolished since being listed or determined eligible. In addition, the survey took photographs looking from each extant resource (or near to each) toward the nearest proposed wind turbine location. These photos and field notes are attached and labeled as "Response to Staff Discovery Request #4."

Thirty-four such resources were identified by the OHPO. Twenty are in the village of Mechanicsburg, and nine are in the city of Urbana. The remaining five are located outside of incorporated communities.

The survey found that one resource in the village of Mechanicsburg is no longer extant (listed in the NRHP database as Hamer's General Store). All of the remaining resources are extant. The resources in Urbana include two historic districts, a farmstead, four houses, a portion of Urbana University, and a church. The resources in Mechanicsburg include one historic district, eight houses, five churches, one farmstead, three commercial buildings, and one Masonic hall.

The resources in rural areas include two farmhouses, a church and associated cemetery, a Native American mound, and a pair of associated country estates.

As stated in the literature review, the impact on archaeological resources are expected to be minor (Exhibit U, page 4), and the project is not expected to have a material impact on any of the NRHP listed architectural resources (various treatments, Exhibit U, pages 8-15). Therefore, Buckeye Wind does not currently intend to conduct further archaeological or architectural survey work.

TV/RADAR

5. Q. What data / forms have been submitted to the FCC and related parties regarding television, radar, and cell phone interference? When were the forms filed? What feedback / determinations have been received?

   A. No data/forms are required to be submitted to the FCC. Please see the Application at Section 4906-13-07(3) and (4) and the associated Exhibit (Exhibit V) for a treatment for the potential interference issues.

   As indicated in the Application, section 4906-13-07(4), Buckeye Wind sent written notification of the proposed facility to the National Telecommunications and Information Administration (NTIA). The NTIA then sent that notification to agencies represented in the Interdepartment Radio Advisory Committee. Although not a member agency of the IRAC, the FCC has appointed a liason to the IRAC. As indicated in the NTIA response (Exhibit V), no concerns regarding signal interference were identified.

6. Q. What mitigation is planned for turbine #37's location in regard to its potential effect on microwave transmission?

   A. Buckeye Wind's mitigation plan for turbine #37 is to place the turbine in a location that avoids microwave interference. It is estimated that a shift of 30 meters may be required to avoid the microwave path.

AVIATION

7. Q. What notification has been provided to Ohio Department of Transport, Office of Aviation, and what determinations have been initially made by that agency, if any?

   A. The Ohio Department of Transportation, Office of Aviation, received information regarding the turbines from Buckeye Wind's Federal Aviation Administration filing of form 7460-1, Notice of Proposed Construction or Alteration. All letters that Buckeye Wind has received from Ohio DOT, Office of Aviation are attached and labeled as "Response to Staff Discovery Request #7." Per John Milling, Aviation Specialist with the Division of Aviation, all proposed turbines have been reviewed and those structures that received no response from the Ohio DOT will not require a permit from the Ohio DOT.

8. Q. Indicate the current FAA Form 7460-1 "Notice of Proposed Construction or Alteration" filing status.

   A. The filing status for all 70 proposed turbines is "Determined." Please see the attached documents labeled "Response to Staff Discovery Request #8" for the initial determination letters. Buckeye Wind is currently working to remedy any issues with the current FAA determinations and will supplement this response as issues are remedied.

SHADOW FLICKER

9. Q. Provide a conversion table (or similar) showing "NP" (non-participating) and "P (participating) landowner designation codes and their corresponding parcel addresses that would enable Staff to convert the coded information to parcel addresses for all receptors listed in Exhibit L., Table 2 (p. 8) and Table 3 (p. 10).

   A. See the attached documents labeled "Response to Staff Discovery Request #9."

10. Q. Indicate the predicted shadow flicker hours for receptor sites NP 43, NP 22, and NP 23 with turbine # 69 as the only contributing turbine (see pg. 111, Table 07-08 for currently submitted data).

    A. Please see the document attached and labeled "Request to Staff Discovery Request # 10." The predicted shadow flicker hours (annually) for receptor sites NP 43, NP 22 and NP 23 with turbine #69 as the only contributing turbine are 1:29, 1:29 and 1:27 respectively.

11. Q. Please provide the contact information (i.e. name, address, phone number etc.) for EAPC personnel located in North Dakota that provided/calculated the shadow flicker amounts for the Buckeye Wind (08-666) project.

A. John Randall
EAPC
3100 DeMers Avenue
Grand Forks, ND 58201
701-775-3024 (office)
JRandall@eapc.net

12. Q. How many receptors are within 1000 Meters (1 Km) of turbine locations and separately, how many turbines are within 1,700 Meters (1.7 Km) of receptors?

A. There are 1,004 residential structures and one church within 1000 meters of the nearest turbine. As provided in the Shadow Flicker Study included in the Application (Exhibit L), there are a total of 2,087 structures within 1700 meters of the nearest wind turbine (see page 7), and correspondingly all 70 turbines are located within 1700 meters of receptors. These structures consist of residential structures, churches, and unknown structures (not all structures beyond 1000 meters have been field verified to type). There are no schools, hospitals, nursing homes, or libraries within 1700 meters of the nearest turbine.

TURBINE MANUFACTURER'S SAFETY STANDARDS

13. Q. Provide a complete copy of the manufacturer's safety manual or similar document for the Repower MM92 turbine.

A. See the attached documents labeled "Response to Staff Discovery Request #13." These documents include a Product Description for the REpower MM92 turbine. Please see section 4 for safety information. Also included is a chapter on General Safety Instructions from the Installation Manual for the Repower MM92.

14. Q. In the ice throw section, the reference "Global Energy Concepts, 2005" indicates that site personnel are most at risk from falling ice from turbines. Please describe the company's policies, safety precautions, rules, warnings, or trainings that will be in effect to prevent worker injury due to falling ice.

A. The documents attached as "Response to Staff Discovery Request #13" address safety in regards to icing and provide general guidelines related to worker safety. Buckeye Wind will also implement safety precautions as part of a Site Safety Plan

for the project. The Plan would include, at a minimum, the following procedures to be observed when an icing event is suspected:

- Stay clear of the tower. A 200 meter radius from the tower base is recommended (two times the tower height)
- Verify that no ice exists on the blades/tower with binoculars. If it is nighttime, wait until daylight to verify. Do not approach the tower at night if you are unsure about ice accumulation.

15. Q. Describe the fire protection system within the nacelle and tower.

A. The nacelle and tower do not contain a fire suppression system. Manual fire extinguishers will be located in the nacelle and at the base of the tower.

As to fire safety, please see the documents labeled "Response to Staff Discovery Request # 13" which include sections addressing fire safety plans. Please also see the document labeled "Response to Staff Discovery Request #15" which includes a Fire Safety document from REpower. Buckeye Wind will also implement safety precautions as part of a Site Safety Plan for the project. The Plan would include, at a minimum, the following fire control procedures and practices:

- Smoke only in designated areas;
- Keep flammable liquids in closed containers;
- Keep site clean: avoid accumulating combustible debris such as paper;
- Follow Hot Work Safety Procedures when welding or performing other activities requiring an open flame;
- Isolate flammable and combustible materials from ignition sources; and
- Ensure fire safety integrity of equipment installations according to NEC specifications.

ICE THROW

16. Q. Describe the use of any warning signs that will be placed in or adjacent to the ice throw risk area.

A. Warning signs are generally not placed specifically for dangers due to falling ice. General warning signs will be placed at all access road gates.

- The Nordex N90 is IEC certified and rated up to class Ib (rated for sites with either low or high wind speeds)

- The REpower MM92 is IEC certified and rated up to class IIb.

The documents attached and labeled as "Response to Staff Discovery Request #19" contain a preview of IEC 61400 part 1 (the full standard is available through purchase on the IEC website, and was not produced here due to licensing restrictions). The certification document for the Nordex N90, also attached as "Response to Staff Discovery Request #19," is an example of the certificates that are received for all turbines that achieve the IEC standard and are certified.

Blades can also receive separate IEC or other international certification. The documents attached and labeled "Response to Staff Discovery Request #19" contain a list of blades, their certifications, and a reference to the applicable design assessment criteria.

Blade safety is further enhanced by quality control certificates that are generally issued by a state-run certification body. The documents attached and labeled "Response to Discovery Request #19" also includes an example of a quality control certificate issued for a Nordex N90 configuration. This EU Component Declaration was achieved after inspection under Danish standards.

20. Q. Provide the rotational speeds (revolutions per minute) at which the Repower MM92, Nordex N90, and Nordex N100 will shut down.

A. The maximum rotational speed for the REpower MM92 is 16.8 rpm, for the Nordex N90; 18.1 rpm, and for the Nordex N100; 14.9 rpm.

21. Q. In the blade shear section, the reference "KPFF, 2006" indicates that "maximum calculated blade throw distance" is 500 feet. Provide an equation or calculation that confirms those claims or that can be applied to a Repower MM92, Nordex N90, Nordex N100 turbine at a hub height of 328 feet and rotor diameter of 328 feet (303 feet for the Repower MM92) and at the maximum rotational speed before which the turbines will shut down.

A. Please see the attached documents labeled "Response to Staff Discovery Request #21" for the referenced KPFF report. Any underlying calculations are not available to Buckeye Wind. While the attached report does not consider the exact parameters of the turbines proposed for the Buckeye Wind Project, the turbine treated in the report is similar to the turbines proposed in the Application with the exception of tower height.

The documents attached as "Response to Staff Discovery Request #21" also contain a portion of the Desert Claim Environmental Impact Statement that was the subject of the KPFF study. This document provides more information on the blade throw assessments. The excerpt also includes information on icing and fire hazards that may be helpful to the Staff.

TURBINE FOUNDATIONS

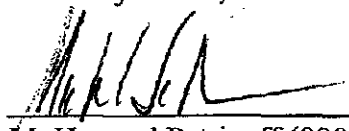
22. Q. Provide detailed engineering plans and specifications of one typical spread footer foundation; the plans shall include cross-sectional views and dimensions.

A. Please see the attached documents labeled "Response to Staff Document Request #22."

23. Q. Provide the engineering calculations that determined the size of one typical spread footer foundation.

A. Please see the attached documents labeled "Response to Staff Document Request #23."

As to objections,



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VERIFICATION

I, Michael Speerschneider, being first duly sworn, declare that I am the Vice President for Buckeye Wind and that the foregoing Responses of Buckeye Wind, LLC to Discovery Requests 1 and 2 of the First Set of Interrogatories From the Ohio Power Siting Board's Staff are true and accurate to the best of my knowledge and belief.

Michael Speerschneider

Sworn and subscribed before me in my presence this 9th day of October, 2009.

NOTARIAL SEAL STATE OF OHIO

MICHAEL J. SETTINERI
Attorney at Law
Notary Public, State of Ohio
My Commission Has No Expiration
Section 147.03 R.C.

Notary Public

CERTIFICATE OF SERVICE

I hereby certify that a true copy of Buckeye Wind's Responses to the Staff's First Set of Interrogatories and Requests for Production of Documents was served by hand delivery on Werner L. Margard and via regular U.S. mail, postage prepaid, and electronic mail on all other parties this 9th day of October, 2009.

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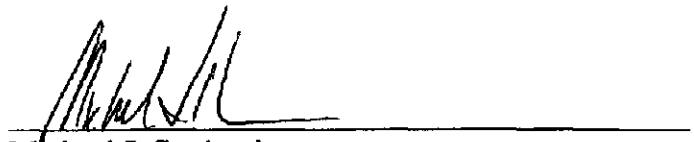

Michael J. Settineri

Wind Turbines, Noise and Health

February 2007

By Dr Amanda Harry M.B.Ch.B. P.G.Dip.E.N.T.

UNW
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Professor James Lovelock CH, PhD, DSc– for kindly reading over the report

Mr Alan Nunn- for initially introducing me to the first couple suffering from noise issues as a result of living near turbines.

Mr John Stewart Chair of the UK noise association

THE EFFECT OF WIND TURBINES ON HEALTH.

I first realised there might be a problem associated with wind turbines when I was introduced to a couple living near a wind farm in Cornwall. The distance from their home to the nearest turbine is about 400 meters. They told me about poor sleep, headaches stress and anxiety symptoms brought on when the wind was blowing in certain directions. At times, they told me that they have been so disturbed by the noise that after several disturbed nights sleep, they have sought refuge in a nearby bed and breakfast establishment (far enough away not to be similarly affected by the noise).

Since that meeting I have spoken to and / or corresponded with 39 people living between 300meters and 2 km from the nearest turbine of a wind farm all of whom were suffering from the consequences of the noise coming from the turbines. This disturbance is by no means always there and is worse in certain wind directions.
The cases mentioned below are from several wind farms in the UK with a variety of turbine sizes from the smaller, older turbines to the taller more modern turbines.
However I have had correspondence from people living near wind farms in New Zealand and Australia and have evidence from other sources, (newspapers, journals and papers) of people being similarly affected in France, Germany, Netherlands and the USA.
What this shows is that there is number of people suffering from the consequences of noise from the wind turbines. I'm sure that the cases mentioned here are probably the "tip of the iceberg" and further independent investigation is warranted. The cases are kept anonymous in order to protect the individuals concerned. There is much concern within communities that if one is seen to complain about the noise that if they decide to move away their properties will be difficult to sell and possibly devalued as a result. Therefore they feel that they are in a "Catch 22" situation.

METHOD

All people involved in this survey were contacted either by phone or in writing. Questionnaires were completed for all cases. Questionnaires were sent to people already known to be suffering from problems which they felt was due to their proximity to wind turbines.
The identity of the people questioned has been with held in order to maintain confidentiality. The respondents were from a number of sites in the UK- Wales, Cornwall and the north of England

Example of questionnaire.

1) Name- (preferred but optional)

2) Age 18-30 30-45
45-60 >60

3) Occupation

4) Address and /or postcode

5) Which wind farm is near your property?

6) How far away from your property is the nearest turbine?

7) How long have you been living at this property?

8) Do you feel that your health has in any way been affected since the erection of these turbines?

9) If yes please answer the following:-
Do you feel that since living near a wind turbine/turbines you have experienced excess of the following symptoms (i.e. more than you did prior to living near these structures)?

Headaches	yes	no
Palpitations	yes	no
Excessive tiredness	yes	no
Stress	yes	no
Anxiety	yes	no
Tinnitus (ringing in ears)	yes	no
Hearing problems	yes	no
Sleep disturbance	yes	no
Migraines	yes	no
Depression	yes	no
Other- please specify		

If you have answered yes to any or the above questions, have you approached your doctor regarding these symptoms? If yes please state any tests and/or treatment initiated.

10) Do you feel that your quality of life has in any way altered since living near the wind turbines? Yes no

If yes could you please explain in what way you feel your life has been altered.

RESULTS

	1	2	3	4
Age	45-60	45-60	45-60	45-60
Occupation	Cleaner/ housewife	Retired Ill health	Head chef	farmer
Distance from turbine	400m	300m	350m	400m
Time at property	36 years	3 years	7years	4years
Health altered	Yes	Yes	yes	yes
Headaches	Yes	Yes	yes	yes
Palpitations	No	no	no	no
Excessive tiredness	Yes	No	yes	yes
Stress	Yes	Yes	yes	yes
Anxiety	Yes	Yes	yes	yes
Tinnitus	No	No	no	no
Hearing problems	No	No	no	yes
Sleep disturbances	Yes	Yes	yes	yes
Migraines	Yes	Yes	no	yes
Other				
Approached doctor	No	No	no	no
Altered quality of life	Yes	Yes	yes	yes

	5	6	7	8
Age	45-60	>60	18-30	18-30
Occupation	Housewife	Retired	Electrician	carer
Distance from turbine	300m	300m	300-500m	300-500m
Time at property	2.5 years	2.5 years	6 months	6 months
Health altered	Yes	Yes	Yes	yes
Headaches	Yes	Yes	Yes	yes
Palpitations	No	No	No	no
Excessive tiredness	No	Yes	Yes	yes
Stress	No	No	No	no
Anxiety	No	No	No	no
Tinnitus	No	No	No	no
Hearing problems	No	No	No	no
Sleep disturbance	No	No	Yes	yes
Migraines	No	no	No	no
Depression	No	no	No	no
Other		Thumping in ears		
Approached doctor	No	Yes-Rx with pain Killers-ongoing assessment	No- didn't associate symptoms with the turbines	
Altered quality of life	Yes	yes	Yes	yes

	9	10	11	12
Age	>60	30-45	30-45	30-45
occupation	Retired	candle maker	Retired-nervous Breakdown	Retired-ill health
Distance from turbine	300m	¼ mile	300m	300m
Time at property	4years	10 years	3 years	3years
Health altered	Yes	no	Yes	yes
Headaches	No	no	Yes	yes
Palpitations	No	no	No	no
Excessive tiredness	No	no	Yes	no
Stress	No	no	Yes	yes
Anxiety	No	no	Yes	yes
Tinnitus	Yes	no	No	no
Hearing problems	No	no	No	no
Sleep disturbance	No	no	Yes	yes
Migraines	Yes	no	Yes	no
Depression	No	no	Yes	yes
Other		See comments at end	Stomach upset	
Approached doctor	No	no	Yes-seen psychiatrist-Ongoing review	no
Quality of life affected	Yes	yes	Yes	yes

	13	14
Age	30-45	>60
Occupation	Veterinary nurse and HGV driver	Retired from farming and Teaching
Post code	TR8	SA38
Wind farm	Bears Down	Blean Bowi
Distance from turbine	Too close	1mile
Time at property	19 months	27years
Health altered	Yes	Yes
Headaches	Yes	Yes
Palpitations	No	Yes
Excessive tiredness	Yes	Yes
Stress	No	Yes
Anxiety	No	Yes
Tinnitus	No	Yes
Hearing problems	No	No
Sleep disturbance	Yes	Yes
Migraines	No	No
Depression	No	Yes
Other	No	Emotional turmoil
Approached doctor	Yes- taking sleepers and Headache tablets	Yes-had heart check up
Quality of life affected	Yes	Yes

	15	16	17	18
Age	45-60	>60	>60	45-60
Occupation	Teacher	Retired	Retired	Charity manager
Distance from turbine	700m	650m	650	½ mile
Time at property	26 years	30+	30+years	Bear Down
Health altered	Yes	Yes	No	No
Headaches	Yes	No	no	No
Palpitations	No	No	No	No
Excessive tiredness	Yes	Yes	No	No
Stress	No	Yes	No	No
Anxiety	Yes	No	No	No
Tinnitus	No	No	No	No
Hearing problems	No	Yes	No	No
Sleep disturbance	Yes	Yes	No	No
Migraines	No	No	No	No
Depression	No	Yes	No	No
Other	No	No	No	No
Approached doctor	No	No	No	No
Quality of life altered	Yes	Yes	Yes	No

	19	20	21	22
Age	>60	>60	>60	>60
Occupation	Retired		Retired	Retired
Distance from turbine			700m	700m
Time at property	20years	20 years	25years	25 years
Adverse health affects	Yes	Yes	Yes	Yes
Headaches			Yes	Yes
Palpitations				
Excessive tiredness	Yes	Yes	Yes	Yes
Stress			Yes	Yes
Anxiety			Yes	Yes
Tinnitus				Yes
Hearing problems				Yes
Sleep disturbance		Yes	Yes	Yes
Migraines				
Depression	Yes		Yes	Yes
Other				
Approached doctor			Yes	Yes- doctor referred me to the hospital. After tests the consultant could find nothing wrong with my ears.
Quality if life affected	Yes	Yes	Yes	Yes

	23	24	25	26
Age	45-60	45-60	>60	57
Occupation	Farmer	Farmer	Retired	Retired police officer
Distance from turbines	430m	430m	1000m	1000m
Time at property	5 ½ years	5 ½	30years	30years
Adverse health affects	No	Yes	Yes	Yes
Headaches			Yes	Yes
Palpitations				
Excessive tiredness			Yes	Yes
Stress			Yes	Yes
Anxiety				Yes
Tinnitus		Yes		
Hearing problems			Yes	
Sleep disturbance				Yes
Migraines			Yes	
Depression				Yes
Other				
Approached doctor		Yes- been under a specialist in Furness General hospital for 1 ½ years	Yes	No
Quality of life affected	Yes	Yes	Yes	Yes

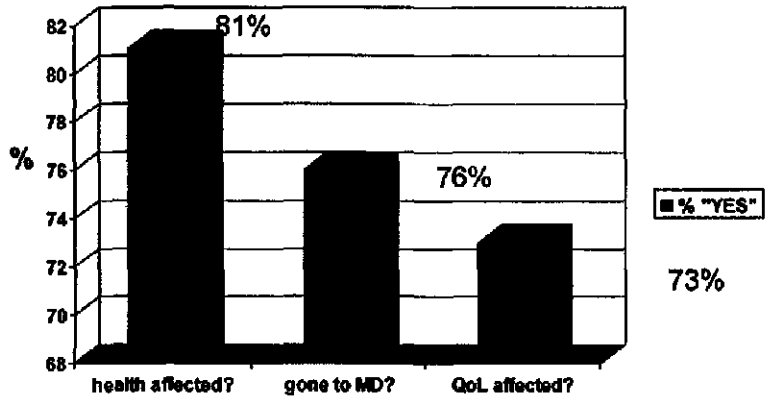
	27	28	29	30
Age	>60	>60	56	79
Occupation	Farmer/ sheep breeder		Pedigree sheep breeder	War veteran
Distance from turbine	½ mile	700m	1/3mile	
Time at property	9 years	33 years	9 years	33 years
Adverse health affect	Yes	Yes	Yes	Yes
Headaches	Yes		Yes	Yes
Palpitations			Yes	
Excessive tiredness	Yes		Yes	Yes
Stress	Yes		Yes	Yes
Anxiety			Yes	Yes
Tinnitus				Yes
Hearing problems				Yes
Sleep disturbance	Yes	Yes	Yes	
Migraines	Yes		Yes	Yes
Depression				
Other			Concentration	
Approached doctor	Yes	No	Yes- have had a 24 hour e.c.g. for investigations of palpitations. Brain haemorrhage 2 years ago.	Yes
Quality of life affected	Yes		Yes	Yes

	31	32	33	34
Age	81	45-60	>60	30-45
Occupation	Retired carpenter	Systems analyst/programmer	Business owner	Retired State registered nurse
Distance from turbine		¾ mile	Less than 1 mile	300m
Time at property	33 years	16 years	16 years	7 years
Health adversely affected	Yes	No	Yes	Yes
Headaches	Yes		No	Yes
Palpitations			No	
Excessive tiredness	Yes	Yes	Yes	Yes
Stress	Yes		Yes	Yes
Anxiety	Yes		No	
Tinnitus	Yes		No	
Hearing problems	Yes		Yes	
Sleep disturbance			Yes	Yes
Migraines	Yes		no	
Depression			No	
Other				
Approached doctor	Yes	Yes	No	No
Quality of life affected	Yes		Yes	Yes

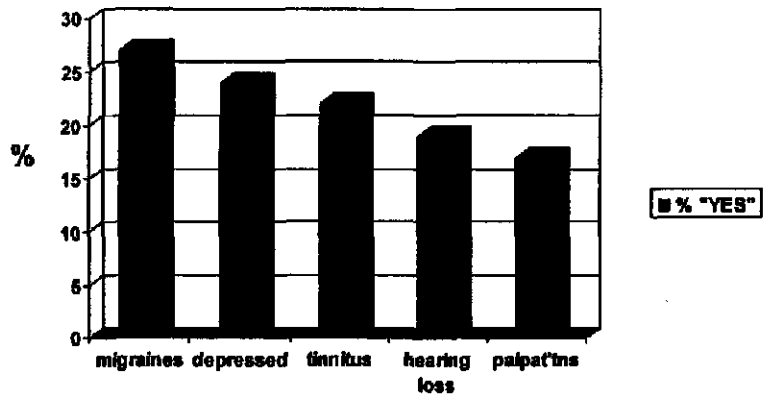
	35	36	37	38
Age	45-60	45-60	45-60	62
Occupation	Retired due to Nervous breakdown	Semi Retired farmer	Semi retired farmer	Retired
Distance from turbine	300m	800m	800m	
Time at property	7 years	11 years	11 years	25 years
Health adversely affected	yes	Yes definitely	Yes	
Headaches	yes	Yes	Yes	
Palpitations		Yes	Yes	
Excessive tiredness		Yes	Yes	Yes
Stress	yes	Yes yes	Yes	
Anxiety	yes	Yes yes yes	Yes	
Tinnitus		Yes	Yes	
Hearing problems		May be		
Sleep disturbance	yes	Yes yes yes	Yes	Yes
Migraines		No	No	
Depression		No	no	
Other	nausea			
Approached doctor	yes	Yes put on antidepressants and anti-hypertensives	Yes	
Quality of life affected	Yes	Absolutely yes	Yes	Yes

	39	40	41	42
Age			45-60	>60
Occupation	Retired phlebotomist	Running own business	Database administrator	Retired farmer
Distance from turbine		600m	3/4mile	1 mile
Time at property	20 years	24 years	7 years	26 years
Adverse affect on health	Yes	Yes	Yes	Yes
Headaches		Yes		Yes
Palpitations				Yes
Excessive tiredness	Yes	Yes		Yes
Stress				Yes
Anxiety		Yes	Yes	Yes
Tinnitus				
Hearing problems				
Sleep disturbance	Yes	Yes		Yes
Migraines				
Depression				Yes
Other	Lack of concentration And irritability		Nausea	
Approached doctor	No	No		Yes
Quality of life affected	Yes	Yes	Yes	Yes

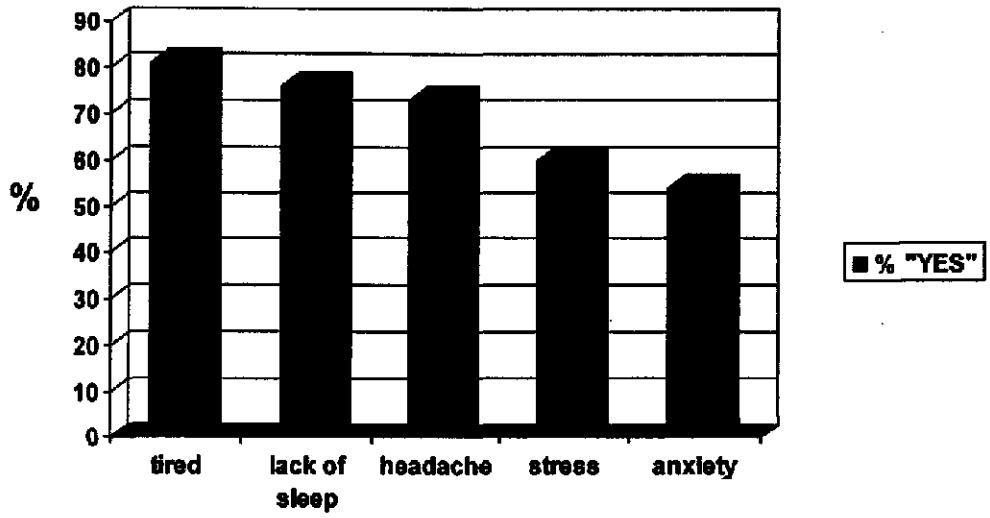
- *Has your health in any way been affected since the erection of these turbines?*
- *As a result, have you gone to see your doctor?*
- *Do you feel that your Quality of Life has in any way been altered since living near the wind turbines?*



Top 5 Self-reported Health Symptoms



Next 5 Self-reported Health Symptoms



ADDITIONAL COMMENTS MADE BY RESPONDANTS

1) I get little sleep when the noise from the turbines is constant in its low frequency noise. I feel so depressed I want to get away and stay away until I know the wind direction has changed.

2) My symptoms are due to lack of sleep when the wind is in the east or northeast

3) I get headaches frequently especially when the turbines are running at a fast rate towards us.

4) I get headaches and thumping in the ears. I also find its continual noise very distressing.

5) Suffer with headaches more and feel tired more so find daily tasks difficult to do.

6) I also find that the sound we get from the farm affects my metal heart valve.

7) I couldn't say whether or not the storbing effect wakes me up but it is impossible to go back to sleep with it there.

8) Constant worry about noise. I feel sick when the turbines are running fast and towards the property. I came here to a rural area for peace after a busy city life. I feel this has been ruined by the turbines.

9) Stressed and extremely anxious as I am constantly disturbed by them when they are turning fast and facing towards me. We are having to live our lives around them due to the constant noise when they are working causing wind pressure throbbing.

10) The strobing even when curtains are closed is "HELL". The noise is a pain. TV blocks it, night and day. Can't sit and read a book or write letters.

11) My plan was to stay here- in my newly converted barn (7 years old) (we farmed here) until I died. We have our own private water supply, a good supply of fire wood, my own painting studio- VERY IMPORTANT TO ME! And a good workshop for my husband; friends nearby, brother and sister nearby. I was born 2 miles away- Now WE HAVE TO MOVE. This move has been forced upon us. We planted 7,000 trees here. Etc.etc.etc.....

12) We will probably have to move, I can see no future for me here.

13) I dare not sleep at home.

14)
Noise disturbance at night –when wind in certain direction, interferes with sleep patterns, causing restlessness. During the day- makes it difficult to stay out of doors for any length of time through excessive thumping sound. Both can cause headaches, anxiety and irritability.

15) Certain wind directions mean excessive noise, like a thrashing machine constantly pounding, making it unpleasant to be in the garden or to have windows open. With strong wind conditions, double glazed windows vibrate and cause an intrusive, almost sub audible interference in some rooms.

16) Tired, disturbed by noise. Feel it as much as hear it. Developers deny there are any problems unless we can prove, but how can we do that?

17) Irritating noise from wind farm in easterly winds. You can almost feel it as well as hear it. It drives you mad over extended periods because of the nature of the noise, not the level per se. Unable to have front doors/windows open when winds are easterly, or use front bedroom if all 7 turbines are in operation.

18) Our quality of life we had before the wind farm came has gone. We no longer control the way we live our lives e.g. if we can work or sit in the garden, or at times, even where we can sit in our own home or get a full nights sleep.

19) I never suffered from any problems before the turbines. I am convinced that living in a continual state of anxiety over the past four and a half years since the noise nuisance started has contributed to my present problems (hypertension and stress). Prior to 1999 I always enjoyed excellent health and rarely visited the doctor's surgery. As my husband and I have been retired since 1994 and our family grown up and living in different areas of the country we do not have any other problems that are likely to cause stress or anxiety.

20) Not being able to choose when I work or sit in my own garden. Not getting full nights sleep. Waking with headaches when the noise is bad and feeling sick. Ears feel like I experience when travelling by plane- feel as if they are swollen inside. I cannot work more than 2-3 hours in the garden when the wind direction if from the east. We cannot see the wind farm from our property but at times the noise is horrendous.

21) My quality of life has been affected by the shadow flicker and the noise

22) I am bothered by the shadow flicker, and the noise while working behind the building.

23) I feel generally off colour

24) As we leave the house, the turbines are always there, menacing, always drawing your attention, depressing, in a beautiful area. Normally I sleep with the bedroom windows closed, if in summer we have a heat wave and the windows are open, I find I am wheezing in time with the turbine noise, it seems to come inside my body. This is an old stone gatehouse south of the site.

25) Quality of life has almost disappeared. No longer able to relax in the garden (when wind speed/ direction cause noise). Glinting and reflection also cause disturbance. Visual dominance is oppressive- extremely angry.

26) Constant sleep disturbance. Unable to work within certain areas, for noise levels, when wind is in certain directions, very stressful.

27) Disturbed sleeping. View blades whishing in the wind. Drawn to blades going round. Little concentration. Ugly to look at. Dominant. Not able to work in yard for long periods of time.

28) Our lives and home have been trashed and must be seen to be believed. We seem to be short tempered, unable to concentrate. Every thing we have such as mattress, duvets, cushions 4" thick, 3 rolls of sound deadening quilt, 3 sheets of corrugated asbestos, blankets, curtains, pillows even floor carpet stacked against the walls to try and keep out the sound. Not the peace I volunteered to fight for.

29) constant noise

30) Constant noise when turbine is facing us and away from us. Sleepless nights which make me irritable. Stress due to husbands anxiety about the turbines.

31) Noise from turbines effects my sleep patterns, I sleep less. I get nausea when the turbines face our home and causes a drumming at low noise frequency. I worry about the turbine blades coming off and killing me

32) Alienation from mainstream community that have the erroneous impression that wind power is a good alternative. Forced to sell property at a reduced rate- that was meant to be our retirement home. Health improved since moving from the property

33) As soon as the wind farm was operating I experienced horrendous continuous noise when the wind was from the east. This was both inside and outside my home. There were many times I had to leave the garden because of the noise. It was like a Chinese water torture, it was a constant pulsating noise. It was almost a feeling of compression as much as noise. I had to move bedrooms at times in order to escape the noise. It imprints on you, if you have had it all day in the garden, it stays with you,

once it's in your head it's hard to get rid of. It's weird. It's a feeling as much as a noise. It's torture.

34) It's an irritating and tiring noise, especially when you have not had any sleep because of it.

35) Even if you shut the window, the noise is still there, but not as much. The problem is, once you get the noise in your head, it's always there, it does annoy you and it is difficult to disregard.

36) The noise is like a whooshing noise. It is intrusive. It keeps me awake- it doesn't affect my husband as much as me but my being awake keeps him awake.

37) Once the noise gets into your head, it also seems to beat at the same frequency as my heart and I find it annoying and am unable to get any sleep- this can go on for nights on end. It's not always the level of the noise, it's the intermittent nature. You think "Oh it's stopped" then it starts up again.

38) If the wind is from the East or the South the noise is horrendous- you can't get away from it. It's inside and outside the house. It's worse at night- I have to bed hop. It's a whooshing, drumming, constant drumming noise. It's annoying. It's frustrating. It wears you down. You can't sleep at night or concentrate during the day. Once it gets inside your head you can't get rid of it. You get up in the morning, tired, agitated and depressed and it makes you short- tempered.

39) Our lives are hell, they have been ruined and it's all due to those turbines.

40) The noise from the wind farm is different and I can't explain why, it just is. All you ever want to do is to get out of the way of it, by whatever means you can.

CONCLUSIONS

I think it is clearly evident from these cases that there are people living near turbines who are genuinely suffering from health effects from the noise produced by wind turbines. These neighbours of turbines clearly state that at times the noise from turbines is unbearable. The developers are usually heard to say that noise is not a problem. Clearly this cannot be the case.
A discussion follows which clearly explains why the characteristic noise from these turbines can be producing the symptoms that are being described above. On searching through the current literature I can find no papers written showing that turbines are harmless, only statements from acousticians giving their personal thoughts. In addition to this some of these acoustic experts have made statements categorically saying that the low frequency noise from turbines does not have an effect on health. I feel that these comments are made outside their area of expertise and should be ignored until proper medical, epidemiological studies are carried out by independent medical researchers.

DISCUSSION

As shown in the case studies, people living near wind farms in the United Kingdom have been complaining of health problems since the construction of the wind farms near their homes. Inquiries reveal that some wind farms located close to peoples residences in Europe, Australia and North America have reported similar problems

The range of symptoms mentioned by complainants includes headaches, sleep disturbance, anxiety, depression, stress, vertigo and tinnitus. People complain of the noise, vibration and shadow flicker (caused by rotation of the blades and the reflection of the sun).

The following seeks to explain why these symptoms and problems could be caused by the wind turbines.

The evidence supplied has been made by a prolonged study of research available worldwide. Some acousticians have expressed the opinion that the level of low frequency noise (in dB (A)) emitted by a wind turbine will not produce health problems. However during my extensive search of the published literature, I have been unable to find any medical evidence to support this opinion.

Although the papers researched are generally not specific to wind turbines they are specific to the type and intensity of noise produced by wind turbines. The noise produced by wind turbines is quite complex therefore our response is likely to be complex also. In addition wind turbines produce a repetitive visual stimulus which goes to reinforce annoyance.

SOUND AND NOISE

Recently the European Union Noise Committee stated that noise is the biggest pollutant and the fastest growing pollutant in Europe.

Noise can be defined as unwanted sound and is commonly associated with annoyance reactions. It is commonly perceived as an environmental stressor and nuisance. Environmental noise is ubiquitous and annoyance is one of the most widely studied adverse reactions to noise. Noise interferes with task performance; cognitive performance modifies social behaviour and causes stress and irritation.

According to the World Health Organisation (WHO), health should be regarded as "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity"- WHO 2001. Under this broad definition, noise induced annoyance is an adverse health effect. As with any psychological reaction, annoyance has a wide range of individual variability, which is influenced by multiple personal and situational factors.

WHO also defines noise annoyance as "a feeling of resentment displeasure, discomfort, dissatisfaction or offence which occurs when noise interferes with someone's thoughts, feelings or daily activities- (WHO paper on Environmental noise- Passchier and Verneer 1993.

Noise annoyance is always assessed at the level of populations, using questionnaires. There is consistent evidence for annoyance in populations, exposed for more than one year to sound levels of 37dBA and severe annoyance at 42dBA.

There is no doubt that annoyance from noise adversely affects human wellbeing.

The level of annoyance can only be described by listeners themselves. These descriptions are often fuzzy and not quantified most of the time. In addition to this different people have different subjective responses on the grade of annoyance. There are many theories regarding noise nuisance and many factors are thought to have an influence e.g. the types of noise source, noise energy, frequency, age , previous noise exposure, types of building structures and weather conditions. Subjective annoyance relates not only to the sound level and frequency but also to the physiological and mental factors of the sound recipients.

Field studies performed among people living in the vicinity of wind turbines showed that there is a correlation between sound pressure levels and annoyance but that annoyance is also influenced by other factors such as attitude to wind turbines an the landscape. However noise annoyance from wind turbines was found at lower sound pressure levels than in studies of annoyance from road traffic noise.
This is because the absolute noise level is less important than the character of the noise produced.

Non-auditory effects of noise, can be defined as all those effects on health and well being which are caused by noise exposure with the exclusion of effects on the hearing organ. Non auditory effects include stress, related physiological and behavioural effects and safety concerns. There have been studies showing that aircraft noise can decrease cognitive function resulting in decreased scholastic achievement.

It is obvious that the health issues relating to wind turbines are caused by these non-auditory effects as the sound pressure levels are not high enough to cause an auditory effect (e.g. hearing impairment resulting from excessive noise exposure).

How does noise affect health?

It is generally considered that noise can be an intrusion into daily activities and tasks, causing annoyance. In certain circumstances in certain susceptible individuals this annoyance may lead to a stress response which in turn may lead to symptoms and subsequently illness.
The response to noise probably depends upon the characteristics of the sound, including intensity, frequency, and complexity of
sound, duration and meaning of the noise i.e. whether the noise is perceived as threatening or not.

Alternatively, noise may affect health directly and not through annoyance. E.g. studies show elevated cortisol levels in individuals subjected to; vibroacoustic disease caused by excessive exposure to low frequency noise resulting in abnormal proliferation of extra cellular matrices.

Any severe extreme imposed on the sonic environment has a profoundly destabilizing effect on the individual.
This is evident in both the areas of high intensity acoustic energy and also its complete absence.
Anechoic chambers, which create an environment void of sound, have the ability to produce similar feelings of disorientation and disturbance that are evident with high intensity sound. The silence envelops the individual in a suffocating manner causing both psychological trauma and also physiological disturbance in the form of balance problems and other related body functions. It is clearly apparent that the human organism is in an extremely delicate state of equilibrium with the sonic environment and any profound disturbance of this system will have profound ramifications to the individual

The auditory system is an extremely complex system .Because of the complexity of the auditory and cerebral systems it becomes easy to understand why the issues surrounding noise annoyance/ disturbance and associated health effects is not a simple one.

Studies in USA have shown a relationship between anxiety and vestibular disorders such as dizziness and migraines vertigo. Anatomical and electrophysiological evidence suggests that serotonin modulates processing in the vestibular nuclei in the brain. Therefore a disturbance in the serotonin balance which occurs in anxiety and depression syndromes can cause vestibular problems.

Low frequency noise is also produced from wind turbines. Low frequency sound is predominately the result off the displacement of air by a blade and of turbulence at the blade surface. The low frequencies contribute to the overall audible noise but also produce a seismic characteristic which is one of the common complaints from neighbours when they say that not only can they hear the noise but they can also feel it.
The various parts of the body have a specific natural frequency or a resonance frequency. The human body is a strongly damped system, therefore, when a part of it is excited at its natural frequency, it will resonate over a range of frequencies instead of at a single frequency.
(fig. 1).

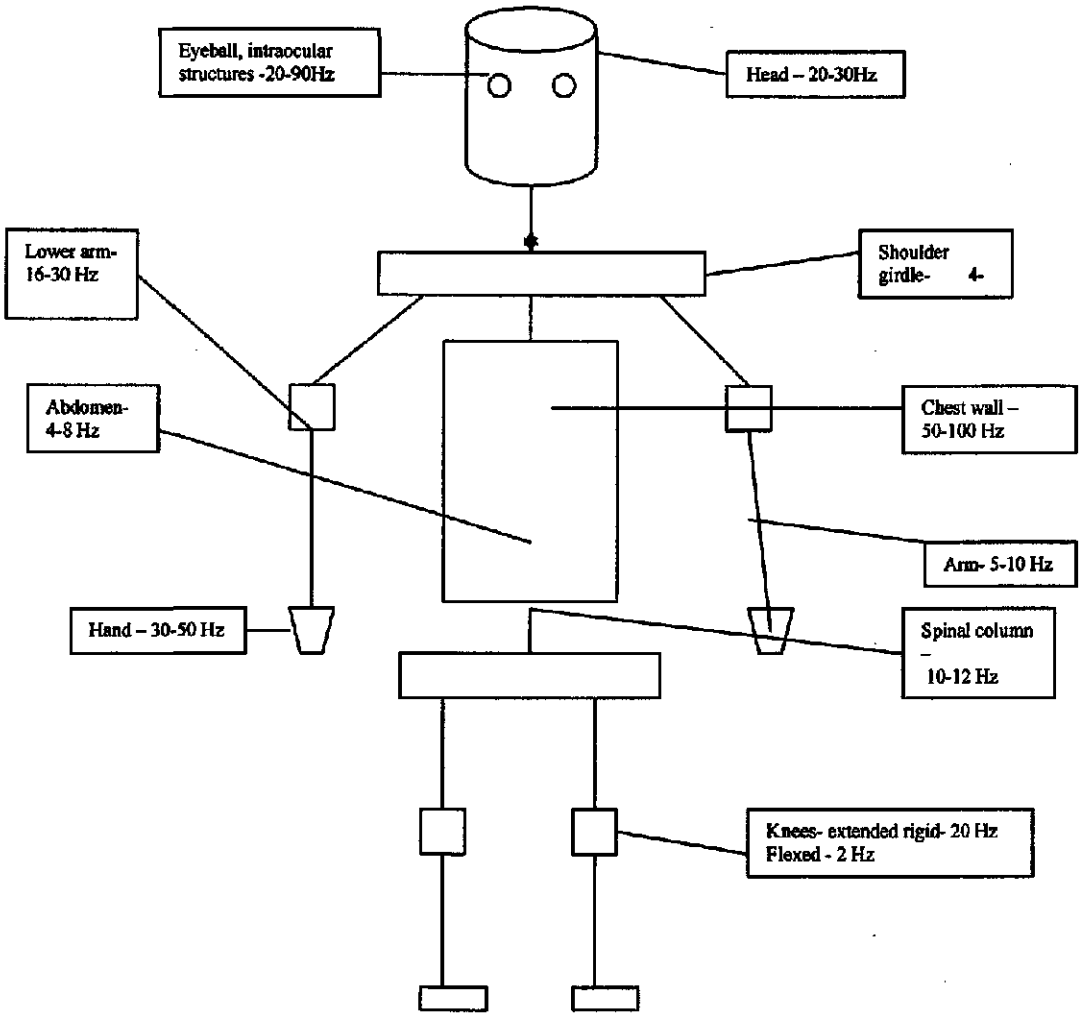
A research paper by G Rasmussen looked at body vibration exposure at frequencies of 1-20 Hz. Part of a table shows:-

Symptoms	Frequency
General feeling of discomfort	4Hz – 9Hz
Head symptoms	13Hz – 20Hz
Influence on speech	13 Hz – 20 Hz
Lump in throat	12 Hz – 16Hz
Chest pains	5Hz – 7Hz
Abdominal pains	4Hz – 10Hz
Urge to urinate	10Hz – 18Hz
Influence on breathing movements	4Hz – 8Hz

Also in the region 60-90 Hz disturbances are felt which suggest eyeball resonances, and a resonance effect in the lower jaw/skull system has been found between 100-200 Hz

Fig. 1

The resonance frequency ranges for various parts of the human body- values taken from the International Standards Organisation –ISO standards 2631



An important contribution to the low frequency part of the sound spectrum may be the result of the sudden variation in air flow the blade encounters when it passes the tower: the angle of attack of the incoming air suddenly deviates from the angle that is optimised for the mean flow. This effect has not been considered important as the blade frequency is of the order of 1Hz where humans' hearing is relatively insensitive. However low frequency modulates well audible, higher frequency sounds and thus creates periodic sound. This effect is stronger at night because in the stable atmosphere there is a greater difference between rotor average and near tower wind speed. In addition to this multiple turbines can interact with each other to further multiply the effect. The effect will be greater for the larger more modern wind turbines.

As wind is variable and not consistent, the nature of the noise produced is also impulsive and unpredictable.

Low frequency noise issues have been researched extensively in Portugal and have been found to cause a complex disease known as vibroacoustic disease. Although this research has been mainly concerned with high levels of low frequency noise, it is felt that over years lower levels of low frequency noise may cause similar problems. It appears that the low frequency noise compromises the mechanotransduction signalling of cells which lead to structural changes of tissues and cells. This damage sustained is dose dependent and it is only in the latter stages that routine medical investigations will become positive. The syndrome can be broken down into various stages:-

Stage 1 - MILD *(1-4 years)* Slight mood swings, indigestion, heartburn, mouth/throat infections, bronchitis
Stage 2 - MODERATE *(4-10 years)* Chest pain, definite mood swings, back pain, fatigue, skin infections (fungal, viral, and parasitic), inflammation of stomach lining, pain and blood in urine, conjunctivitis, allergies.
Stage 3 - SEVERE *(> 10 years)* psychiatric disturbances, haemorrhages (nasal, digestive, conjunctive mucosa) varicose veins, haemorrhoids, duodenal ulcers, spastic colitis, decrease in visual acuity, headaches, severe joint pain, intense muscular pain, neurological disturbances.)

Low frequency noise exposure has also been shown in many studies to interfere with performance and cognitive function in the workplace. The effects are greatest in noise sensitive particularly low frequency noise sensitive individuals. In this group of people salivary cortisol levels are elevated during exposure.

For many years research has been carried out using noise as a non lethal weapon. Recently the Israeli army used such a weapon for crowd dispersal. Witnesses describe d a minute-long blast of sound emanating from a white Israeli military vehicle. Within seconds, protestors began falling to their knees, unable to maintain their balance. The technology is believed to be similar to the LRAD — Long-Range Acoustic Device — used by U.S. forces in Iraq as a means of crowd control.

Professor Pratt a professor of neurobiology specializing in human auditory responses at Israel's Technion Institute explains that by stimulating the inner ear, which houses the auditory and vestibular systems, with high intensity acoustic signals that are below the audible frequencies- below 20 Hz, the vestibular organ can be stimulated and create a discrepancy between inputs from the visual system and somatosensory system and the vestibular organ will erroneously report acceleration (because of the low- frequency inaudible sound). It doesn't have to be a loud sound This will create a sensation similar to motion sickness. Such cases have been reported in relation to air conditioning systems.

Work by Fritz van den Berg shows why the characteristics of the noise produced by wind turbines increases and alters at night . He showed that the noise at night can be 15-18dBs higher at night time than during the day because of atmospheric changes (ref. Fritz van den Berg).
Therefore when we are resting in bed at night, the noise from the wind turbines can be at their loudest and most disturbing.

Those people who are disturbed by the noise are often particularly aware of the problems at night. – this statement can be partially explained by lower background noise levels at night, and also the fact that atmospheric stability increases at night giving a greater differential between rotor averaged and near tower wind speed . This explains why the characteristic of the noise emitted from turbines takes on a "beating" character early evening and night-in agreement with the blade passing frequency.

Noise induced sleep disturbance is well known to have adverse health effects and has been studied extensively although not with particular reference to wind turbines. Due to the indisputable restorative function of sleep, noise induced sleep disturbances are regarded as the most deleterious effects of noise.

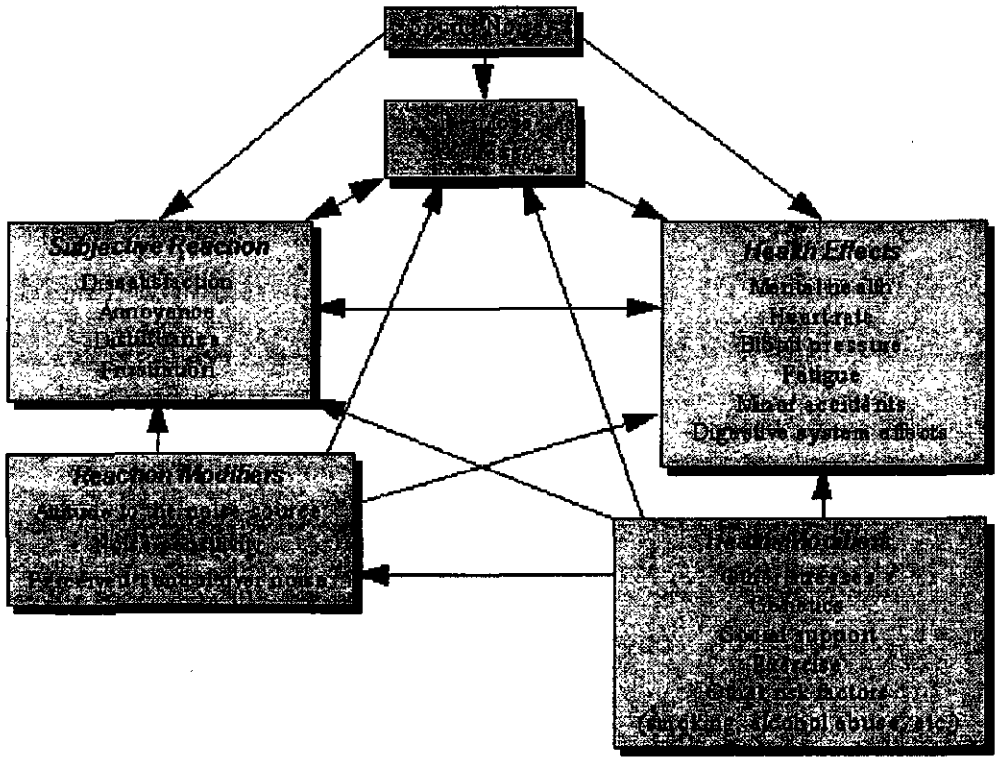
Nocturnal noise disturbance has been shown to disrupt nocturnal cortisol secretion. Nocturnal noise excites areas of the brain such as the amygdyla (functions as the fear centre) and cortical areas (arousal, annoyance and awakening). Noise –even levels below awakening threshold – can induce cortisol secretion. Repeated night time disturbance will result in an accumulation of cortisol levels in the blood. In the long term this can result in long term stress activation.

Several epidemiological studies in patients with primary insomnia found to be at a higher risk of developing major depression in the following years.
It has also been shown that women with increased morning cortisol levels show a higher risk of a major depressive episode within the next 12 months.

Psycho physiological reactions such as effects on heart rate and respiration rate have been observed during exposure to noise whilst subjects sleep. These have been found to be induced by road traffic noise with levels exceeding 40 dB LA max (both in lab and in field studies). Hardly any habituation occurs during or between nights. Children have higher psycho physiological reactivity than adults. In addition for these types of reactions, the difference between the background noise levels and the maximum sound pressure level is of more importance than the absolute sound level. (Vernet 1983).

The potential adverse health effects are usually classified according to the type of noise. Sudden or impulsive noise appears to create more disturbance than non impulsive noise (Job 1996). Intermittent noise has a greater effect than louder more continuous noise (Westman and Walters 1981). Predictability and controllability are clearly influencing factors in an individual's response to noise and this has been born out by surveys conducted by Eja Pederson in a paper presented in Berlin in Oct 2005.

It has been shown in several studies that depressed people and the elderly have a diminished variability in circadian cortisol levels and a raised morning cortisol in common. (Kern et al in 1996, Van Cauter et al 1998, Deushle et al 1998). It would therefore be likely that the elderly and patients already suffering depression might be more susceptible to noise induced arousals.



However we as humans experience our environment through multi sensory channels e.g. acoustic, visual, proprioceptive, vibrational and psychological and emotional issues.

Therefore all these factors have to be considered when we try to explain why people might be disturbed by wind turbines. When discussing noise with people who are disturbed by turbines, frequent complaints are of vibration leading to an intrusional

and invading noise that they feel they cannot get away from. People say that they can "feel the noise".

I would suggest that several factors are therefore concerned in this annoyance. The "periodic noise" as described previously and the low frequency component. I think that the presence of these two together has an additive effect compounding both. The periodic noise draws the attention to the vibrational component and therefore becomes more annoying than if either were present individually.

In addition to this there is the visual stimulation of the turbine blades rotating- this is particularly disturbing in certain light conditions where strobing occurs, but provide a constant reminder of the presence of the turbines by their movement.

Psychological and social issues must also be considered. E.g. pre-existing psychological problems and also perceptions of having a wind turbine built close to their homes. Most people live in the countryside because they appreciate the quiet and the visual amenity. Therefore reluctance to having a wind farm nearby will exacerbate any problems.

SUMMARY

There are many people living near wind turbines who are suffering from problems with their health.

The noise produced from wind turbines is an extremely complex one and I feel that it is the complexity of the noise and vibration which causes the disturbance.

From my discussions with people suffering from ill health who live near wind farms, it seems that the symptoms suffered can occur up to a mile from the wind farm. Until further independent medical and epidemiological research has been carried out I would suggest that no wind turbines should be sited closer than 1.5 miles away from the nearest wind turbine.

The current UK guidance for establishing a safe distance between turbines and dwellings is the ETSU-R-97. This document was produced when turbines were approximately 20% the size of the currently proposed turbines. The guidelines pay scant reference to low frequency noise and the complexity of the noise profile produced by the turbines.
The continued use of ETSU-R-97 has been publically condemned by Professor FFowcs- Williams and G.P.Van den Berg.

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Appendix 1

Something in the [redacted]

THE SUNDAY TIMES - JANUARY 20, 2002

To some people they are "grotesque"blights on the countryside; to others,graceful machines that offer a welcome alternative to nuclear power and a way of tackling global warming. There are now more than 60 [redacted] farms in Britain – the windiest nation in Europe –with 853 [redacted] producing enough power to run 500,000 homes a year. The numbers are set to rise as the government cranks up its drive to generate 10% of Britain's electricity from green energy sources by 2010.

Last week Powergen announced that it is considering building one of the biggest [redacted] farms in the world in the Thames Estuary, sinking several hundred [redacted] into a sand bank in a project worth £500m. It comes in the wake of plans announced in December for a huge onshore [redacted] farm on the Hebridean island of Lewis.

If the project gets planning permission, 300 [redacted] will be built, eventually meeting 1% of Britain's electricity needs. An increasing number of homeowners therefore have to get used to the prospect of living near the whirling blades. Margaret Gough, for one, cannot stand the sight of the towers that straddle the grassy slopes near her mid-Wales home. When she and her late husband retired to a village outside Aberystwyth 15 years ago, they chose a bungalow which had stunning views – until the Mynydd Gorddu [redacted] farm opened several years later. "The reason we bought this property was for the scenery," says Gough. "It was such a beautiful skyline: if I stood in the garden and looked around all I could see was tree- covered hillsides. Now when I look out I can see about eight or nine [redacted]."

I stand under the turbine in Swaffham in Norfolk [the world's most efficient turbine andat 67m, thought to be Europe's tallest] and you don't know it's turning." Surveys have found that although up to 96% of people say they approve of [redacted] farms, about a quarter would not like to live close to one. Householders' main objections are that [redacted] are "ugly" and they may bring down the value of their properties. Michael Williams, manager of estate agent Shearer & Morris in Aberystwyth, says that unless homes are very close to [redacted] property prices are unaffected. "I've sold quite a few properties within a mile of [redacted] farms without any bother," he says. Nevertheless, some homeowners are fighting back. Martin Wright, Chairman of the Cefn Croes Campaign, is trying to halt the construction of the biggest [redacted] farm in Britain. Under the £35m project – already approved by Brian Wilson, the energy minister – 39 [redacted], each 100m high, will be cited at Cefn Croes, near Devil's Bridge in Ceredigion, mid-Wales. Wright says he objects to [redacted] farms because he fears that vast swathes of rural Britain will be lost to the machines. "Mid-Wales is full of them," he laments. "The reason I oppose them isn't because I don't want them in my back yard – there's a [redacted] farm on the mountain above my house and I can't say it disrupts my life – it's to do with the wider issue of the value of our landscape.

"[redacted] power is a good idea, but the only way it is going to have any impact on our energy needs is to cover the whole country with [redacted]. So unless we are going to go down that path, why bother?
"We are going to ruin some of the lovely wildernesses that have been protected since the war: you can't build bungalows, but you can put up a 100m high turbine. That doesn't seem right."

Archaeologist Dr [redacted], also from Wales, claims he moved because infrasound, sound with a frequency below an audible level, from a [redacted] farm made his wife ill. Problems started not long after the Llangwyryfon [redacted] farm, 12 miles from Aberystwyth, opened 10 years ago. The [redacted]' house was 350m from three of the 20-plus [redacted] and 650m from six of the machines. "Our initial intention was to stay put, even though we were disturbed by the changes and damage," says [redacted]. "We had been assured the [redacted] would make no noise, but we were so close we could hear the [redacted] whistling through them. "We also discovered that not only did they broadcast audible sound, they produced infrasound. It started to make my wife sick." Finally, six years ago, the [redacted] decided to sell their house and move to a new home five miles away.

Dr Peter Musgrove, head of development at National [redacted] Power, which used to own Llangwyryfon, says; "The issue of the infrasound has been looked into in considerable detail and no evidence has been found that it is emitted by the [redacted]."
Not everybody objects to [redacted], however. John Theobald and his wife Sue are more than happy to live in the lee of a [redacted] farm. Their bungalow overlooks Delabole in Cornwall, the oldest commercial [redacted] farm in Britain, which attracts thousands of visitors a year. From their windows, they have a clear view of all 10 [redacted].
"My wife and I are inveterate supporters of renewable energy anyway, but I love them," says Theobald, who runs a woodturning business and a bed-and-breakfast. "They change colour depending on the weather: some days they look thunderously grey and broody; other days, when the sun goes down, they turn pink and purple.
"Having said that, I don't think anyone would like to live right underneath the tower." "We live about four or five fields away and only occasionally hear the noise from the [redacted] if the [redacted] is in the East."
In fact, the noise is diminishing all the time as technology advances.
"Noise is no longer an issue," asserts Peter Edwards, owner of Delabole farm.

Blowing hot and cold: Martin Wright, above, from mid-Wales, fears turbine blight
The Theobalds: see no problems with [redacted]
Source: *The Sunday Times*, 20 January 2002

Appendix 2

Flurry of complaints after wind change

Jul 25, 2005

A wind change at Meridian power company's giant wind farm on the Ruahine Ranges has prompted a flood of complaints from nearby residents.

Residents in the small Manawatu town of Ashurst say that in an easterly there is an intrusive rumble for days on end. They say the windmills emitted a low frequency noise for three days on end, making their lives a living hell.

The Te Apiti windfarm turbines have a steady sound in the prevailing westerly wind but when the wind suddenly, and unusually, turned easterly last weekend Ashurst residents say it bombarded them with noise and vibration.

"On Monday night the rumbling was so bad it sounded like one of those street cleaning machines was driving up and down near the house. In fact it sounded like it was going to come through the house," says Wendy Brock.

Geoff Keall said whether people were inside or outside it had an impact.

The blades on each of the 55 turbines are the size of a Boeing 747 wing and they produce enough electricity to power 45,000 homes.

Tararua District Council says measuring the noise is difficult, but it is concerned for the residents. Spokesman Mike Brown from Tararua District says he believes Meridian is also concerned and they will be talking together to see what can be done to resolve the issue.

But Meridian says it's a small number of people making a big noise about nothing.

Spokesman Alan Seay says they monitor the sound levels at a number of points and the monitoring has shown quite clearly they were well within the guidelines.

There's growing opposition from the public to windfarms.

Previously people have been generally supportive of windpower, but when a power company recently applied to instal a further 40 wind turbines, it attracted objections from more than 250 people.

However, despite the latest complaints windfarms on the Ruahine and Tararua ranges are expected to expand.

Appendix 3

FEATURE: And the beat goes on . . .and on and on

18.02.2006
KATHY WEBB

They call it the train that never arrives. It's a low, rumbling sound that goes on and on ... and on.

Sometimes, in a stiff easterly, the rumbling develops into a roar, like a stormy ocean.

But worst of all is the beat. An insidious, low-frequency vibration that's more a sensation than a noise. It defeats double-glazing and ear plugs, coming up through the ground, or through the floors of houses, and manifesting itself as a ripple up the spine, a thump on the chest or a throbbing in the ears. Those who feel it say it's particularly bad at night. It wakes them up or stops them getting to sleep.

Wendy Brock says staff from Meridian Energy promised her the wind turbines at Te Apiti, 2.5km from her Ashhurst home in southern Hawke's Bay, would be no noisier than waves swishing on a seashore.

"They stood in my lounge and told me that."

But during a strong easterly, the noise emitted by the triffid-like structures waving their arms along the skyline and down the slopes behind the Brock family's lifestyle block is more like a thundering, stormy ocean. Sometimes it goes on for days. And when the air is still, there's the beat - rhythmic and relentless, "like the boom box in a teenager's car".

"It comes up through the floor of our house. You can't stop it."

Mrs Brock says she can feel it rippling along her spine when she's lying in bed at night. Blocking her ears makes no difference.

"It irritates you, night after night. Imagine you've done your day's work, then you go to bed, and there's this bass beat coming up through the floor and you can't go to sleep. You can't even put headphones on and get away from it.

"My older son sometimes gets woken up by the noise. He gets up and prowls around the house."

She tells of other Ashhurst residents who "feel" the sound hitting their chests in the Ashhurst Domain 3km from the turbines. She says one woman is so distressed by the sensation she has put her home on the market.

Not everyone in the village hears the infrasound - Mrs Brock reels off the names of residents wondering what the fuss is all about - but says those who do feel the sound are distressed by it and have nowhere to turn for redress.

There's little point complaining to the Tararua District Council because all it does is record each complaint and forward it to Meridian, and nothing ever happens.

"What are they (the council) going to do to Meridian - fine them, or shut down the turbines?" asks Mrs Brock.

Meridian is dismissive of complaints about noise from Te Apiti.

"Infrasound is just not an issue with modern turbines," insists spokesman Alan Seay.

"We take it very seriously. We have looked into it seriously, but the advice we are getting from eminently qualified people is that it is just not an issue."

Many people claiming to be putting forward scientific argument about noise from turbines "are not qualified in this area of expertise. I have a problem with some of their statements", Mr Seay said.

He asked Hawke's Bay Today for the names of those complaining about noise from Te Apiti.

Asked why he wanted the names, he replied: "There is a group of people there. They are opposed to wind farms per se".

Asked why he thought they were opposed, Mr Seay said "I don't want to speculate. They just are. Possibly for the visual impact."

Meridian had complied with all legal requirements for sound emissions from Te Apiti, and "the people of Ashhurst are very happy to have those turbines there. They have become an icon," Mr Seay said.

Meridian is currently appealing noise restrictions placed on its proposed 70-turbine wind farm at Makara, near Wellington, where some houses will be about 1km away, and downwind of, the turbines.

J ohn Napier lives on the Woodville side of the Te Apiti turbines, about 2km from the nearest one.

When they first began operating, he couldn't believe the roaring noise they made.

"We can hear it in our bedroom at night."

One night, about 2am, he got out of bed to check whether the bedroom windows were vibrating, and about five times since, he has been woken up and thought "they're making a racket tonight".

He doesn't hear the infrasound beat so much. It's mainly "a roar like a train going through a tunnel or over a bridge, but it never stops".

He complained to Meridian about the noise, and the company put a noise meter on his property for a couple of weeks, but wouldn't tell him the results.

"Wind farm companies say noise from turbines is not an issue, but it is an issue all right. I would be very concerned if I lived in Karori (near Makara, in Wellington)," Mr Napier said.

Harvey Jones, who lives in a valley 3km from Te Apiti, says there is an easterly wind blowing across the wind farm about 10 percent of the time. The wind goes across the top of the hill, but the noise from the turbines rolls down the valley. It sounds like a train constantly passing by, and the stronger the wind, the louder the noise. When there's a westerly blowing, he can even hear the turbines in Woodville, 6-7km away.

"Once you get tuned in to it you can easily pick it up," he says.

Mr Jones says the amount of noise generated by the Te Apiti turbines was unexpected, and landowners prepared to put turbines on their land at Te Pohue should think very carefully about the possibility of a repeat scenario.

He predicts disaster for the residents of Makara and Karori.

"They're going to get hammered, but they don't realise."

Steve Griffin, of Te Pohue, is secretary of the Outstanding Natural Landscape Protection Society, formed to oppose two windfarms proposed for his area on the Napier-Taupo road.

Lines company Unison has resource consent to put up about 50 turbines, and Hawke's Bay Windfarms plans to erect 75 turbines nearby.

The landscape protection society is appealing all the consents in the Environment Court.

Mr Griffin, who is "sick to death of wind farms", says the prospect of 128 giant industrial turbines visually

disrupting pristine skyline and covering more than 16km of prominent mountain range near Te Pohue is bad enough. But he and other residents are worried sick about the noise potential - both normal-range and infrasound - from the turbines. Each turbine will have an 80m tower and three 45m blades. They will be 125m high and 90m wide, each taking up the equivalent of 1.5 rugby fields.

They will encircle Te Pohue village and its school, in a valley downwind of the turbines in prevailing winds - and nobody in authority seems to care, he says.

The Government has thrown the doors wide open to wind farm developers, in a bid to meet its Kyoto commitments; there are no national guidelines specific to wind turbines. That stance is unbalanced and unfair, Mr Griffin says.

"Our view is that while wind farms are part of our energy solution, sites must be selected in a socially responsible manner.

"They should not be placed within 5km of schools, hospitals, rest homes, or the private homes of those not involved with a wind farm development."

They should also be kept out of coastal, and recreation areas, and those with high scenic value, he says.

The landscape protection society wants the Government to establish national guidelines for wind farms, and review noise-testing standards to include measurement of low-frequency sound.

Low-frequency sound - sometimes called infrasound - is controversial.

Dr Geoff Leventhall, a noise vibration and acoustics expert from the UK who looked into infrasound at the request of Genesis Power, says "I can state quite categorically that there is no significant infrasound from current designs of wind turbines".

He says "the ear is the most sensitive receptor in the body, so if you cannot hear it you cannot feel it". Engineer Ken Mosley, of Silverstream, has an entirely different view.

The foundations of modern turbines create vibrations in the ground when they are moving, and also sometimes when they are not moving, Dr Mosley says.

"This vibration is transmitted seismically through the ground in a similar manner to earthquake shocks and roughly at similar frequencies.

"Generally, the vibrations cannot be heard until they cause the structure of a house to vibrate in sympathy, and then only inside the house. The effects inside appear as noise and vibrations in certain parts of a room. Outside these areas, little is heard or felt.

"However, the low frequency components of the noise and vibration can cause very unpleasant effects which eventually cause the health of people to deteriorate to an extent where living in the property can become impossible."

Dr Mosley says that wherever wind farms are built close to houses, people complain about noise and vibration.

He quotes a scientist in South West Wales, David Manley, who has been researching noise and vibration phenomena associated with turbines since 1994.

An acoustician and engineer, Dr Manley writes "it is found that people living within 8.2km of a wind farm cluster can be affected and if they are sensitive to low frequencies they may be disturbed".

Two GPs in the UK have researched the health effects of noise and vibrations from turbines. Amanda Harry documented complaints of headaches, migraines, nausea, dizziness, palpitations, sleep disturbance, stress, anxiety and depression. People suffered flow-on effects of being irritable, unable to concentrate during the day, losing the ability to cope.

Bridget Osborne, of Moel Maelogan, a village in North Wales, where three turbines were erected in 2002, is reported as saying "there is a public perception that wind power is 'green' and has no detrimental effect on the environment, but these turbines make low-frequency noises that can be as damaging as high-frequency noises.

"When wind farm developers do surveys to assess the suitability of a site they measure the audible range of noise but never the infrasound measurement - the low-frequency noise that causes vibrations that you can feel through your feet and chest.

"This frequency resonates with the human body, their effect being dependent on body shape. There are those on whom there is virtually no effect, but others for whom it is incredibly disturbing."

Dr Mosley says wind-power generators in New Zealand are aware of such literature on turbine noise and infrasound from all around the world.

"Are they therefore just ignoring what is happening in the rest of the world in the hope that once turbines are up and running, people will quietly endure, or when the noise/vibration situation really starts to damage their health, the community will cut their losses, leave their homes and quietly fade away? Of course, wherever they end up, they must still pay their electricity bills, which is rather like paying the landlord who has evicted you."

The New Zealand Wind Energy Association, which did not return calls from Hawke's Bay Today, acknowledges that turbines produce infrasound, but insists it is so minimal from modern turbines that human beings cannot perceive it. Its website says "there is no evidence to indicate that low frequency sound or infrasound from current models of wind turbine should cause concern."

Infrasound was more of a problem with older turbines, which had their blades downwind of the turbine tower, the association says.

"That caused a low frequency thump each time a blade passed behind the tower."

In contrast, modern turbines "have their blades upwind of the tower, thus reducing the level of this type of noise to below the threshold of human perception, thereby minimising any possible effect on human health or wellbeing".

The association has published excerpts of a report by Dr Leventhall, who suggests that infrasound is a concept that could be classified as pop-science, seized upon by emotionally-overwrought wind farm opponents.

"When a group of residents decides to object to a development, they often support each other with strong emotions, which can sometimes lead them astray. The emphasis on low-frequency noise is an example of this. Over the past 30 years there has been a great deal of confusion and misinformation about low frequency noise, mainly in the popular media. Much of it can best be described as "hot air" but complainants' uncritical acceptance of what they read in unreliable sources has two unfortunate effects:

* It detracts from those people who have genuine low-frequency noise problems, often from industrial exhaust fans, compressors and similar.

* It undermines the credibility of the complainants, who may be harming their own cause in their apparent 'grasping at straws' approach."

Dr Leventhall goes on to say "the rational study of low frequency noise, its effects and criteria for control, has been bedevilled by exaggerations, half-truths and misrepresentations, much of it fomented by media stories over the last 35 years. The result in the UK, and it is probably similar in other countries, is that an incorrect concept - 'low frequency noise is a hazard' - has taken root in the national psyche, where it lies dormant waiting for a trigger to arouse it. The current trigger is wind turbines."

Dr Leventhall says:

* High levels of low-frequency noise are needed before people can perceive it, and the levels must

increase as frequency reduces.

* The ear is the most sensitive receptor in the body, so if you cannot hear it you cannot feel it.

* When there are problems with predominantly low-frequency noise, that is because assessment methods do not cater for it. That leads to the noises being dismissed as not being a nuisance, which in turn leaves unhappy complainants in a distressed state.

Up on the Napier-Taupo road, the printer in Steve Griffin's office is working overtime in preparation for an Environment Court battle. It might be a David and Goliath confrontation, but there's too much at stake to sit back and take it quietly, he says.

Appendix 4

Guantanamo Serenade

Jon Ronson knew from his investigation into US military intelligence that top brass had adopted some strange practices. Jamal al-Harith, the Briton released from Guantánamo in the spring, confirmed it: here, in our second extract from Ronson's revealing new book, he describes the discordant sounds and apparently random music played to him during all-day interrogation sessions, and four psychological warfare experts give their reaction

Saturday November 6, 2004
The Guardian

The more I've delved into the US military's psychological warfare, the more examples of New Age-style, First Earth Battalion tactics I've been noticing in the war on terror. I learned of one fact in particular that struck me as entirely incongruous, something at once banal and extraordinary. It happened to a Mancunian called Jamal al-Harith in a place called the Brown Block. Jamal doesn't know what to make of it either, so he mentioned it to me only as an afterthought when I met him in the coffee bar of the Malmaison Hotel, near Manchester Piccadilly station, one June morning this year.

Jamal is a website designer. He lives with his sisters in south Manchester. He is 37, divorced, with three children. He said he assumed MI5 had followed him here to the hotel, but he's stopped worrying about it. He said that he keeps seeing the same man watching him from across the street, leaning against a car, and that whenever the man thinks he's been spotted, he looks briefly panicked and immediately bends down to fiddle casually with his tyre.

Jamal laughed when he told me this. He was born Ronald Fiddler into a family of second-generation Jamaican immigrants. When he was 23, he learned about Islam and converted, changing his name to Jamal al-Harith: he liked the sound of it. He says al-Harith basically means "seed planter".

In October 2001, Jamal visited Pakistan as a tourist, he says. He was in Quetta on the Afghanistan border, four days into his trip, when the American bombing campaign began. He quickly decided to leave for Turkey and paid a local truck driver to take him there. The driver said the route would take them through Iran, but somehow they ended up in Afghanistan, where they were stopped by a gang of Taliban supporters. They asked to see Jamal's passport, and he was promptly arrested and thrown in jail on suspicion of being a British spy.

Afghanistan fell to the coalition. The Red Cross visited Jamal in prison. They suggested he cross the border into Pakistan and make his own way back home to Manchester, but Jamal had no money, so instead he asked to be put in contact with the British embassy in Kabul.

Nine days later - while he waited in Kandahar for the embassy to transport him home - the Americans picked him up.

"The Americans," Jamal said, "kidnapped me." When he said "kidnapped", he looked surprised at himself for using such a dramatic word.

The Americans in Kandahar told Jamal he needed to be sent to Cuba for two months for administrative processing, and so on, and the next thing he knew he was on a plane, shackled, his arms chained to his legs and then chained to a hook on the floor, his face covered in earmuffs and goggles and a surgical mask, bound for Guantánamo Bay.

In the weeks after Jamal's release, two years later, he gave a few interviews, during which he spoke of the shackles and the solitary confinement and the beatings - the things the outside world had already imagined about life inside that mysterious compound. He said they beat his feet with batons, pepper-sprayed him and kept him inside a cage that was open to the elements, with no privacy or protection from the rats and scorpions that crawled around the base. But these were not sensational revelations.

He spoke to ITV's Martin Bashir, who asked him (off-camera), "Did you see my Michael Jackson documentary?"

Jamal replied, "I've, uh, been in Guantánamo Bay for two years."

When I met Jamal, he began to tell me about the more bewildering abuses. Prostitutes were flown in from the US - he doesn't know whether they were there to smear their menstrual blood on the faces of the more devout detainees. Or perhaps they were brought in to have sex with the soldiers, and some psychological operations (PsyOps) boffin - a resident cultural analyst - devised this other job for them as an afterthought, exploiting the resources at the army's disposal.

"One or two of the British guys," Jamal told me, "said to the guards, 'Can we have the women?' But the guards said, 'No, no, no. The prostitutes are for the detainees who don't actually want them.' They explained it to us: 'If you want it, it's not going to work on you.' "

"So what were the prostitutes doing to the detainees?" I asked.

"Just messing about with their genitals," said Jamal. "Stripping off in front of them. Rubbing their breasts in their faces. Not all the guys would speak. They'd come back from the Brown Block [the interrogation block] and be quiet for days and cry to themselves, so you know something went on, but you don't know what. But for the guys who did speak, that's what we heard." I asked Jamal if he thought that the Americans at Guantánamo were dipping their toes into the waters of exotic interrogation techniques.

"They were doing a lot more than dipping," he replied. And that's when he told me about what happened to him inside the Brown Block.

Jamal said that, being new to torture, he didn't know whether the techniques tested on him were unique to Guantánamo, or as old as torture itself, but they seemed pretty weird to him. His description of life inside the Brown Block made Guantánamo Bay sound like an experimental interrogation lab, teeming not only with intelligence agents, but also with ideas. It was as if, for the first time in the soldiers' careers, they had prisoners and a ready-made facility at their disposal, and they couldn't resist putting all their concepts - which had until then languished, sometimes for decades, in the unsatisfactory realm of the theoretical - into practice.

First there were the noises.

"I would describe them as industrial noises," said Jamal. "Screeches and bangs. These would be played across the Brown Block into all the interrogation rooms. You can't describe it. Screeches, bangs, compressed gas. All sorts of things. Jumbled noises."

"Like a fax machine cranking up into use?" I asked.

"No," said Jamal. "Not computer-generated. Industrial. Strange noises. And mixed in with it would be something like an electronic piano. Not as in music, because there was no rhythm to it."

"Like a synthesiser?"

"Yes, a synthesiser mixed in with industrial noises. All a jumble and a mishmash."

"Did you ever ask them, 'Why are you blasting these strange noises at us?' " I said.

"In Cuba you learn to accept," said Jamal.

The industrial noises were blasted across the block. But the strangest thing of all happened inside Jamal's own interrogation room. The room was furnished with a CCTV camera and a two-way mirror. Jamal would be brought in for 15-hour sessions, during which time they got nothing out of him because, he said, there was nothing to get. He said his past was so clean - not even a parking ticket - that at one point someone wandered over to him and whispered, "Are you an MI5 asset?"

"An MI5 asset!" said Jamal. He whistled. "Asset!" he repeated. "That was the word he used!"

The interrogators were getting more and more cross with Jamal's apparent steely refusal to crack. Also, Jamal used his time inside the Brown Block to do stretching exercises, keeping himself sane. Jamal's exercise regime made the interrogators more angry, but instead of beating him, or threatening him, they did something very odd.

A military intelligence officer brought a ghetto blaster into his room. He put it on the floor in the corner. He said, "Here's a great girl band doing Fleetwood Mac songs."

He didn't blast the CD at Jamal. This wasn't sleep-deprivation, and it wasn't an attempt to induce the Bucha Effect[1]. Instead, the agent simply put it on at normal volume.

"He put it on," said Jamal, "and he left."

"An all-girl Fleetwood Mac covers band?" I said.

"Yeah," said Jamal.

This sounded to me like the tip of a very strange iceberg.

"And what happened next?" I asked.

"When the CD was finished, he came back into the room and said, 'You might like this.' And he put on Kris Kristofferson's greatest hits. Normal volume. And he left the room again. And then, when that was finished, he came back and said, 'Here's a Matchbox Twenty CD.' "

"Was he doing it for entertainment purposes?" I asked.

"It's interrogation," said Jamal. "I don't think they were trying to entertain me."

"Matchbox Twenty?" I said.

I didn't know much about Matchbox Twenty. My research reveals them to be a four-piece country rock band from Florida, who do not sound particularly abrasive (like Metallica and Burn Motherfucker Burn!) nor irritatingly repetitive (like Barney The Purple Dinosaur and Ya! Ya! Das Is A Mountain). They sound a bit like REM. The only other occasion when I had heard of Matchbox Twenty was when Adam Piore from Newsweek told me that they, too (like Metallica and Barney), had been blasted into the shipping containers where detainees were held at al-Qa'im in Iraq. I mentioned this to Jamal and he looked astonished.

"Matchbox Twenty?" he said.

"Their album More Than You Think You Are," I said.

There was a silence.

"I thought they were just playing me a CD," said Jamal. "Just playing me a CD. See if I like music or not. Now I've heard this, I'm thinking there must have been something else going on. Now I'm thinking, why did they play that same CD to me as well? They're playing this CD in Iraq and they're playing the same CD in Cuba. It means to me there is a programme. They're not playing music because they think people like or dislike Matchbox Twenty more than other music. Or Kris Kristofferson more than other music. There is a reason. There's something else going on. Obviously I don't know what it is. But there must be some other intent."

"There must be," I said.

Jamal paused for a moment and then he said, "You don't know how deep the rabbit hole goes, do you? But you know it is deep. You know it is deep."

Subsequently, I talked to Joseph Curtis (not his real name), who worked on the night shift at the Abu Ghraib prison, in charge of the computer network. I asked if he knew anything about the music. He said, sure, they blasted loud music at the detainees all the time. "What about quieter music?" I said, and told him Jamal's story about the ghetto blaster and the Fleetwood Mac all-girl covers band and Matchbox Twenty.

Joseph laughed. He shook his head in wonderment. "They were probably fucking with his head," he said.

"You mean they did it just because it seemed so weird?" I asked. "The incongruity was the point of it?"

"Yeah," he said.

"But that doesn't make sense," I said. "I can imagine that might work on a devout Muslim from an Arab country, but Jamal is British. He was raised in Manchester. He knows all about ghetto blasters and Fleetwood Mac and country and western music."

"Hm," said Joseph.

"Do you think ...?" I said.

Joseph finished my sentence for me.

"Subliminal messages?" he said.

"Or something like that," I said. "Something underneath the music."

"You know," said Joseph, "on a surface level that would be ridiculous. But Guantánamo and Abu Ghraib were anything but surface."

Jamal seemed fine when I met him in Manchester. I asked if he felt at all unusual after listening to Matchbox Twenty and he said no. But one shouldn't read too much into this. There is a very strong chance, given the history of the goat staring and the wall walking and so on that US military intelligence honchos went in for, that they blasted Jamal with silent sounds and it just didn't work.

In late June 2004 I sent an email to Jim Channon and everyone else I'd met during my two-and-a-half-year journey who might have some inside knowledge about the current use of the kinds of psychological interrogation techniques that had first been suggested in Jim's First Earth Battalion manual. I wrote:

Dear ---

I hope you are well.

I was talking with one of the British Guantánamo detainees (innocent - he was released) and he told me a very strange story. He said at one point during the interrogations the MI [military intelligence] officers left him in a room - for hours and hours - with a ghetto blaster. They played him a series of CDs - Fleetwood Mac, Kris Kristofferson, etc. They didn't blast them at him. They just played them at normal volume. Now, as this man is western, I'm sure they weren't trying to freak him out by introducing him to western music. Which leads me to think ... Frequencies? Subliminal messages?

What's your view on this? Do you know any time when frequencies or subliminal sounds have been used by the US military for sure?

With best wishes,

Jon Ronson

I received four replies straight away.

Commander Sid Heal (the Los Angeles Sheriff's Department non-lethals expert who told me about the Bucha Effect): "Most interesting, but I haven't a clue. I know that subliminal messages can be incorporated and that they have a powerful influence. There are laws prohibiting it in the US, but I'm not aware of any uses like you describe. I would imagine, however, that it would be classified and no one without a 'need to know' would be aware anyway. If it were frequencies, it would probably need to be in the audible range or they wouldn't need to mask them with other sounds."

Skip Atwater (General Stubblebine's former psychic spying headhunter): "You can bet this activity was purposeful. If you can get anybody to talk to you about this, it would be interesting to know the 'success rate' of this technique."

Jim Channon: "Strikes me the story you tell is just plain kindness (which still exists)."

I couldn't decide if Jim was being delightfully naive, infuriatingly naive, or sophisticatedly evasive.

Then Colonel John Alexander responded to my email. He remains the US army's leading pioneer of non-lethal technologies, a role he created for himself in part inspired by Jim's First Earth Battalion manual.

Colonel Alexander: "Re your assertion he was innocent. If so, how did he get captured in Afghanistan? Don't think there were many British tourists who happened to be travelling there when our forces arrived. Or maybe he was a cultural anthropologist studying the progressive social order of the Taliban as part of his doctoral dissertation and was mistakenly detained from his education. Perhaps if you believe this man's story you'd also be interested in buying a bridge from me? As for the music, I have no idea what that might be about. Guess hard rockers might take that as cruel and unusual punishment and want to report it to Amnesty International as proof of torture."

Jokes about the use of music in interrogation didn't seem that funny any more - not to me, and I doubt they did to him, either. I emailed him back: "Is there anything you can tell me about the use of subliminal sounds and frequencies in the military's arsenal? If anyone alive today is equipped to answer that question, surely you are."

Colonel Alexander's response arrived instantly. He said my assertion that the US army would ever entertain the possibility of using subliminal sounds or frequencies "just doesn't make sense".

Which was strange. I dug out an interview I'd conducted with the colonel the previous summer. I hadn't been that interested in acoustic weapons at that point, but the conversation had, I now remembered, briefly touched on them.

"Has the army ever blasted anyone with subliminal sounds?" I had asked him.

"I have no idea," he said.

"What's a 'psycho-correction' device?" I asked him.

"I have no idea," he said. "It has no basis in reality."

"What are silent sounds?" I asked.

"I have no idea," he said. "It sounds like an oxymoron to me." The colonel gave me a hard look, which seemed to suggest that I was masquerading as a journalist and was, in fact, a dangerous and irrational conspiracy nut.

"I'm confused," I said. "I don't know much about this subject, but I'm sure I've seen your name linked with something called a 'psycho-correction device'."

Yes, he said, he had sat in on meetings where this sort of thing was discussed, but there was no evidence that machines like this would ever work. "How would you do that [blast someone with silent sounds] without it affecting us? Anybody who's out there would hear it."

How could you blast someone with silent sounds "without it affecting us"? This struck me at the time as an unassailable argument, one that cut through all the paranoid theories circulating on the internet about mind-control machines putting voices into people's heads. Of course it couldn't work.

The thing is, I now realised, if silent sounds had been used against Jamal inside an interrogation room at Guantánamo Bay, there was a clue in Jamal's account, a clue that suggested that military intelligence had craftily solved the vexing problem highlighted by Colonel Alexander.

"He put the CD in," Jamal had said, "and he left the room."

Next, I dug out the recently leaked military report entitled Non-Lethal Weapons: Terms And References. There were a total of 21 acoustic weapons listed, in various stages of development, including the Infrasound ("Very low-frequency sound which can travel long distances and easily penetrate most buildings and vehicles ... biophysical effects: nausea, loss of bowels, disorientation, vomiting, potential internal organ damage or death may occur. Superior to ultrasound ...").

And then, the last entry but one - the Psycho-Correction Device, which "involves influencing subjects visually or aurally with embedded subliminal messages".

I turned to the front page. And there it was. The co-author of this document was Colonel John Alexander.

[1] In the 1950s, helicopters started falling out of the sky, crashing for no apparent reason, and the pilots who survived couldn't explain it. They had been flying as normal and then suddenly they felt nauseous, dizzy and debilitated; they lost control of their helicopters. A Dr Bucha was called in to solve the mystery. What he found was that the rotor blades were strobing the sunlight, and when it reached an approximation of human brainwave frequency, it interfered with the brain's ability to send correct information to the rest of the body.

· This is an edited extract from The Men Who Stare At Goats, by Jon Ronson, published by Picador on November 19 at £16.99. To order a copy for £16.14, with free UK p&p, call 0870 836 0875. Jon Ronson's three-part television series, The Crazy Rulers Of The World, starts on Channel 4 tomorrow. · Jamal al-Harith is one of four Britons released from Guantánamo in March, after more than two years' imprisonment, who claim they were repeatedly tortured at the camp and, it was announced last week, are suing Donald Rumsfeld and other US military leaders for £6m compensation each.

Appendix 5

Western Morning News

SHATTERED DREAM OF QUIET LIFE

09:00 - 06 January 2004

All they wanted was the good life in Cornwall, and they needed it for the sake of their health - but no sooner had Colin and Kathy Bird fled the city for a modest rural home than their dream was shattered by the noise from wind turbines.

Last year at Christmas the couple booked into B &Bs in Newquay rather than endure sleepless nights in their caravan home at St Eval.

This year they have saved up £1,000 to live in Malta for a month because they cannot bear another winter at home when high winds turn the turbines.

When that noise from the Bears Down wind farm begins, says Kathy,

it's like a "a deep throbbing, or a train that never gets there".

For Colin it's worse. "You never rest your brain, you never get away from them," he says.

What makes it worse for the couple is that they moved to Cornwall to escape the noise of the city.

Colin, 48, had suffered a nervous breakdown when he worked as a car factory worker in Coventry. But he was stirred by warm memories of boyhood holidays in Cornwall. And the couple spent six months each year for three years until 2000 in a rented caravan there, and found it blissfully peaceful.

So they plunged what little money they had into their new life. They bought the neighbouring caravan and moved in one year before the 16-turbine wind farm opened in October 2001.

Their caravan is made mostly of aluminium, which exacerbates the tin can effect.

But they point out that they were there before the wind farm, and they don't have the money to move anywhere else.

Kathy, 43, says: "I did put in a letter of complaint about the plans. I was very concerned about the wildlife - buzzards and peregrine falcons. Then, of course, noise was one of my concerns, but I never realised how bad it would be. At first I thought it was something in the home, but it was the turbines.

"They get to a critical speed, which I believe is 40 knots, and then it disturbs us all the time. It's just as if we're in a box and it's reverberating all the time.

"It's almost like a motion sickness, and it always seems to be worst at Christmas.

"It's the constancy of them that gets to you, it can be for anything like three or four days, it's this deep throbbing."

The couple calculate that they booked into B &Bs four times last

year to escape the turbines. But sometimes they just drive around until the wind dies down.
National Wind Power, which owns the Bears Down site, has paid for double-glazing of the caravan to try to curb the noise effect, but this has had little impact.
Kathy and Colin, like their neighbours, complain of headaches, anxiety, sleeplessness and nausea - 97 per cent questioned by Plymouth GP Amanda Harry complained of one symptom or another.
One neighbour, who asked not to be named, describes the effect of the noise as being like "Chinese water torture".
His home is further back from the wind farm, and better insulated against external noise, but he said: "We get a beating sound, it's like a bus engine sitting parked, and we do get headaches. I understand the need for renewable energy, but the problem is that they do not contribute much. To get the things going they have to use electricity anyway."
To add to his sense of injury, he estimates that the wind farm has devalued his property by 25 per cent. Colin's health has got worse since moving to what he dreamed would be the perfect home for the rest of his days. At first he had no opinion of the turbines' appearance, but now he describes them as being "like ogres looking at you".
So what do the couple want, and how do they see a way out of their nightmare?
Kathy wants the turbines stopped at night so that they can sleep, and "some form of compensation" for their misery and troubles.
Colin explains: "We can't afford anywhere else, so what's it going to be like for the rest of our lives? We came here thinking we'd get peace and quiet for the rest of our lives. And it's beautiful - Cornwall has everything.
"But then this happens - you'd need to be in a Chieftain tank with earphones not to hear those things."
Kathy adds: "We came here to live simply, and we both had to retire early because of ill-health. Colin just needed a very quiet environment, and we'd been here before and had three years of peace and quiet and it was gorgeous.
"But this is systematically ruining our lives - and I just feel that people are not aware of the damage these things are doing to health."
The issue is set to come to the fore with a legal test case in Cumbria where people living between 600-800 metres from the 60-metre turbines in the village of Askham complained of headaches and nausea. Barrister John Campbell is representing three couples at Kendal Magistrates Court in a fight to get wind turbines near their homes declared a statutory nuisance under the Environmental Health Act.

He said: "There are a number of complaints of sleep disturbance, headaches, and migraines that are driving people mad. They say it's a pervasive thump, thump noise from the blades."
He said that if they won the test case, which is expected to take several days, the turbines would either have to be stopped or removed.
Meanwhile, one couple living in a residential caravan near the Bears Down site have saved up £1,000 to go to Malta for a month because they say they cannot cope with life next to the turbines in winter when the winds are high.
In desperation last year, they booked into B &Bs in Newquay at Christmas.
Kathy and Colin Bird took early retirement through ill health from their jobs in Coventry as they sought a quiet life in Cornwall. Then they moved into their caravan in 2000, before the wind farm was built. But Mrs Bird now says: "It's just a throb when the wind is up - it's like the sound of a car going by with the stereo blaring, but it doesn't pass."
Matthew Spencer, chief executive of the South West Renewable Energy Agency (Regen) yesterday disputed whether the noise from turbines was the cause of their health complaints.
He said: "People may perceive that is their problem, but the turbines are not very noisy. Nothing has been proved about the health effects, but I would take these initial findings with a pinch of salt. These are arguments that people who are opposed to wind farms use."
He pointed out that travelling at 40mph would create a noise of 55 decibels at 100 metres while a wind turbine produced a noise of 35 decibels at 350 metres.
He said there was no evidence that the new generation of larger turbines planned for the South West would be a problem. "They are becoming less noisy as they are being developed," he said.
He added that the guidelines for the turbines were that they should not be within 400 metres of people's homes, and that noise had not proved a problem in the eyes of planners.
National Wind Power, which owns and operates the Bears Down wind farm, yesterday failed to respond to a series of questions put by the Western Morning News.

Appendix 6

Western Morning News
WIND TURBINES HAVE EATEN INTO MY VERY SOUL
09:00 - 09 January 2004
Mark Taplin has lived in the shadow of wind turbines for more than a decade. As part of our on-going debate on the issue, he describes how the experience has affected his life
Opposed: Mark Taplin says turbines have ruined his way of life MY world has been overshadowed by the spectre of wind turbines for 12 years, and I have lived with the reality for the past eight years of generating machines spinning their blades 75 metres above my house, the closest a mere 440 metres away. They have imposed themselves on my life and eaten into my soul - small wonder that I feel compelled to contribute to the deluge of column inches that this latest debate has generated. I live in a modest cottage which nestles in a small secluded Cornish valley, surrounded by a few acres that I can call my own.
I came here to pursue my ambition of an Arcadian existence, growing my own fruit and vegetables and indulging in a bit of self taught husbandry.
I was eager to leave behind the smug and affluent rural neighbourhood where I had grown up, and endured the tiresome label of leading "the good life".
I was accustomed to a degree of hardship and was prepared for the vicissitudes of the Westcountry climate. I was not expecting a rural idyll "preserved in aspic". I had a grasp of the commercial imperatives that exerted control over the countryside as the end of the century approached. However, what I was not prepared for was the impact on my life of my nearest neighbours - the wind turbines at Four Burrows.
I am not the first, nor will I be the last, to find the terms "windmill" and "windfarm" misplaced. Wind turbines do not mill grain, nor do they harvest the product of their own endeavours.
Arguably they save some forms of pollution, but are responsible in turn for some negative by-products, from the concrete in their foundations to the tips of their blades, offending many by their very sight and sound. I have always considered myself as one who was aware of environmental issues, and I try to live in harmony with the countryside. But, sadly, the intrusive neighbours on my doorstep have introduced a massive note of discord into my peaceful existence.
Why? Because whatever the individual thinks of them aesthetically, I cannot avoid the noise. I hear them nearly all the time. It is not easy to equate it to other noise sources, and I find the attempts at comparisons trite. The dilemma for one such as me is that the industry has always argued that as the wind picks up speed and the

power output and noise level produced increases, the natural background noise created by the wind will mask any turbine noise. Where this argument falls down, however, is when you find yourself in a comparatively sheltered position on lower ground than the turbines and not buffeted by the wind. Then you hear a great deal more than if you stand up close with the wind rushing past your ears. When small but violent changes in wind direction shear past the turbines, the chomp and swoosh of the blades passing the towers creates a noise, albeit mercifully brief, that beggars belief. It is as if a ghostly steam engine were pumping an abandoned mine working.

But this surprising and unacknowledged phenomenon does thankfully pass as the wind abates, whereas the bane of my life - the "tonal" (mechanical whine or resonance) noise - does not. It is ever present when a turbine is generating at more than mere tickover,

despite the manufacturer's claims.

So, how can I hear tonal noise? It has been so distinct at times that I foolishly assumed everyone would own up and do something about it. Sadly, that is where the technicalities come in, and it boils down to mathematics. The wind industry is better supported than local council environmental health departments, and they were well ahead of the game when they formulated the criteria for establishing tones. It is a loaded issue and not what you might call a level playing field. Whatever I hear, they will claim that it does not qualify as a tone - which means that I am stuck with it. Once you hear tonal noise it follows you around, not in your imagination but because the human ear has a natural habit of homing in on an annoying sound.

But, going back to the beginning, what turned me into an "anti" soon after I found myself thrown on to the learning curve in 1992? Was it the way that the whole thrust of renewable energy development was being hijacked by the wind lobby, the cavalier attitude of a new breed of opportunistic developers, the obscenely generous price support structure offered at that time under the Non Fossil Fuel Obligation and the greedy scramble for another subsidy? Was it the arrogance of politicians who jumped on the green bandwagon, the pressure group zealots who adopted the moral high ground in the name of saving the planet and the naive level of argument from the "better than nuclear, nicer than pylons" brigade? Was it the exasperating lesson of having to teach myself all about parliamentary statements, planning procedures and the technicalities of noise attenuation, which only served to disenchant me, when all the while I would much rather have been getting on quietly with my life? Or was it just a selfish determination to defend my precious green and pleasant Shangri La from industrial machines which threatened to invade my privacy?

I resent the same old stale public relations lecture from the vested interest lobby who do not appear to know how or when to apologise.
I do not warm to those who disregard for the sensibilities of others who can be passionate about preserving a particular landscape that is special to them. I cannot accept that wind turbine generators are benign.
I have contributed to the debate with this account not to seek sympathy, but as a reminder to those of a different persuasion that the route down which wind power development has been driven in recent years can cause very real harm. Noise apart, it has turned me, a potential supporter, against my turbine neighbours and what they stand for.

Appendix 7

Meridian pays family to move

02 August 2005

By LEE MATTHEWS

Meridian Energy has paid an undisclosed sum of money to shift a family from their farm where Te Apiti's wind turbines are located, because noise and vibration made it too difficult to live in their house.

Company spokesman Alan Seay would not say how much the compensation is, as it is a confidential agreement between Meridian and the Bolton family. He understands they will move off their farm and build elsewhere.

He also said the payout is not a surprise, as it had been anticipated in the initial lease agreements with the land owners. It is not part of any of the 20 conditions imposed by the wind farm's resource consent.

"Te Apiti is built on two farm properties. It was recognised right from the start that this family could have issues with noise . . . their house was a only a few hundred metres from the turbines," Mr Seay said.

"The possibility of having to shift was part of the initial lease agreement. These were houses actually in the wind farm, as opposed to neighbouring (houses)."

Meridian has also made a confidential deal with the other farm owners affected. Mr Seay said he understands this has involved building alterations, such as double-glazing windows to reduce noise.

There are no other claims for any kind of compensation for nuisance from Te Apiti, and Mr Seay said he does not anticipate any in future. "This one was made because it was a foreseen situation."

Feedback from the Ashhurst community about Te Apiti has "all" been positive, apart from "one or two vociferous" opponents whom he understands to be working with people objecting to Meridian's proposed Makara wind farm.

"Nimby (not in my back yard) syndrome . . . it's what we've got to expect from some of these groups . . . it's misleading and distorting."

Last November, Ashhurst resident Colin Mahy complained that sun reflection flickering into his house from the Te Apiti turbines was "driving him mad". Meridian had told him to draw his curtains.

Mr Seay said that he had given that advice. "Sun flash is a very momentary thing, it only occurs in certain circumstances and it doesn't last long."

Appendix 8

GWEN's Diary

These wind turbines, they're 76m high, there are three of them, they have a looming presence over the beautiful Teifi Valley, I've been trying hard to come to terms with living within a mile of them ever since they appeared there on Moelfre hill twelve months ago. They don't belong here, they shine in the sunlight, they glow in the moonlight, they stand out stark white against the dark rain clouds, unlike everything else surrounding them they never change. No lichen, no birds encircling them, no ivy creeping up their metallic towers. There is nothing of nature within them ,they don't belong here on Moelfre overlooking the Tivy Valley.

Those living six, ten, fifteen miles and more away from them agree. They can be seen by the inhabitants of many small towns and villages as totally scarring the wondrous outline of the gentle rise from Moelfre to Frenni Fach Frenni Fawr, Foeldrigarn ,Preseli and Caerningly above
Newport. The council planners must have been mad to grant them permission.

I've lived here on my farm now with my husband for twenty six years, I know every nook and cranny of the fifty acres. Our farm is only two miles from the farm where I was born sixty years ago, I grew up looking towards Moelfre and was delighted to be farming within my own community. I've been teaching in local schools, I paint landscapes in a converted shed, I've enjoyed good health, twenty six years of hard but rewarding work, I had planned to spend my remaining days here.

Now I sleep in my outhouse shed, it's not comfortable, I don't want to sleep there, I don't choose to be so far from amenities all night and suffer the sounds of mice within a yard of my head. The trouble is that when I am in the house my heart beat seems to alter, there seems to be a repeated slightly thumping pressure on my lungs. There's a slight throbbing in my head, like a headache without the pain. I feel slightly sick. I know that slightly is a term I've used for all the ailments but it is not a normal state of well being. It makes me feel on edge .When I visit a friend on the other side of the valley that's when I feel normal, and that state of normality suddenly seems the most wonderful feeling on earth. To me this is a tragic turn of events. Compared to the total sum of human misery I admit it might sound trivial. Today we had the fire wood cut up for next winter, here we enjoy our own spring water, my garden, my roses and clematis, and oh the first violets and primroses in the woods. The seven thousand trees we've planted, my studio, this is what our life has been about! Now I feel robbed of all I hold dear, and to complicate the situation my husband is not effected by the turbines, he doesn't like the visual impact but they don't make him ill. The low frequency noise/vibrations from the turbines [not the blades] play havoc with my health.

Where do I go from here? When the company was granted permission for the development the local paper reported that this was a lifeline for the struggling Welsh speaking local farmer who otherwise would have had to leave the land, Hey I'm a Welsh speaking local too, where's my lifeline?
I belong here, those turbines DO NOT.

06/04/03

Diary Tuesday 8th April.

Sat in the gallery yesterday, in Carmarthen, felt well all day. In the evening went to the Teivy Arts meeting, felt well, enjoyed the company and chat. Came home at ten fifteen sat talking to Henning for a while went to bed [the bed in the house, the wind was fairly light] and the throbbing in my head started. Tried to ignore it, listened to the radio, switched it off, throb throb, feeling of anxiety, tried to sleep, but at twelve thirty I reluctantly took a Nytol tablet. Slept.
This morning I went to see my doctor to have a check up to see if there is some physical cause for my disturbed heart rhythm. She examined my heart, all well, felt my pulse rate, all well, lungs, all well, took my blood pressure, 120/80 that's good. Never felt better, She looked up my records for the hearing test in 1992 but there were no specific detailed figures given for the test only the conclusion that this patient had normal hearing. [had the test because I had been suffering from tinnitus that year]
After lunch I sat down in the living room by the window to read, after five minutes I had to move I couldn't stand the heart rhythm and the churning in my head. I tried to override it I really wanted to get on with my book but I could not stay there any longer. The wind is from the south today and the turbines have their backs turned directly at us.
Went outside to do some gardening and took Tess for a walk, it's always better outside. Thought about buying a wooden garden shed to live in, perhaps in the woods.
Back in the house I felt extremely uncomfortable. At five o'clock I baby sat for Lindsay in the old farmhouse until her mother arrived. The noise of the children and telly filled the house so I couldn't compare the two houses for turbine noise.

Wednesday 9th April.

Last night I tried something new, I have a C D of the sound of waves called Ocean Spray, it's called white noise, for relaxation and sound masking. I carried my CD player from the studio up to the bedroom. It's not a portable so it was heavy. The wind was from the south so I knew there would be throbbing in my head. It sounded great,[the sound of waves] I slept quite soon but woke up at five o'clock with a dreadful headache, had to take two soluble aspirins. Wind still from the south and my headache was still with me at ten o'clock. Took more painkillers and kept to our plan of walking on the Preselis.

Three hour walk, beautiful weather, felt great. My mind is going around in circles about what to do in this situation. It's clear that no one else suffers from the same symptoms as me on this farm. There are six adults and three children living here. I really don't want to disrupt everyone else's lives.
Plans: Sell the whole place. Sell only this house; Rent a place and find a tenant for this house; Build a small place for me in some "quiet corner of the farm" if there is such a place; My head is reeling with all the pros and cons. Haven't painted for weeks because of my bed being in the studio. Feel sick again. Trouble is that when I feel ill where can I lie down, in my bedroom? That's where I feel ill.
Later on the wind came from the North, then life gets back to normal again and no way are we going to sell up and move away.

Friday 11th April
North wind, yesterday was no problem to me. What a difference it makes, once the pain has gone there's no need to plan an alternative future for us. Have moved the bed from my studio, I really need to get on with my work. Have moved it to the loft, above another outhouse, I shall sleep there next time the wind is from the south. I'm feeling quite hopeful again that I can live with this once I've learned how to, but in order to make it possible some alterations will have to be made to the loft.
Saturday 12th April
I was far too optimistic yesterday, this is typical of how it goes. Last night was the worst so far. I went to my bed in the house and played the CD of the waves, slept quite soon, CD was on repeat mode. At one forty five am I woke up with the throbbing in my head, really bad, weight on my chest and a distinct pain in my heart. Tried to calm myself, CD was still playing, tried to meditate but was filled with a real sense of panic and felt an urgent need to escape. Too cold to go to the loft so I carried my duvet down to the kitchen which is the furthest room away from the turbines. With the cushions from the settee I made a camp bed but there was no sleep so at six o'clock I dragged it all back upstairs, Got up, had only about three hours sleep.
Shall have to try out the loft tonight, it's the sound of vermin that worries me, and the cold, but nothing could be worse than the way I felt last night.
Sunday 13th April
The loft is as bad as the bedroom. I realized this in the afternoon yesterday when I tried to catch up with some sleep. Spent last night at by brothers' house in the village three miles away. Slept. This is really getting us down, it's taking over our lives. We're now back to selling and moving away, it can't go on like this.
Monday 14th April
Wind from the south again, feel really depressed this morning. Phoned the council about noise pollution, someone will 'phone back today or tomorrow [or never]. I've got to get out of here today, all the symptoms are with me again, Henning is quite sick of hearing about them and I'm sick of suffering them.
Tuesday 14th April,
Wind still from the south, slept in the dining room last night but only after taking a Nytol tablet. Estate agent came out this morning, we'll probably have to move I can see no future for me here. I have to go out today to get some relief from the way I feel.

Gwen has now moved and does not live near wind turbines- she says that all her symptoms have settled.

Appendix 9

A) **Nick Priest on behalf of 30 families, Chybucca, Allet, Truro, Cornwall, TR4 9DL**

.....the only two families who lived near to the Carland Cross wind farm, Newquay, have now moved out because of unsolvable noise problems. At least one home now lies derelict.

Is this positive rural diversification or rural community extinction? The Welsh Affairs Select Committee have recommended that no dwellings should be within 1.5km of a wind farm. There are 30 families within such distance.

(Extract from noise abatement society, July 1997, 'Windfarms certainly do make a noise').

Appendix 10

B) Natalie Gregg, The Courier Mail, Queensland, Australia, 04 Oct 2004

Rural residents in two states can't sleep at night because of noise from a Queensland Government owned corporation's alternative energy plant. Homeowners in Queensland and Vixctoria have all but resigned themselves to the noise of the Stanwell Corp. wind turbines, which they claim have devalued their properties.

Mrs Newman said the throbbing, thumping noise from the generators could be heard at all hours of the day, "It was very frustrating in the beginning and makes us extremely upset, but there is nothing we can do about it." Within 12 months the couple, who are in their fifties, had had enough and they decided to move but they still cannot find a buyer.

Appendix 11

C) Times on Line, 10 Jan, 2004 "wind farms ruin peace, says judge"
Wind farms can ruin the peace of the countryside and destroy the value of nearby homes, a judge has ruled.

District Judge Michael Buckley said that the noise, visual intrusion and flickering of light through the blades of turbines reduced the value of a house by a fifth. He said that the value of a remote house in Marton, in the Lake District, fell significantly because of the construction of a wind farm 40m high turbines, 500 metres away.

Appendix 12

D) Mag. Lotta Nilson, Laholm, Sweden. (lotta.nilson.fsi@swipnet.se)

Wind turbines produce nothing but a nightmare for neighbourhoods; conflicts between former friends and within families, stress, ill health.....I left my home because of a wind turbine placed 650m from my house. One day in November 1998 mine and my neighbour's lives changed dramatically. The wind turbine, totally about 90m high started to rotate for the first time. The noise is a torture. After one year I understood we would not get any help and that no one can or will measure the sound level.....Hundreds of families in my small, former beautiful community on the west coast of Sweden are suffering enormously.

Appendix 13

E) Murray R. Barber, Bradworthy, Devon. 12 July 2005

I understand that Energiekontour A.G. is responsible for operating the Forestmoor wind farm, Bradworthy, Devon. Our home is located 650m from the nearest of three turbines. I wish to complain about noise nuisance created by the wind farm.....

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REVIEW ARTICLES

Behavioral and Physiological Consequences of Sleep Restriction

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Adequate sleep is essential for general healthy functioning. This paper reviews recent research on the effects of chronic sleep restriction on neurobehavioral and physiological functioning and discusses implications for health and lifestyle. Restricting sleep below an individual's optimal time in bed (TIB) can cause a range of neurobehavioral deficits, including lapses of attention, slowed working memory, reduced cognitive throughput, depressed mood, and perseveration of thought. Neurobehavioral deficits accumulate across days of partial sleep loss to levels equivalent to those found after 1 to 3 nights of total sleep loss. Recent experiments reveal that following days of chronic restriction of sleep duration below 7 hours per night, significant daytime cognitive dysfunction accumulates to levels comparable to that found after severe acute total sleep deprivation. Additionally, individual variability in neurobehavioral responses to sleep restriction appears to be stable, suggesting a trait-like (possibly genetic) differential vulnerability or compensatory changes in the neurobiological systems involved in cognition. A causal role for reduced sleep duration in adverse health outcomes remains unclear, but laboratory studies of healthy adults subjected to sleep restriction have found adverse effects on endocrine functions, metabolic and inflammatory responses, suggesting that sleep restriction produces physiological consequences that may be unhealthy.

Keywords: Sleep restriction, neurobehavioral functions, physiology
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There is ample scientific evidence to support the conclusion that sleep is an essential physiological need state that must be satisfied to ensure survival.[1-3] Experimental work on sleep restriction has now begun to focus on the basic question of how much sleep people need each day to be healthy and safe. Chronic sleep restriction is frequently experienced due to medical conditions, sleep disorders, work demands, social and domestic responsibilities, and life style. This paper reviews recent research on the effects of chronic sleep restriction on neurobehavioral and physiological functioning relative to implications for health and safety.

SLEEP DURATION

Population-Based Estimates of Sleep Duration

Habitual sleep duration among adults shows considerable variance within and between individuals.[4] The largest available database to date on self-reported sleep duration involved 1,116 million Americans (age ≥30 years; mean = 57 years for women and 58 years for men)[5] who were queried about their sleep duration in 1982 as part of an American Cancer Society study. Sleep duration was distributed approximately normally, with 52.4% of subjects reporting <7.5 hours of sleep per night. In this sample, 19.7% of subjects reported sleeping <6.5 hours, and 4.0% reported sleeping <5.5 hours per night. At the other end of the spectrum, 9.2% of probands slept ≥8.5 hours, and 3.3% reported sleeping ≥9.5 hours per night. There were only very small differences in sleep duration between men and women in this study. It is not known to what extent these self-reported sleep durations accurately reflected physiologic sleep obtained, but this uncertainty plagues all epidemiological and survey studies of sleep duration. Since the data were acquired more than 24 years ago,[5] it is uncertain whether these sleep duration estimates can be interpreted as being consistent with more recent population trends of declining sleep duration.

A 2005 Gallup poll in the USA found that among 1,500 adults (age ≥18 years; mean = 49 years) the average self-reported sleep duration was 6.8 h on weekdays and 7.4 h on weekends.[6] However, there was considerable variation in reported sleep duration—16% of those interviewed reported sleeping <6 h per day on weekdays, while 10% did so on weekends.[6] The proportion of U.S. adults reporting that they slept ≥8 h on weekdays decreased by 9% from a 1998 poll to a 2005 poll, while those reporting <6 h of sleep on weekdays increased by 4% over the same time period.[6] Table 1 displays the results, which suggest that sleep duration as reported by American adults decreased over the past 8 years. There is considerable debate as to whether or not sleep duration has been decreasing among adults, and, if so, whether this is resulting in higher rates of chronic sleep restriction or sleep debt.[7,8]

Disclosure Statement
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Table 1—Percentage of Participants that Reported Sleep Times in 4 Categories on Weekdays and Weekends from the 1998 and 2005 National Sleep Foundation Gallop Polls.

Hours of sleep	1998 weeknight	2005 weeknight	diff.	1998 weekend	2005 weekend	diff.
≥ 8	35	26	-9	53	49	-4
7-7.9	28	31	+3	23	24	+1
6-6.9	23	24	+1	14	15	+1
< 6	12	16	+4	8	10	+2

Data collected from N = 1506 participants (mean age 40.9 yr; 51% female) randomly selected based on U.S. Census household data (e.g., household has individuals over 18 yr).[6] Telephone interviews were conducted between September and November 2004. Values in the table are expressed as percentages. Over the years, respondents who reported sleeping ≥7 h on weeknights decreased from 63% in 1998 to 57% in 2005. Additionally, the percentage of people who reported sleeping >7 h on weekend nights has dropped from 76% in 1998 to 73% in 2005. Overall, there appears to be an increase in the percentage of people sleeping <6 h/night and a decrease in those sleeping >7 h/night both during the week and on weekends.

NEUROBEHAVIORAL CONSEQUENCES OF SLEEP RESTRICTION

Unlike total sleep deprivation, which has been extensively investigated experimentally, the effects of partial sleep deprivation have received less scientific attention, even though sleep restriction is more prevalent as a result of medical conditions and sleep disorders, as well as lifestyle (e.g., shiftwork, jet lag, prolonged work hours).

Partial sleep deprivation can occur in 3 ways. The first involves preventing sleep from being physiologically consolidated and is referred to as sleep fragmentation, which can occur in certain sleep disorders (e.g., untreated obstructive sleep apnea). During sleep fragmentation, the normal progression and sequencing of sleep stages is typically disrupted to varying degrees, resulting in less time in consolidated physiological sleep, relative to time in bed. The second type of partial sleep deprivation involves loss of specific physiological sleep stages, and is, therefore, referred to as selective sleep stage deprivation. This is presumed to be less common than the other types, but prevalence estimates do not exist for any type of sleep restriction. Selective sleep stage deprivation can occur if sleep fragmentation is isolated to a specific sleep stage (e.g., when apneic episodes disrupt primarily one stage of sleep such as REM sleep, or when medications suppress a specific sleep stage). The third type of partial sleep deprivation is sleep restriction, which is also referred to as sleep debt,[9] which is characterized by reduced sleep duration. Sleep restriction is the focus of this review because it is common, it relates to the fundamental question of how much sleep people need, and there is considerable experimental evidence of its neurobehavioral and physiological effects. Of particular interest are the questions of what changes when sleep is steadily reduced from 8 hours' to 4 hours' duration each day (i.e., the range many people experience sleep restriction), and whether there are cumulative dose response effects of this reduction on sleep physiology and waking functions.

Changes in Sleep Architecture During Sleep Restriction

Sleep restriction alters sleep architecture, but it does not affect all sleep stages equally. Depending on the timing and duration of sleep, and the number of days it is reduced, some aspects of sleep are conserved, occur sooner, or intensify, while other aspects of sleep time are diminished. For example, healthy adults fell asleep more quickly and had decreased time in NREM stage 2 sleep and REM sleep when restricted to 4 h of nocturnal sleep for multiple nights, but they had no decrease in NREM slow wave sleep (SWS) relative to a typical 8-h nocturnal sleep period[10-13] (see Figure 1). While visually scored NREM SWS was conserved, slow wave sleep activity (SWA) derived from power spectral analysis of delta wave activity (0.5-4.0 Hz) in the EEG during NREM stages 2, 3, and 4 sleep showed some dynamic increases as restriction of sleep to 4 h continued for more than a day.[11,12] The conservation of SWS and intensification of SWA during sleep restricted to 4 h/night in healthy adults, has suggested the hypothesis that NREM EEG slow waves are essential and perhaps protected aspects of the physiological recovery afforded by sleep to waking brain functions. It remains to be determined whether the lack of SWS and SWA response to sustained (chronic) restriction of sleep to 4 h a night, relative to steady increases in physiological and neurobehavioral measures of sleepiness,[12] can account for the latter deficits. Neither SWS nor NREM SWA show the magnitude of increases following chronic sleep restriction observed following total sleep deprivation.[12] Consequently, while SWS and NREM SWA may be largely conserved in chronic sleep restriction to 4-7 hours per night, they do not appear to either reflect the severity of daytime cognitive deficits or prevent these deficits, raising serious doubts about SWS and NREM SWA as the only aspects of sleep critical to waking functions.

Experimental Control of Wakefulness in Sleep Restriction Experiments

Experimental protocols that restrict healthy adult sleep duration across consecutive days provide the most appropriate paradigms for addressing the question of whether waking neurobehavioral deficits accumulate, and, if so, the rate of accumulation as the reduced sleep duration is maintained for multiple days. However, the cost and logistical complexities of maintaining tight experimental control over the sleep and waking activities of a large number of subjects, 24-hours a day for 1-3 weeks have resulted in only a few experiments on chronic sleep restriction being done in a scientifically sound manner. Most early experimental reports (before 1965) on the waking neurobehavioral effects of prolonged sleep restriction to durations people commonly experience (i.e., 4-6 h sleep per day) bordered on the anecdotal and lacked adequate sample sizes and control groups.[9] Subsequent experimental reports (1970-1995) on the cognitive and subjective effects of sleep restricted to 4-6 hours a night often failed to ensure that subjects maintained the assigned sleep–wake schedules; used infrequent, confounded and/or insensitive measures of sleep and waking; lacked sophisticated time series analyses; and generally drew conclusions not substantiated by the quantitative results (for reviews, see [9,14,15]). These methodological inadequacies and small sample sizes resulted in conflict as to whether or not sleep restriction resulted in cumulative waking cognitive and subjective changes, which prompted 3 widely repeated conclusions: (1) that reducing nightly sleep duration to between 4 and 6 h had little adverse effects on daily functions[16-19]; (2) that only a "core sleep" duration of 4-6 h was physiologically essential, and any additional sleep beyond that core duration was optional sleep

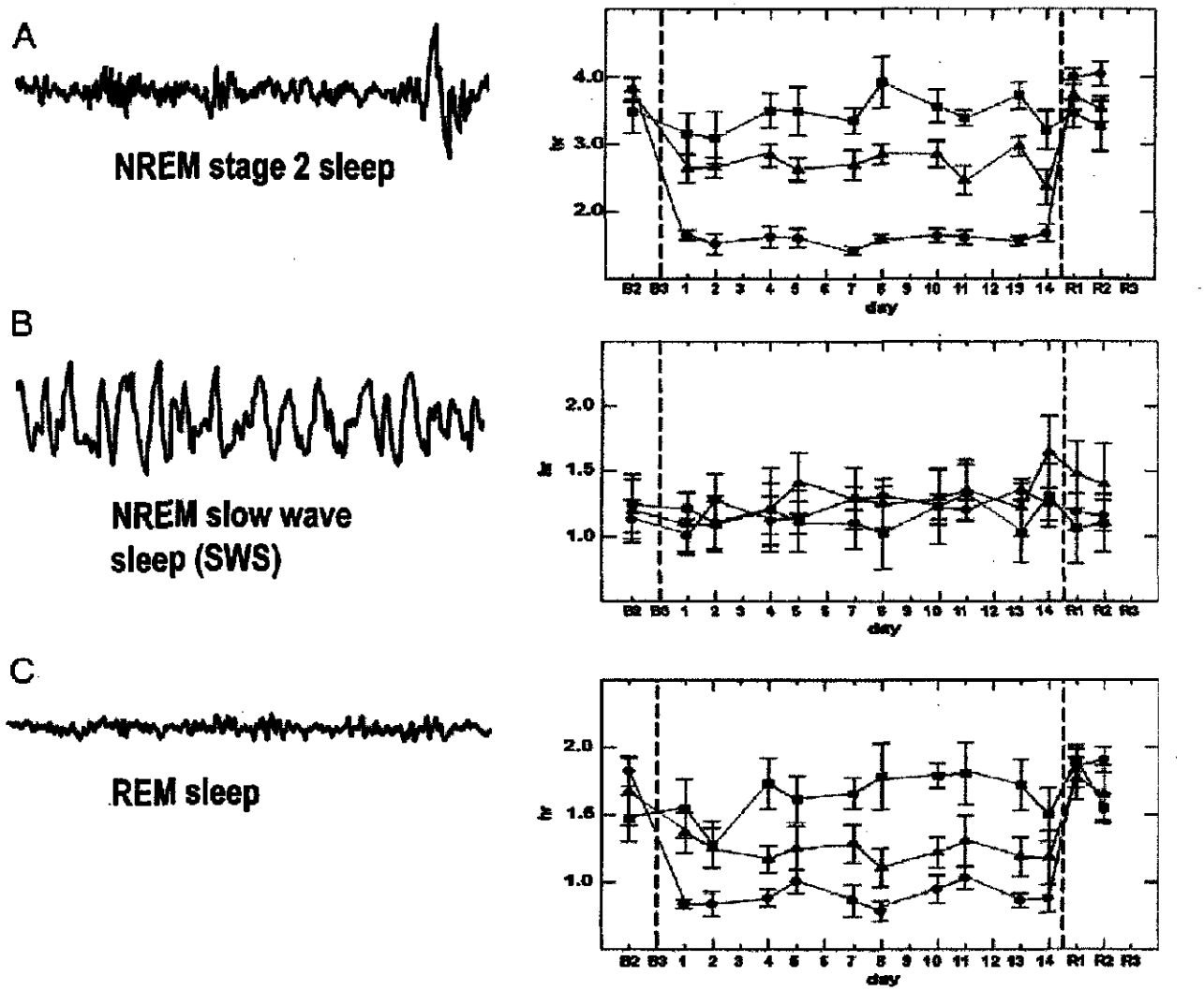

Figure 1—The effects of sleep restriction on NREM stage 2 sleep in Panel A; on NREM slow wave sleep (SWS) in Panel B; and on REM sleep in Panel C. Data are adapted from Van Dongen et al.[12] Following 8 hours of time in bed on baseline nights (B1, B2, B3), sleep was restricted for 14 consecutive nights to either 4 hours of time in bed (•, n = 13 healthy adults), 6 hours of time in bed (▲, n = 13), or 8 hours of time in bed (■, n = 9). Restriction was implemented by delaying bed time and holding sleep offset time constant (07:30). Sleep restriction nights were followed by 3 nights of 10 hours of time in bed for recovery sleep (R1, R2, R3). Sleep stages were scored polysomnographically for 2 out of every 3 nights during the experiment. Panel A: During the 14 nights of restriction to 4 h of time in bed, NREM stage 2 sleep was decreased an average of more than 2 h per night relative to the 8-h control condition ($p < 0.001$). Stage 2 sleep was decreased approximately 1 h per night in the 6-h condition relative to the control condition ($p < 0.001$). Panel B: In contrast to NREM stage 2 sleep, NREM slow wave sleep (SWS) showed no significant reduction in either the 4-h or 6-h sleep restriction conditions relative to the 8-h control condition. Panel C: Relative to the 8-h control condition, REM sleep was reduced by approximately 47 minutes a night during the 14 nights of restriction to 4 h time in bed ($p < 0.01$), and by 24 minutes a night during the 14 nights of restriction to 6 h time in bed ($p < 0.05$).

that reflected residual capacity[9,20]; and (3) that an individual could adapt to a reduced amount of sleep with few neurobehavioral consequences.[20] These conclusions were subsequently shown to be incorrect, as tightly controlled experiments on chronic partial sleep restriction failed to support them.[10,12,15] The results of these more recent, scientifically controlled studies will be discussed in following sections.

Physiological Sleep Propensity During Sleep Restriction

The tendency to fall asleep is among the most well validated measures of sleepiness. It is based on the assumption that sleepiness is a physiologic need state that leads to an increased tendency to fall asleep, and it is operationalized as the speed of falling asleep in both sleep-conducive and nonconducive conditions.[21]

The effects of chronic sleep restriction on daytime physiological sleep propensity has been evaluated using the multiple sleep latency test (MSLT)[22] and the maintenance of wakefulness test (MWT).[23] During the MSLT, the subject is instructed to close the eyes and try to fall asleep, while lying supine for 20-min periods, two hours apart, four to five times throughout the day, while polysomnography (PSG) recordings are made (these include EEG, EOG, and EMG). The MWT uses a similar protocol to the MSLT, but subjects are seated upright and instructed to try to stay awake. The time taken to fall asleep on both tests is a measure of sleep propensity.

The MSLT has been shown to vary linearly following a single night of sleep restricted to between 1 and 5 h of time in bed.[24]

In addition, the MSLT showed progressive shortening (i.e., more sleep propensity) when healthy young adults were restricted to 5 h of sleep a night for 7 consecutive nights.[24] This seminal finding of sleep propensity increasing across days of sleep restriction was confirmed in a later study using the psychomotor vigilance task as a measure of daytime behavioral alertness.[15]

Dose-response effects of chronic sleep restriction on daytime sleep propensity have also recently been found in an experiment on the effects of reduced nocturnal sleep dosages on daytime sleep latencies of commercial truck drivers.[10] A significant increase in sleep propensity across 7 days of sleep restricted to either 3 or 5 h per night was observed, with no differences found when sleep was restricted to 7 or 9 h per night.[10] Sleep propensity, as measured by the MWT, has also been found to increase in experiments in which adults were restricted to 4 h for sleep for 7 nights[13,25] and for 5 nights.[13,25]

In an epidemiological study of predictors of objective sleep tendency in the general population,[26] a dose-response relationship was found between self-reported nighttime sleep duration and objective sleep tendency as measured by MSLT. Persons reporting >7.5 hours of sleep had significantly less probability of falling asleep on the MSLT than those reporting to between 6.75 to 7.5 h per night (27% risk of falling asleep) and than those reporting sleep durations less than 6.75 h per night (73% risk of falling asleep).[26] Consequently, to date, studies consistently suggest that chronic curtailment of nocturnal sleep increases daytime sleep propensity.

Sleep loss has also been found to affect oculomotor responses. Eyelid closure and slow rolling eye movements are part of the initial transition from wake to drowsiness and light sleep (i.e., stage 1 sleep). Eye movements and eye closures have been studied during sleep loss protocols, under the premise that increases in the number and duration of slow eye movements and slow eyelid closures are reflections of increased sleep tendency. It has been demonstrated experimentally that slow eyelid closures during performance demands reliably track lapses of attention on a vigilance task[27,28] and during simulated driving.[29,30] Chronic sleep restriction has been reported to lead to a decrease in saccadic velocity in subjects allowed only 3 h or 5 h of time in bed for sleep over 7 nights, and an increase in the latency to pupil constriction.[10] These changes in oculomotor activity were positively correlated with sleep latency, subjective sleepiness measures, and accidents on a simulated driving task.[31]

Effects of Sleep Reduction on Behavioral Alertness and Cognitive Performance

Restricted sleep time affects many different aspects of waking cognitive performance, but especially behavioral alertness.[32] Performance on psychomotor vigilance tasks requiring vigilant attention is very sensitive to sleep loss in general and sleep restriction in particular.[33,34] Many experiments have demonstrated that sleep deprivation increases behavioral lapses during performance,[33,34] which are assumed to reflect microsleeps.[35,36] As sleep loss continues, lapses can range in duration from 0.5 seconds to well over 10 sec, and they can progress to full blown sleep attacks (i.e., lapses from which subjects will not spontaneously arise without additional stimulation).[35,36] It has been hypothesized[37,38] that the lapses produced by sleep loss may originate in sleep-initiating subcortical systems (e.g., hypothalamus, thalamus, and brainstem).[39] This has been conceptualized as "wake state instability,"[33,34,37] which refers to moment-to-moment shifts in the relationship between neurobiological systems mediating wake maintenance and those mediating sleep initiation.[39,40] Behavioral alertness as measured by psychomotor vigilance tasks—or other sustained attention tasks—has proven to be very sensitive to sleep restriction.[35,37,38]

The 2 most extensively controlled experiments on chronic sleep restriction in healthy adults have found systematic evidence that behavioral alertness—as measured by psychomotor vigilance testing[35,36]—deteriorated steadily across days when nightly sleep duration was between 3 and 7 h,[10] with deterioration being more rapid as time allowed for sleep was reduced. In the experiment by Belenky and colleagues,[10] commercial truck drivers were kept in the laboratory for 14 d and randomized to seven nights of 3, 5, 7, or 9 h in bed for sleep per night. Those in the 3- and 5-h conditions had growing daytime deficits over the week in response to speed and number of lapses on the psychomotor vigilance task (PVT).[10] Subjects allowed 7 h/night had a significant decrease in PVT response speed. In contrast, performance in the group allowed 9 h time in bed was stable over the week. A similar experiment completed in our laboratory[12] kept healthy adults (mean age 28 y) in the laboratory for 20 days, randomizing them to either 4, 6, or 8 h time in bed per night for 14 consecutive nights. Psychomotor vigilance test performance and working memory performance were tested every 2 hours throughout each day. Cumulative daytime deficits in both PVT and cognitive throughput were observed for the 4- and 6-h sleep restriction conditions, but not the 8-h condition. In order to quantify the magnitude of cognitive deficits experienced during 14 days of restricted sleep, the effects of sleep restriction were compared to 1, 2, and 3 nights of total sleep deprivation.[12] This comparison revealed that both 4- and 6-h sleep periods resulted in the development of impairments of behavioral alertness that increased to levels found after 1, 2, and even 3 nights of total sleep deprivation.[12]

Figure 2 shows the number of PVT lapses per test bout each day from both of these controlled large-scale dose-response sleep-restriction experiments.[10,12] The remarkable similarity and internal consistency of the dependence of severity of PVT lapsing on the chronic sleep dose suggests that when the nightly sleep period is restricted to ≤7 h, healthy adults have increasing numbers of lapses of attention in proportion to the dose of sleep allowed (between subjects) and the number of days of sleep restriction (within subjects). A similar finding was observed for cognitive throughput performance on a working memory task,[12] which is shown in Figure 3.

The cognitive performance findings from these 2 major laboratory-based dose-response experiments on the effects of chronic sleep restriction in healthy adults are consistent with those on the effects of sleep restriction on physiological sleep propensity measures (MSLT, MWT) described above.[10,13,24,25] Collectively they suggest that there is a neurobiological integrator that either accumulates homeostatic sleep drive or the neurobiological consequences of excess wakefulness.[10,12] There has as yet been no definitive evidence of what is accumulating and destabilizing cognitive functions over time when sleep is regularly restricted to less than 7 hours per night, but one intriguing line of evidence suggests that it may involve extracellular adenosine in the basal forebrain.[41-43]

Although functional neuroimaging of cognitive changes produced by total sleep deprivation have been extensively studied,[44,45]

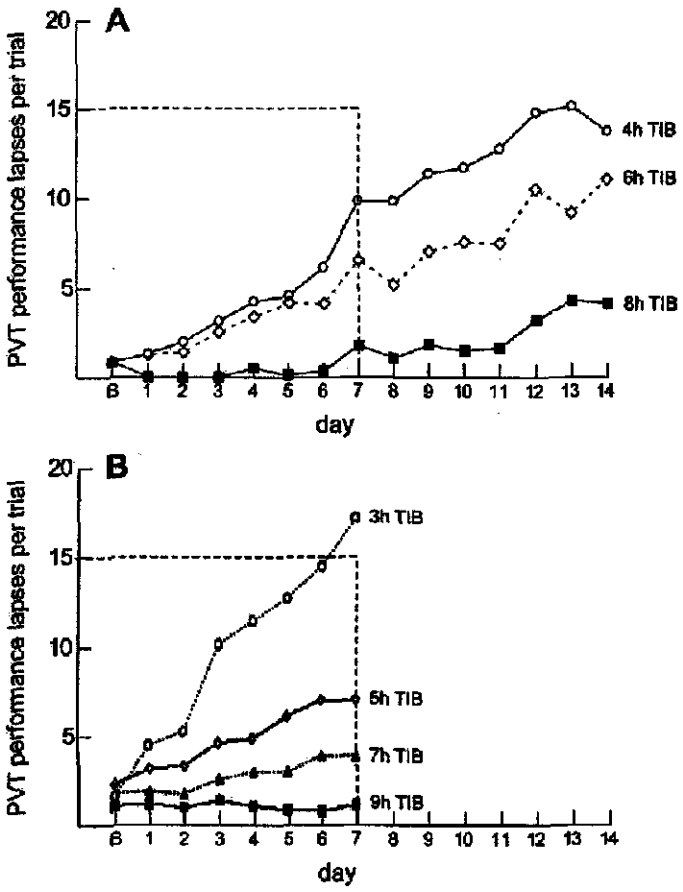

Figure 2—The effects of varying doses of nocturnal sleep time on lapses of attention from the psychomotor vigilance test (PVT). Panel A from Van Dongen et al. [12] involved experimental sleep restriction of n = 36 healthy adults for 14 consecutive nights. In this experiment sleep was restricted for 14 consecutive nights. Subjects were randomized to 4 h time in bed (n = 13), 6 h time in bed (n = 13), or 8 h time in bed (n = 9). PVT performance was assessed every 2 h (9 times each day) from 07:30 to 23:30. The graph shows systematic increases in lapses of sustained attention when sleep was restricted to either 4 h ($p < 0.001$) or 6 h ($p < 0.001$) per night, but not when sleep was restricted to 8 h per night ($p = 0.29$). *The increase in lapsing* was worse in the 4-h sleep condition than in the 6-h sleep condition ($p = 0.036$), further supporting a dose-response relationship within and between conditions. The horizontal dotted line shows the level of lapsing found in a separate experiment when subjects had been awake continuously for 64-88 h. For example, by day 7, subjects in the 6-h sleep restriction condition averaged 54 lapses (6 lapses x 9 test times) that day, while those in the 4-h sleep condition averaged 70 lapses that day. Panel B shows comparable sleep restriction data from Belenky et al.[10] In this study sleep was restricted for 7 consecutive nights in n = 66 healthy adults. They were randomized to 3 h time in bed (n = 13), 5 h time in bed (n = 13), 7 h time in bed (n = 13), or 9 h time in bed (n = 16). Performance was assessed 4 times each day from 09:00 to 21:00. PVT lapses increases steadily across days in the 3-h ($p = 0.001$) and 5-h ($p = 0.001$) sleep restriction conditions (PVT response speed, but not lapses, was reduced in the 7-h condition, not shown). As in Panel A, the horizontal dotted line shows the level of lapsing found in a separate experiment when subjects had been awake continuously for 64-88 h.[12] Considering data in both Panels A and B, it is clear that restriction of nocturnal sleep time to <7 h per night in healthy adults results in systematic increases in lapses of waking attention that get progressively worse across days, in a dose-response manner.

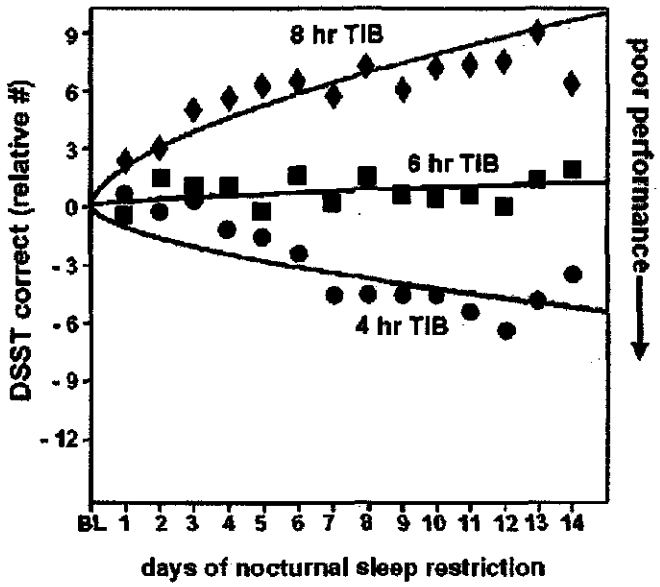

Figure 3—Digit symbol substitution task (DSST) performance responses to varying doses of daily sleep across 14 days. Data from n = 35 subjects (8h condition n = 9, 6h condition n = 13 and 4h condition n = 13). Mean DSST per day (07:30–23:30), measured at 2-h intervals expressed relative to baseline (BL). The curves represent statistical nonlinear model-based best-fitting profiles of the DSST performance response to sleep loss. Adapted from Van Dongen et al.[12]

there are as yet no experimental reports on the effects of chronic sleep restriction on brain activation. While the neurobehavioral effects of chronic sleep restriction appear similar to those of total sleep deprivation,[12] the primary physiologic measure of homeostatic sleep—slow wave activity in the spectrally analyzed NREM EEG—shows a much more muted response to the former than to the latter, suggesting that there may be a different neurobiological mechanisms sub-serving the adverse effects of chronic sleep restriction.

Sleep Restriction Effect on Subjective Reports of Sleepiness and Mood

Like NREM SWA, subjective sleepiness responses during chronic sleep restriction show a different dynamic profile than those found for total sleep deprivation. While the latter results in immediate increases in feelings of sleepiness, fatigue and cognitive confusion, with concomitant decreases in vigor and alertness[21,35,36,38,46,47] chronic sleep restriction yields much smaller changes in these psychometric ratings of internal state.[10,12] Thus, in contrast to the continuing accumulation of cognitive performance deficits associated with nightly restriction of sleep <8 h, ratings of sleepiness repeatedly made by subjects on standardized sleepiness scales did not parallel performance deficits.[12] As a consequence, after a week or two of sleep restriction, subjects were markedly impaired and less alert, but rated themselves subjectively as only moderately sleepy (see Figure 4). This suggests that people frequently underestimate the cognitive impact of sleep restriction and overestimate their performance readiness when sleep restricted. Other experiments using driving simulators have found comparable results.[48]

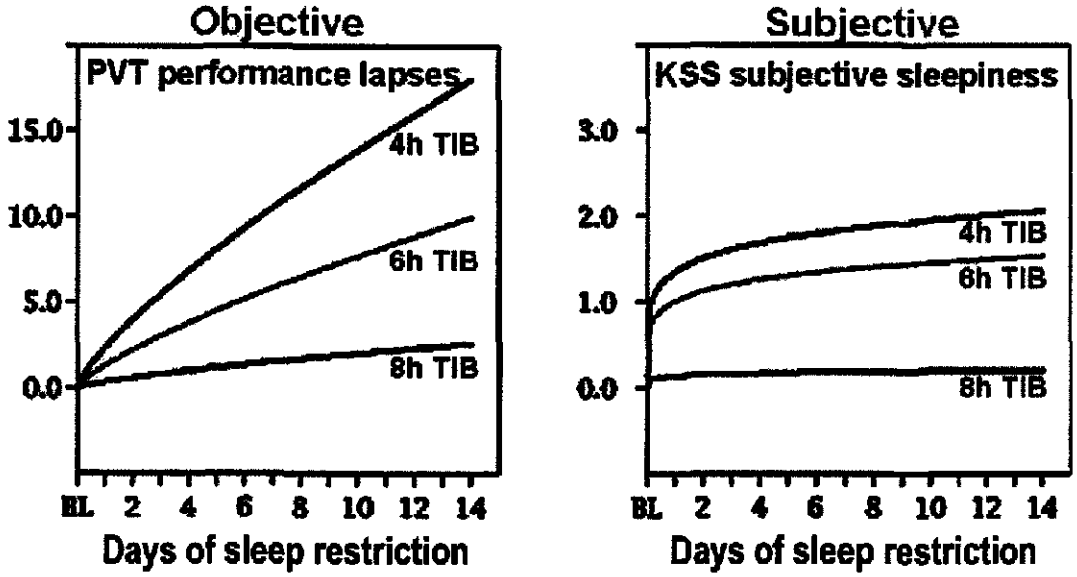

Figure 4—Data from n = 35 subjects (8h condition n = 9, 6h condition n = 13 and 4h condition n = 13). Restriction of nocturnal sleep in healthy adults resulted in near-linear increases in Psychomotor Vigilance Test (PVT) lapses of attention across 14 days (coefficients of change near 1.0), but subjective ratings of sleepiness and fatigue (regardless of the psychometric scale used) showed a nonlinear coefficient below 0.5 for change over days. This meant that as objective performance continued to decline near-linearly, there were only minor further increases in the subjective ratings of sleepiness. By the end of the 14 days of sleep restriction, when performance was at its worst levels, subjects in the 4-h and 6-h sleep period conditions reported feeling only slightly sleepy. Therefore, unlike performance measures, sleepiness ratings appeared to show adaptation to chronic partial sleep deprivation. The lack of reports of intense feelings of sleepiness during chronic sleep restriction may explain why sleep restriction is widely practiced—people have the subjective impression they have adapted to it because they do not feel particularly sleepy. Adapted from Van Dongen et al.[12]

Driving and Simulated Driving Following Sleep Reduction

One real-world risk associated with sleep restriction is decreased driving ability. Studies have primarily focused on the effects of short-term sleep restriction on driving ability and crash risk.[49,50] An epidemiological study found an increased incidence of sleep-related crashes in drivers reporting <7 h of sleep per night on average.[51] Additional contributing factors to these crashes included poor sleep quality, dissatisfaction with sleep duration (i.e., undersleeping), daytime sleepiness, previously driving drowsy, amount of time driving and time of day (i.e., driving late at night). Studies have also examined the effects of sleep restriction on performance on various driving simulators. It has been found that driving performance decreased (e.g., more crashes) and subjectively reported sleepiness increased when sleep was restricted to between 4 and 6 h per night.[31,48,52-57]

Individual Differences in Responses to Sleep Restriction

Interindividual variability in sleep and circadian parameters are substantial, and this is equally the case for neurobehavioral and physiological responses to sleep deprivation.[4,21,31,35-38,46,47] Sleep loss not only increases cognitive performance variability within subjects (intrasubject variability that is characterized as state instability),[21,35,36,38,46,47] but it also exposes marked neurobehavioral differences between subjects. That is, as sleep loss continues over time, intersubject differences in the degree of cognitive deficits also increase markedly.[31,37] This interindividual variability is also seen in responses to experimentally restricted sleep. For example, while sleep duration limited to less than 7 h per day resulted in cumulative cognitive performance deficits in a majority of healthy adults,[10,12] not everyone was affected to the same degree.[10,12] At opposite ends of the spectrum are those who experience very severe impairments even with modest sleep restriction versus those who show few if any neurobehavioral deficits until sleep restriction is severe (in duration or chronicity). Moreover, there is some data to suggest that the nature of the cognitive impairments can be quite different among subjects for different cognitive tasks,[9,58] such that those with increasing problems performing working memory tasks may not have problems with psychomotor vigilance. Recently, and perhaps most importantly for future studies of the possible genetic contributors to differential vulnerability to sleep loss, is the finding that the neurobehavioral responses to sleep deprivation were stable and reliable within subjects,[59] suggesting they were trait-like.[58,59] The biological bases of differential responses to sleep loss are not known, although recent neuroimaging studies suggest that it may be possible to predict them before subjects are deprived of sleep.[45,60,61]

In summary, when sleep duration in healthy adults was experimentally reduced <7 h per night, many waking neurobehavioral functions progressively deteriorated. A range of cognitive tasks (e.g., decision making) and normal daily behaviors (e.g., driving) were adversely affected by reduced sleep time.[35,38,46,47,50] These adverse neurobehavioral effects of sustained sleep restriction have the potential to lower productivity and increase the risks for errors and accidents.

PHYSIOLOGICAL CONSEQUENCES OF SLEEP RESTRICTION

As noted above, recent epidemiological studies have found that both relatively long sleepers (≥8 h sleep per day) and relatively short sleepers (<7 h sleep per day) had increased risks of all-cause mortality.[5,62,63] There is also epidemiological evidence that reduced sleep duration is associated with larger body mass

index (BMI).[64,65] Laboratory studies of experimental restricted sleep in healthy adults suggest some mechanisms by which sleep duration may influence obesity, morbidity, and mortality.

A range of physiological indices have been found to be altered by reduced sleep time. While the clinical significance of these findings in healthy adults is unknown, the indices affected have been related to health outcomes in patient populations. Several studies have reported an increased incidence and risk of medical disorders and health dysfunction related to shift work schedules, which have been attributed to both circadian disruption and sleep disturbance (for review, see [66]). Short-term sleep restriction results in a number of abnormal physiologic changes, including reduced glucose tolerance,[67] increased blood pressure,[68] activation of the sympathetic nervous system,[69] reduced leptin levels,[70] and increased inflammatory markers.[71] Although the magnitude of the physiologic changes found in these short-term studies was modest, the changes provide a potential mechanism whereby long-term sleep restriction may affect health.

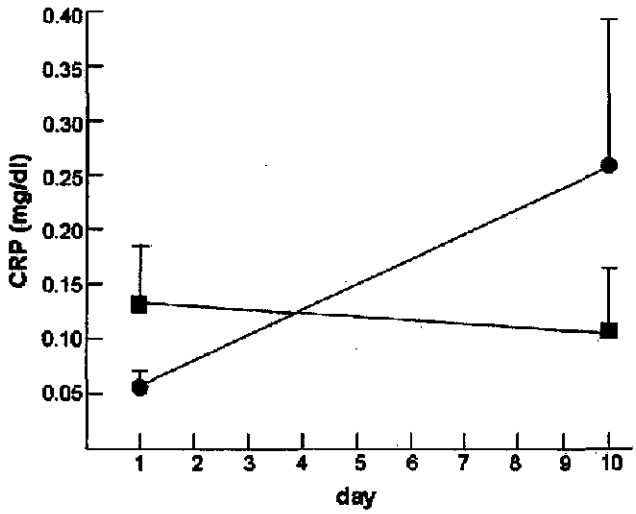

Figure 5—Mean (SEM) plasma high-sensitivity C-reactive protein (CRP) in n = 4 subjects undergoing 10 consecutive nights of sleep restricted to 4.2 h time in bed, and in n = 5 control subjects who had 10 consecutive nights of sleep restricted to 8.2 h time in bed (closed squares). Significance of difference in change from baseline to day 10 between groups ($p = 0.08$ for interaction) by mixed-models analysis of variance on log-transformed data: the change from baseline to day 10 for the 4-h sleep restriction group was significant ($p = 0.05$), whereas the change from baseline to day 10 in the 8-h control group was not ($p = 0.72$). Figure adapted from Meier-Ewert et al.[71]

Endocrine Responses

A number of recent studies have focused on endocrine and metabolic consequences of chronic sleep restriction. Comparison of sleep restriction (4 h/night for 6 nights) to sleep extension (12 h/night for 6 nights) in healthy young adults revealed an elevation in evening cortisol, increased sympathetic activation, decreased thyrotropin activity, and decreased glucose tolerance in the restricted versus extended sleep condition.[67] Similarly, an elevation in evening cortisol levels, and advance in the timing of the morning peak in cortisol, so that the relationship between sleep termination and cortisol acrophase was maintained, was found following 10 nights of sleep restricted to 4.2 h time in bed for sleep each night compared to baseline measures and a control group allowed 8.2 h time in bed for sleep for 10 nights.[72] In the same protocol, a significant delay in melatonin onset[73] and in the timing of the peak in growth hormone, equivalent to the delay in sleep onset induced to achieve the restricted sleep period, were found, with no effect on growth hormone levels during the sleep period.[74]

Changes in the timing of the growth hormone secretory profile associated with sleep restriction to 4 h per night for 6 nights, with a bimodal secretory pattern have also been reported.[75] Decreased leptin levels (adipocyte-derived hormone that suppresses appetite) and increased ghrelin (predominantly a stomach-derived peptide that stimulates appetite) have been reported when sleep was restricted to 4 h a night relative to a 12-h control condition.[70,76] These effects are similar to what has been found for total sleep deprivation.[77] Thus, it is possible that sleep restriction produces alterations in the secretory profiles of appetite-regulating hormones, which in turn alter the signaling of hunger and appetite and promote increased weight gain and obesity.[76]

The possibility that sleep restriction may be associated causally with obesity by altered regulation of appetite-regulating hormones has also been suggested by findings of a study of 1,024 volunteers from the Wisconsin Sleep Cohort Study—a population-based longitudinal study of sleep disorders.[64] In this study, participants underwent nocturnal polysomnography and reported on their sleep habits through questionnaires and sleep diaries. Following polysomnography, morning fasted blood samples were evaluated for serum leptin, ghrelin, adiponectin, insulin, glucose, and lipid profile. Relationships among these measures, BMI, and sleep duration revealed a curvilinear (U-shaped) association between sleep duration and BMI. In persons sleeping <8 hours (74.4% of the sample), increased BMI was proportional to decreased sleep duration. Short sleep was associated with low leptin and high ghrelin independent of BMI. Since reduced leptin and elevated ghrelin are likely to increase appetite, this may explain the increased BMI observed with short sleep duration and how chronic sleep curtailment could contribute to obesity.[13]

Immune Responses

The potential impact of chronic sleep restriction on immune responses has received little attention, although total sleep deprivation has been shown to activate non-specific host defense mechanisms and to elevate certain inflammatory cytokines (IL-6, TNF) in healthy young adults.[78,79] Although the effects of sleep restriction on cellular and humoral immune responses are largely unexplored, antibody production to vaccination has been reported to be decreased by sleep restriction. In one study it was reported that antibody titers were decreased by more than 50% 10 days post-vaccination for influenza.[80] Subjects had been vaccinated immediately following 6 nights of sleep restricted to 4 h per night compared to those who were vaccinated following habitual sleep duration. By 3-4 weeks post-vaccination, there was no difference in antibody levels between the 2 groups. In a another study, attenuation of the febrile response to an endotoxin (E. coli) challenge in subjects undergoing chronic sleep restriction to 4 h/night for 10 nights (relative to subjects allowed 8 h for sleep) was observed.[81]

These two limited studies suggest that sleep restriction alters the acute immune response to vaccination, and decreases the febrile response to an endotoxin signal.

In a third experiment in which healthy young adults had their sleep restricted to 6 h per night, the 24-h secretory profile of IL-6 was increased in both sexes and TNF-alpha was increased in men.[82] Both IL-6 and TNF-alpha are markers of systemic inflammation that may lead to insulin resistance, cardiovascular disease and osteoporosis.[83]

Cardiovascular Responses

An increase in cardiovascular events and cardiovascular morbidity associated with reduced sleep durations has been reported in a number of epidemiological studies[5,62,84-87] and in a case-control study examining insufficient sleep due to work demands.[88] In the Nurses' Health Study, there was evidence of increased risk of coronary events in female subjects obtaining ≤7 h sleep per night compared to those averaging 8 h per night.[62] In another epidemiological study, a 2-3–fold increase in risk of cardiovascular events was found for subjects with an average sleep duration of ≤5 h per night (or chronically having <5 h of sleep per night at least twice per week) was reported.[88] Similar findings have also been observed in studies examining cardiovascular health in shift workers, who typically experience chronic reductions in sleep duration, in addition to circadian disruption.[89-92]

The mechanisms underlying the link between chronic sleep restriction and increased cardiovascular risk are unknown; however, one potential mechanism may be by activation of inflammatory processes during sleep loss, as described above. C-reactive protein (CRP) is an inflammatory marker that is positive predictor of increased risk for cardiovascular disease.[93] We have found that high-sensitivity CRP was increased in healthy adults following both total sleep deprivation and chronic sleep restriction.[71] Figure 5 illustrates these findings. It remains to be determined how chronic sleep restriction activates mechanisms involved in cardiovascular morbidity and mortality, but elevated CRP may be a link.

CONCLUSION

Restricted sleep time—particularly when chronic can cause significant and cumulative neurobehavioral deficits and physiological changes, some of which may account for the epidemiological findings that reduced sleep durations are associated with obesity, cardiovascular morbidity, traffic accidents and death. Recent careful controlled experiments in healthy adults reveal that as sleep was repeatedly restricted to less than 7 h per night, significant daytime cognitive dysfunction (i.e., state instability, reduced vigilant attention and working memory) accumulated as restriction continued to levels comparable to that found after severe acute total sleep deprivation. This strongly suggests the existence of a neurobiological integrator in the brain that instantiates either the need for sleep across days or the accumulation of excess wakefulness. These experiments also reveal that individuals differ markedly in their cognitive vulnerabilities to sleep restriction, which suggests a trait-like (possibly genetic) basis for the response. Research also demonstrates that experimentally induced chronic sleep restriction results in several adverse physiologic consequences, including reduced glucose tolerance, increased blood pressure, and increased inflammatory markers in healthy adults. Consistent with these reports are epidemiologic studies that find self-reported short sleep duration is associated with obesity, heart disease, and mortality. Thus, current research findings on the effects of sleep restriction on neurobehavioral and physiological functioning suggest that adequate sleep duration (7-8 hours per night) is vital.

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Perception and annoyance due to wind turbine noise—a dose–response relationship

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Installed global wind power increased by 26% during 2003, with U.S and Europe accounting for 90% of the cumulative capacity. Little is known about wind turbines' impact on people living in their vicinity. The aims of this study were to evaluate the prevalence of annoyance due to wind turbine noise and to study dose–response relationships. Interrelationships between noise annoyance and sound characteristics, as well as the influence of subjective variables such as attitude and noise sensitivity, were also assessed. A cross-sectional study was performed in Sweden in 2000. Responses were obtained through questionnaires ($n=351$; response rate 68.4%), and doses were calculated as A-weighted sound pressure levels for each respondent. A statistically significant dose–response relationship was found, showing higher proportion of people reporting perception and annoyance than expected from the present dose–response relationships for transportation noise. The unexpected high proportion of annoyance could be due to visual interference, influencing noise annoyance, as well as the presence of intrusive sound characteristics. The respondents' attitude to the visual impact of wind turbines on the landscape scenery was found to influence noise annoyance.
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I. INTRODUCTION

Wind turbines generate renewable energy and thus contribute to sustainable development. However, disturbance from wind turbines may be an obstacle for large-scale production (Rand and Clarke, 1990; Ackerman and Söder, 2000). Few studies have so far been directed to the prevalence of disturbance, and existing knowledge of annoyance due to wind turbines is mainly based on studies of smaller turbines of less than 500 kW (Wolsink *et al.*, 1993; Pedersen and Nielsen, 1994).

Global wind power installed at the end of 2003 reached 39 GW according to American Wind Energy Association (2004), an increase of 26% in just one year. United States (7 GW) and Europe (29 GW) account for 90% of the cumulative capacity. In Sweden, more than 600 wind turbines are operating today with a total installed capacity of 0.4 GW, producing 600 GWh per year. They are placed in 84 of Sweden's 290 municipalities both along the coasts and in rural inland areas, concerning a number of people. The goal set up by the Swedish government for 2015 is 10 TWh, leading to an increase of 1600% from today. Most of these new turbines will probably be situated off shore, but as the cost for building on land is considerably lower, the development on land is expected to continue. Already, turbines are being erected near densely populated areas. Preliminary interviews conducted among 12 respondents living within 800 m of a wind turbine, and a register study of the nature of complaints to local health and environments authorities, indicated that the main disturbances from wind turbines were due to noise, shadows, reflections from rotor blades, and spoiled views (Pedersen, 2000).

All wind turbines in Sweden are upwind devices. The most common type is a 600 or 660 kW turbine with three rotor blades, rotor diameter 42–47 m, constant rotor speed 28 rpm (84 blade passages per minute, a blade passage frequency of 1.4 Hz), and hub height of 40–50 m. They often operate singly or in multiple units of 2 to 10. The noise emission at the hub is 98–102 dBA measured at wind velocity 8 m/s at 10 m height. Earlier turbines were often downwind devices and contained low-frequency noise (Hubbard *et al.*, 1983). In contrast to these, modern machines have the rotor blades upwind and the noise is typically broadband in nature (Fig. 1), (Persson Waye and Öhrström, 2002; Björkman, 2004). There are two main types of noise sources from an upwind turbine: mechanical noise and aerodynamic noise. Mechanical noise is mainly generated by the gearbox, but also by other parts such as the generator (Lowson, 1996). Mechanical noise has a dominant energy within the frequencies below 1000 Hz and may contain discrete tone components. Tones are known to be more annoying than noise without tones, but both mechanical noise and tones can be reduced efficiently (Wagner *et al.*, 1996). Aerodynamic noise from wind turbines has a broadband character. It originates mainly from the flow of air around the blades; therefore the sound pressure levels (SPLs) increase with tip speed. Aerodynamic noise is typically the dominant component of wind turbine noise today, as manufacturers have been able to reduce the mechanical noise to a level below the aerodynamic noise. The latter will become even more dominant as the size of wind turbines increase, because mechanical noise does not increase with the dimensions of turbine as rapidly as aerodynamic noise (Wagner *et al.*, 1996).

Previous international field studies of annoyance from wind turbines have generally found a weak relationship between annoyance and the equivalent A-weighted SPL (Rand

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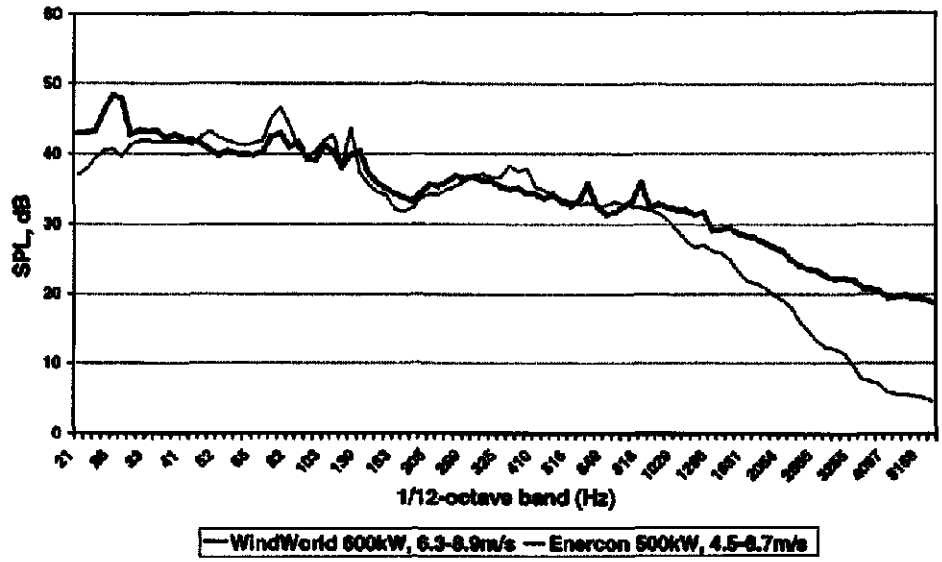

FIG. 1. Frequency spectra of two upwind three-bladed wind turbines recorded at down wind conditions; WindWorld 600 kW and Enercon 500 kW.

and Clarke, 1990; Wolsink *et al.*, 1993; Pedersen and Nielsen, 1994). It is possible that different sound properties, not fully described by the equivalent A-weighted level, are of importance for perception and annoyance for wind turbine noise. Support for such a hypothesis was given in a previous experimental study where reported perception and annoyance for five recorded wind turbine noises were different, although the equivalent A-weighted SPL were the same (Persson Waye and Öhrström, 2002). The results from that study and subsequent experiments suggested that the presence of sound characteristics subjectively described as lapping, swishing, and whistling was responsible for the differences in perception and annoyance between the sounds (Persson Waye and Agge, 2000). The descriptions swishing and whistling were found to be related to the frequency content in the range of 2000 to 4000 Hz (Persson Waye *et al.*, 1998) while the description lapping probably referred to aerodynamically induced fluctuations and was found to best be described by specific loudness over time (Persson Waye *et al.*, 2000). Sound characteristics such as described here could be of relevance for perception and annoyance, especially at low background levels.

It has been suggested that the perception of wind turbine noise could be masked by wind-generated noise. However, most of the wind turbines operating today have a stable rotor speed, and, as a consequence, the rotor blades will generate an aerodynamic noise even if the wind speed is slow and the ambient noise is low. Furthermore, noise from wind turbines comprises modulations with a frequency that corresponds to the blade passage frequency (Hubbard *et al.*, 1983) and is usually poorly masked by ambient noise in rural areas (Arlinger and Gustafsson, 1988).

It has also been shown in previous field studies that attitude to wind turbines is relevant to perceived annoyance (Wolsink *et al.*, 1993; Pedersen and Nielsen, 1994). Such a relationship, however, was not found in an experimental study where the participants were exposed to wind turbine noise (Persson Waye and Öhrström, 2002). The difference could be due to the fact that the subjects in the latter study had very little personal experience of wind turbines generally, or to their lack of visual impression during the noise exposure.

There is clearly a need for field studies to investigate the impact of wind turbines on people living in their vicinity and to further explore the presence of disturbances. In particular, dose–response relationships should be investigated to achieve a more precise knowledge of acceptable exposure levels. As noise annoyance may be interrelated to the presence of intrusive sound characteristics, ambient sound pressure level, and visual intrusion as well as individual variables, all these factors should be taken into account and their relative importance evaluated.

The aims of this study were to evaluate the prevalence of annoyance due to wind turbine noise and to study dose–response relationships. The intention was also to look at interrelationships between noise annoyance and sound characteristics, as well as the influence of subjective variables such as attitude and noise sensitivity.

II. METHOD

A. General outline

The investigation was a cross-sectional study comprising respondents exposed to different A-weighted sound pressure levels (SPL) from wind turbines. Five areas totaling 22 km^2 comprising in total 16 wind turbines and 627 households were chosen within a total area of 30 km^2 (Table I). Subjective responses were obtained through questionnaires delivered at each household and collected a week later in May and June 2000. The response rate was 68.4%. A-weighted SPLs due to wind turbines were calculated for each respondent's dwelling. Comparisons were made of the extent of annoyance between respondents living at different A-weighted SPLs.

B. Study area and study sample

The criteria for the selection of the study areas were that they should comprise a large enough number of dwellings at varying distances from operating wind turbines within a

TABLE I. Description of study areas.

Area	Square km	Wind turbines	Households	Study population	Responses	Response rate (%)
A	3.7	2	89	75	54	72.0
B	4.7	3	44	33	23	69.7
C	8.3	8	70	59	49	83.1
D	3.3	2	393	325	210	64.6
E	2.0	1	31	21	15	71.4
Total	22.0	16	627	513	351	68.4

comparable geographical, cultural, and topographical structure. Suitable areas were found in a municipality in the south of Sweden. More than 40 wind turbines are located in this region, either in small groups with two to five turbines or as single objects. The landscape is flat and mainly agricultural but small industries, roads, and railroads are also present. Most people live in privately owned detached houses in the countryside or in small villages. The wind turbines are visible from many directions. To define the study area, preliminary calculations of sound distribution were made so that the area would include dwellings exposed to similar A-weighted SPL irrespective of the number of wind turbines. Of the 16 wind turbines in the selected five areas, 14 had a power of 600–650 kW, the other two turbines having 500 kW and 150 kW. The towers were between 47 and 50 m in height. Of the turbines, 13 were WindWorld machines, 2 were Enercon, and 1 was a Vestas turbine. Figure 1 shows a $\frac{1}{12}$-octave band spectra of a WindWorld turbine sound recorded 320 m from a turbine in area A at 6.3–8.9 m/s and a spectra of an Enercon turbine sound recorded 370 m from the turbine in area E at 4.5–6.7 m/s. Both recordings were done under downwind conditions.

The study sample comprised one selected subject between the ages of 18 and 75 in each household in the area within a calculated wind turbine A-weighted SPL of more than 30 dB ($n=513$). The subject with birth date closest to May 20 was asked to answer a questionnaire.

C. Questionnaire

The purpose of the study was masked in the questionnaire; the questions on living conditions in the countryside also included questions directly related to wind turbines. The response of most questions was rated on 5-point or 4-point verbal rating scales. The key questions relevant for this paper were translated into English and are presented in the Appendix. The questionnaire was divided into four sections. The first section comprised questions regarding housing and satisfaction with the living environment, including questions on the degree of annoyance experienced outdoors and indoors from several sources of annoyance, wind turbines included. The respondent was also asked to rate his/her sensitivity to environmental factors, one being noise.

The second section of the questionnaire comprised questions on wind turbines, related to the respondent by the recent development of wind turbines in the community. The response to different visual and auditory aspects of wind turbines as noise and shadows were asked for, followed by questions on frequency of disturbances and experiences during certain activities and weather conditions. Respondents were also asked to describe their level of perception and annoyance related to the wind turbine sounds they could hear, using verbal descriptors of sound and perceptual characteristics. These descriptors were obtained from previous experimental studies were subjects initially verbally described their perception of annoying sound properties for five recorded wind turbine sounds (Persson Waye and Öhrström, 2002). This, together with some given adjectives, resulted in a total of 14 adjectives that were rated on unipolar scales with regard to annoyance. In this field study, the original descriptors were complemented with regionally used phrases. Several questions on attitude to wind turbines were also included.

The third section of the questionnaire concerned health aspects such as chronic illnesses (diabetes, tinnitus, cardiovascular diseases, hearing impairment) and general well-being (headache, undue tiredness, pain and stiffness in the back, neck or shoulders, feeling tensed/stressed, irritable). Respondents were asked questions about their normal sleep habits: quality of sleep, whether sleep was disturbed by any noise source, and whether they normally slept with the window open. The last section comprised questions on employment and working hours.

D. Calculations and measurements of noise exposure

For each respondent, A-weighted SPLs (dB) were calculated as the sum of contributions from the wind power plants in the specific area. The calculations were made with calculation points every fifth meter. The calculations followed the sound propagation model for wind power plants adopted by the Swedish Environmental Protection Agency (2001) and used as a basis for granting of building permission. The model assumes downward wind of 8 m/s at 10-m height. The calculation model is slightly different depending on the distance between the source and the receiver. For the cases in this study the following equation was used:

$$L_A = L_{WA,corr} - 8 - 20\lg(r) - 0.005r, \quad (1)$$

where r is the distance from the source to the receiver in meters. The atmospheric absorption coefficient is estimated to be 0.005 dB/m. $L_{WA,corr}$ is a modified sound power level of the wind power:

$$L_{WA,corr} = L_{WA} + k \cdot \Delta v_h. \quad (2)$$

TABLE II. Study sample, study population, and response rate related to sound category (dBA).

Sound category	<30.0	30.0–32.5	32.5–35.0	35.0–37.5	37.5–40.0	>40.0	Total
Study sample	25	103	200	100	53	32	513
Study population	15	71	137	63	40	25	351
Response rate	60.0%	68.9%	68.5%	63.0%	75.5%	78.1%	68.4%

L_{WA} is the A-weighted sound power level of the wind power plant, which in this study was given by the manufacturer; k describes how the sound power level varies with the wind speed at 10 m height and

$$\Delta v_h = v_h\left(\frac{\ln(H/z_0)}{\ln(h/z_0)}\frac{\ln(h/0.05)}{\ln(H/0.05)} - 1\right), \tag{3}$$

where v_h is the wind speed at 10-m height, H the height of the hub, h is 10 m, and z_0 the surface roughness length. In these calculations, $z_0 = 0.05$ m (fields with few buildings) was used and therefore no value of k was needed. The SPL calculated this way is an estimate for the equivalent level for a hypothetical time period with continuous performance at downwind conditions 8 m/s at 10-m height.

To verify the calculations, to record frequency spectra, and to study background sound, a mobile caravan equipped with a sound level meter (Larson & Davis type 820), digital audio tape recorder (Sony TCD-D8 DAT), and meteorological instruments (Davis Weather Monitor type II) was used. The mobile station was placed on different sites of the study area. Both the meteorological instruments and the noise recording instruments were computer controlled and directed remotely via a cellular phone. The microphone was attached on a vertical hardboard facing the noise source. The equipment and procedures are thoroughly described by Björkman (2004). The sound pressure levels measured on the reflecting plane were corrected by −6 dB to present the free field value. The ambient sound pressure level varied from 33 dB $L_{\text{Aeq,5 min}}$ to 44 dB $L_{\text{Aeq,5 min}}$. The variations were mainly due to the amount of traffic within a 24-h time period. The lower background levels typically occurred during evening and nights.

The respondents were classified into six sound categories according to the calculated wind turbine A-weighted SPL at their dwelling. Table II shows the number of respondents living within each sound category and also the study sample and response rate for each sound category.

Data for the distance between the dwelling of the respondent and the nearest wind turbine were obtained from property maps, scale 1:10 000. The distance differed within each sound category, depending on the number of wind turbines in the area—the larger number of wind turbines, the shorter distance at the same A-weighted SPL. Table III shows the relationship between distance and A-weighted SPL. Two values are given for each category: the range and the median interval.

E. Statistical treatment of data

Due to the fact that most of the data were categorical (ordered or nonordered) and not continuos data, and therefore no assumptions on probability distribution could be made, nonparametric statistical methods were used, all described by Altman (1991). Data from verbal rating scales were calculated as proportions with 95% confidence intervals. When relevant, the two highest ratings of annoyance (rather annoyed and very annoyed) were classified as annoyed and the three lower ones as not annoyed (do not notice, notice but not annoyed, and slightly annoyed). In the analysis of attitude, negative and very negative were classified as negative; in the analysis of sensitivity, rather sensitive and very sensitive were classified as sensitive. More advanced statistical analyses were carried out using SPSS version 11.0. Relationships between variables were evaluated using Spearman's nonparametric rank correlation (r_s). Pearson's chi-square (chi2) was used to test that all sound categories contained the same proportion of observations. To evaluate differences between two unmatched samples of observations on an ordinal scale (e.g., comparing men and women's answers on a 5-graded verbal rating scale), the Mann–Whitney test was used (z_{MW}); a nonparametric test equivalent to the t test, but based on ranks (Altman, 1991). All significance tests were two-sided and p-values below 0.05 were considered statistically significant. When exploring several relationships at the same time, 1 out of 20 calculations would be classified as statistically significant by chance. This risk of mass significance was avoided using Bonferroni's method when appropriate, reducing the p-value considered statistically significant by dividing it with the number of correlations calculated at the same time (Altman, 1991).

Binary logistic multiple regression was used to study the impact of different variables on annoyance of wind turbine noise (annoyed–not annoyed). Sound category was used as the dose variable. Logistic regression is a method used to make a nonlinear function into a linear equation, using odds rather than straightforward probability. The equation is

TABLE III. Distance between dwelling and nearest wind turbine related to sound category (dBA).

Sound category	<30.0	30.0–32.5	32.5–35.0	35.0–37.5	37.5–40.0	>40.0
Range (m)	650–1049	550–1199	450–1099	300–799	300–749	150–549
Median interval (m)	850–899	750–799	550–599	450–499	350–399	300–349

TABLE IV. Characteristics of the respondents given as proportions of respondents in each sound category (dBA) and in total.

Sound category	<30.0	30.0–32.5	32.5–35.0	35.0–37.5	37.5–40.0	>40.0	Total
n	15	71	137	63	40	25	351
Gender: Male (%)	27	35	39	50	50	48	42
Residence: Detached houses/farms (%)	100	83	61	100	97	96	81
Occupation: Employed (%)	67	59	58	53	69	67	60
Sensitive[a] to noise (%)	62	44	49	53	58	50	50
Negative[b] to wind turbines (%)	8	10	11	18	20	8	13
Negative[b] to visual impact (%)	43	33	38	41	40	58	40
Long-term illness (%)	20	29	28	16	30	24	26
Age: Mean	46	47	47	50	48	48	48
(SD)	(13.3)	(13.7)	(14.3)	(14.6)	(13.1)	(14.3)	(14.0)

[a]Sensitive consists of the two ratings: rather sensitive and very sensitive.
[b]Negative consists of the two ratings: rather negative and very negative.

$$\ln\left(\frac{p}{1-p}\right)=b_0+b_1x_1+b_2x_2+\cdots, \quad (4)$$

where, in this case, p is the probability of being annoyed by noise from wind turbines, x_1-x_n are the variables put into the model, and b_1-b_n are the logarithmic value of the odds ratio for one unit change in the respective variable (Altman, 1991). A relevant measurement of explained variance using nonparametric statistics is Nagelkerke pseudo-R^2 (Nagelkerke, 1991).

To estimate how consistently the respondents answered to questions measuring similar response, Cronbach's alpha (Miller, 1995) was calculated as a testing of the internal consistency reliability of the questionnaire. Five of the questions regarding wind turbine noise were compared: annoyance outdoors, annoyance indoors, annoyance of rotor blades, annoyance of machinery, annoyance as a describing adjective. Demographic data on age and gender of the population in the four parishes in the study area were collected from local authorities. The study population was compared to these demographical data, parish-by-parish, and divided into 10-year categories for age and gender, as well as in total.

III. RESULTS

A. Study population

The overall response rate was 68.4%, ranging from 60.0% to 78.1% in the six sound categories (Table II). No statistically significant differences in variables related to age, gender, or employment were found among sound categories (Table IV). A statistically significant difference was found between sound categories as to whether respondents lived in apartments or detached houses (chi2=62.99, df=5, $p<0.001$). Overall, most of the respondents (80%) lived in privately owned detached houses or on farms. The remaining lived in tenant-owned or rented apartments. The latter were more frequent in sound category 32.5–35.0 dBA (Table IV). However, there was no statistically significant difference between the respondents living in privately owned detached houses or on farms, on one hand, and those living in tenant-owned or rented apartments, on the other hand, regarding subjective factors, when correcting for requirements to avoid mass significance. Most of the respondents did not own a wind turbine or share of a wind turbine (95%, $n=335$). No statistically significant differences in variables related to noise sensitivity, attitude, or health were found between the different sound categories.

The mean age in the study population was 48 years (SD =14.0) (Table IV) which did not differ statistically significantly from the demographic data (45 years, SD=15.2). The proportion of women in the study population was slightly higher than in the demographic data; in the study population, 58% women and 42% men (Table IV), compared to 49% women and 51% men in the demographic data. However, no statistically significant differences were found between men and women regarding perception and annoyance due to wind turbine noise, noise sensitivity, or attitude to wind turbines. Differences between genders were found regarding well-being. Women suffered more often from headache ($z_{MW}=-3.243$, $n=328$, $p<0.001$), undue tiredness ($z_{MW}=-3.549$, $n=327$, $p<0.05$), pain and stiffness in back, neck or shoulders ($z_{MW}=-3.312$, $n=331$, $p<0.001$), and tension/stress ($z_{MW}=-3.446$, $n=328$, $p<0.001$).

B. Main results

The proportion of respondents who noticed noise from wind turbines outdoors increased sharply from 39% ($n=27$, 95%CI: 27%–50%) at sound category 30.0–32.5 dBA to 85% ($n=53$, 95%CI: 77%–94%) at sound category 35.0–37.5 dBA (Table V). The proportion of those annoyed by wind turbine noise outdoors also increased with higher sound category, at sound categories exceeding 35.0 dBA. The correlation between sound category and outdoor annoyance due to wind turbine noise (scale 1–5) was statistically significant ($r_s=0.421$, $n=341$, $p<0.001$). No respondent self-reported as annoyed at sound categories below 32.5 dBA, but at sound category 37.5–40.0 dBA, 20% of the 40 respondents living within this exposure were very annoyed and above 40 dBA, 36% of the 25 respondents (Table V).

To explore the influence of the subjective factors on noise annoyance, binary multiple logistic regression was used (Table VI). Eight models were created, all containing sound category as the prime variable assumed to predict noise annoyance. The three subjective factors of attitude to visual impact, attitude to wind turbines in general, and sensitivity to noise were forced into the model one-by-one, two-by-two, and finally all together. In the first model only noise

TABLE V. Perception and annoyance outdoors from wind turbine noise related to sound exposure.

	<30.0 $n=12$ %(95%CI)	30.0–32.5 $n=70$ %(95%CI)	32.5–35.0 $n=132$ %(95%CI)	35.0–37.5 $n=62$ %(95%CI)	37.5–40.0 $n=40$ %(95%CI)	>40.0 $n=25$ %(95%CI)
Do not notice	75 (51–100)	61(50–73)	38(30–46)	15(3–23)	15(4–26)	4(19–57)
Notice, but not annoyed	25(1–50)	24(14–34)	28(20–36)	47(34–59)	35(20–50)	40(19–57)
Slightly annoyed	0	14(6–22)	17(10–23)	26(15–37)	23(10–35)	12(19–57)
Rather annoyed	0	0	10(5–15)	6(0–13)	8(−1–16)	8(19–57)
Very annoyed	0	0	8(3–12)	6(0–13)	20(8–32)	36(17–55)

exposure was used as the independent variable. The Exp(b) was 1.87, i.e., the odds for being annoyed by noise from wind turbines would increase 1.87 times from one sound category to the next. When adding the subjective factor of attitude to visual impact as an independent variable, the influence of the noise exposure decreased, but was still statistically significant. The pseudo-R^2 increased from 0.13 to 0.46, indicating that the new model explained 46% of the variance in annoyance. Adding the two remaining subjective factors did not improve the model as the coefficients did not reach statistical significance.

Noise from rotor blades was reported as the most annoying aspect of wind turbines. Of the respondents, 16% ($n=54$, 95%CI: 12%–20%) were annoyed by noise from rotor blades. Changed view (14%, $n=48$, 95%CI: 10%–18%), noise from machinery (9%, $n=33$, 95%CI: 6%–12%), shadows from rotor blades (9%, $n=29$, 95%CI: 6%–11%), and reflections from rotor blades (7%, $n=22$, 95%CI: 4%–9%) were also reported.

C. Attitude and sensitivity

Almost all respondents (93%, $n=327$, 95%CI: 91%–96%) could see one or more wind turbines from their dwelling or garden. When asked for judgments on wind turbines, the adjectives that were agreed on by most respondents were "environmentally friendly" (79%), "necessary" (37%), "ugly" (36%), and "effective" (30%). Only the word "annoying" (25%) was judged higher among those in higher sound categories than among those in lower sound categories ($z_{MW}=-3.613$, $n=351$, $p<0.001$).

The high judgment of the word "ugly" corresponds to the outcome of the attitude questions. Of the respondents, only 13% ($n=44$, 95%CI: 9%–16%) reported that they were negative or very negative to wind turbines in general, but 40% ($n=137$, 95%CI: 34%–44%) that they were negative or very negative to the visual impact of wind turbines on the landscape scenery (Table IV).

All correlations between sound category, noise annoyance, and subjective factors are shown in Table VII. Noise annoyance was correlated to both sound category and the three subjective factors, strongest to attitude to the wind turbines' visual impact on the landscape. The subjective factors were also correlated to each other, except for general attitude and sensitivity to noise. Of all the respondents, 50% ($n=169$, 95%CI: 45%–55%) regarded themselves as rather sensitive or very sensitive to noise (Table IV).

When comparing those annoyed by wind turbine noise and those not, no differences were found regarding the judgments of the local authorities, with the exception of perceived opportunity to influence local government ($z_{MW}=-2.753$, $n=300$, $p<0.005$). Those annoyed reported negative changes to a higher degree ($z_{MW}=-5.993$, $n=307$, p

TABLE VI. Results of multiple logistic regression analyses with 95% confidence intervals.

	Variables	b	p-value	Exp(b) (95%CI)	Pseudo-R^{2a}
1	Noise exposure	0.63	<0.001	1.87(1.47–2.38)	0.13
2	Noise exposure	0.55	<0.001	1.74(1.29–2.34)	0.46
	Attitude to visual impact	1.62	<0.001	5.05(3.22–7.92)	
3	Noise exposure	0.62	<0.001	1.86(1.45–2.40)	0.20
	Attitude to wind turbines	0.56	<0.001	1.74(1.30–2.33)	
4	Noise exposure	0.63	<0.001	1.88(1.46–2.42)	0.18
	Sensitivity to noise	0.56	<0.005	1.75(1.19–2.57)	
5	Noise exposure	0.55	<0.001	1.73(1.28–2.33)	0.46
	Attitude to visual impact	1.66	<0.001	5.28(3.26–8.56)	
	Attitude to wind turbines	−0.10	0.319	0.91(0.64–1.28)	
6	Noise exposure	0.57	<0.001	1.77(1.30–2.40)	0.47
	Attitude to visual impact	1.59	<0.001	4.88(3.08–7.72)	
	Sensitivity to noise	0.22	0.344	1.25(0.79–1.96)	
7	Noise exposure	0.63	<0.001	1.88(1.45–2.45)	0.24
	Attitude to wind turbines	0.58	<0.001	1.78(1.32–2.41)	
	Sensitivity to noise	0.59	<0.005	1.80(1.22–2.67)	
8	Noise exposure	0.56	<0.001	1.76(1.29–2.39)	0.47
	Attitude to visual impact	1.63	<0.001	5.11(3.10–8.41)	
	Attitude to wind turbines	−0.10	0.597	0.91(0.64–1.29)	
	Sensitivity to noise	0.21	0.373	1.23(0.78–1.94)	

[a]Nagelkerke (1991).

TABLE VII. Correlation between noise annoyance, sound category (dBA) and the subjective variables. Statistically significant correlations in boldface. To avoid the risk of mass significance $p<0.008$ were required for statistical significance.

	Sound category	Attitude to visual impact	Attitude to wind turbines	Sensitivity to noise
Noise annoyance	**0.421**	**0.512**	**0.334**	**0.197**
Sound category	...	**0.145**	0.074	0.069
Attitude to visual impact		...	**0.568**	**0.194**
Attitude to wind turbines			...	0.023
Sensitivity to noise				...

<0.001); 83% compared to 37% among those not annoyed. Of the 138 respondents who reported negative changes overall, 41% ($n=57$, 95%CI: 33%–50%) specified wind turbines in the response to an open question.

D. The occurrence of noise annoyance

Among those who noticed wind turbine noise ($n=223$), 25% ($n=47$, 95%CI: 18%–31%) reported that they were disturbed every day or almost every day and 17% ($n=33$, 95%CI: 12%–23%) once or twice a week. Annoyance was most frequently reported when relaxing outdoors and at barbecue nights.

Perception of wind turbine noise was influenced by weather conditions. Of the respondents who noticed wind turbine noise, 54% stated that they could hear the noise more clearly than usual when the wind was blowing from the turbines towards their dwelling. Only 9% reported that the noise was heard more clearly when the wind was from the opposite direction. The noise was also more clearly noticed when a rather strong wind was blowing (39%), but 18% reported that the noise was more clearly noticed in low wind. For warm summer nights, 26% noticed the noise more clearly than usual.

E. Sound characteristics

There was a statistically significant correlation between sound category and annoyance due to noise from rotor blades ($r_s=0.431$, $n=339$, $p<0.001$) and from the machinery ($r_s=0.294$, $n=333$, $p<0.001$). In all sound categories, a higher proportion of respondents noticed noise from rotor blades than from the machinery (Fig. 2). The proportion who noticed noise from rotor blades was similar to the proportion of respondents who noticed wind turbine noise in general. Noise from rotor blades was noticed in lower sound categories than noise from the machinery, i.e., it could be heard at a greater distance. However, comparing the numbers of annoyed with the numbers of those who could hear noise from the two sources, respectively, both noises were almost equally annoying. Of the 215 respondents who noticed noise from rotor blades, 25% ($n=54$, 95%CI: 19%–31%) were annoyed. Of the 101 respondents who noticed noise from the machinery, 30% ($n=30$, 95%CI: 21%–39%) were annoyed.

Among those who noticed noise from wind turbines, swishing, whistling, pulsating/throbbing, and resounding were the most common sources of annoyance according to verbal descriptors of sound characteristics (Table VIII). These descriptors were all highly correlated to noise annoyance. All other verbal descriptors of sound characteristics were also statistically significantly correlated to noise annoyance, but to a lower degree. When analyzing annoyance due to noise from rotor blades, the strongest correlated verbal descriptor of sound characteristics was swishing ($r_s=0.807$, $n=185$, $p<0.001$), which can be compared to noise annoyance due to noise from the machinery—which had the highest correlation with scratching/squeaking ($r_s=0.571$, $n=133$, $p<0.001$).

F. Indoor noise annoyance and sleep disturbance

A total of 7% of respondents ($n=25$, 95%CI: 5%–10%) were annoyed by noise from wind turbines indoors. Forty-five percent ($n=24$, 95%CI: 32%–59%) of those who were annoyed by noise from wind turbines outdoors were also

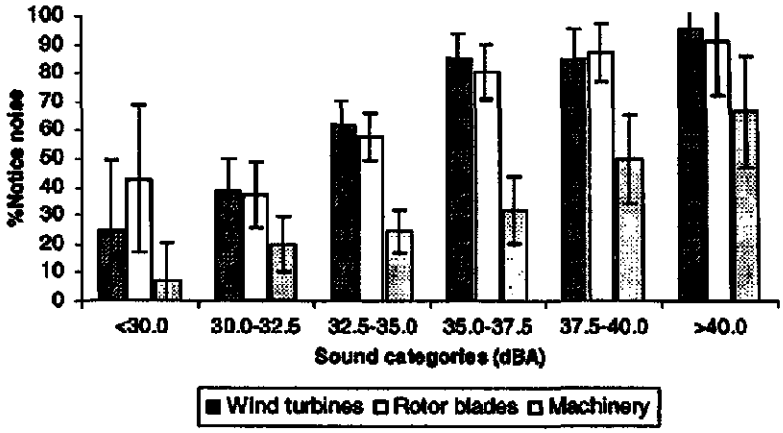

FIG. 2. Proportions with 95% confidence intervals of perception outdoors due to noise (notice but not annoyed, slightly annoyed, rather annoyed, very annoyed) from wind turbines, from rotor blades, and from machinery, related to sound categories.

TABLE VIII. Verbal descriptors of sound characteristics of wind turbine noise, based on those who noticed wind turbine sound ($n=223$). Statistically significant correlations in boldface. To avoid the risk of mass significance $p<0.0062$ were required for statistical significance.

	Annoyed by the specified sound character	Correlation to noise annoyance
Swishing	33%(27%–40%)	**0.718**
Whistling	26%(18%–33%)	**0.642**
Pulsating/throbbing	20%(14%–27%)	**0.450**
Resounding	16%(10%–23%)	**0.485**
Low frequency	13% (7%–18%)	**0.292**
Scratching/squeaking	12% (6%–17%)	**0.398**
Tonal	7% (3%–12%)	**0.335**
Lapping	5% (1%–8%)	**0.262**

annoyed indoors. There was a statistically significant correlation between indoor annoyance and sound category ($r_s=0.348$, $n=340$, $p<0.001$).

Regarding sleep disturbance, 23% ($n=80$, 95%CI: 18%–27%) of respondents stated that they were disturbed in their sleep by noise. Several sources of sleep disturbance, such as road traffic, rail traffic, neighbors, and wind turbines, were reported in an open question. At lower sound categories, no respondents were disturbed in their sleep by wind turbine noise, but 16% ($n=20$, 95%CI: 11%–20%) of the 128 respondents living at sound exposure above 35.0 dBA stated that they were disturbed in their sleep by wind turbine noise. Of those, all except two slept with an open window in the summer. No statistically significant correlations were found between sleep quality in general and outdoor noise annoyance, indoor noise annoyance, attitude to visual impact, attitude to wind turbines in general, or sensitivity to noise.

IV. DISCUSSION

A. Method

The results were based on the questionnaire survey and calculated A-weighted SPL. The purpose of the study was masked in order to avoid other factors such as attitude and ownership influencing the answers. The survey method is well established and has been used in several previous studies exploring annoyance due to community noise (e.g., Öhrström, 2004).

The results indicate a high validity for the questionnaire. The questions detected annoyance by odor from industrial plants in the area where the biogas plant is located [of those annoyed by odor from industrial plants, 83% ($n=19$) lived close to the biogas plant]; it also detected annoyance by noise from trains in the areas where the train passes [all of the respondents who reported that they were annoyed by noise from railway traffic ($n=12$) lived in areas where the railway passed]. There was a high correspondence between the responses to the general question of noise from wind turbines at the beginning of the questionnaire and the more specific questions later (alpha: 0.8850, $n=326$), also indicating high reliability of results.

The response rate at the different sound categories ranged from 60.0% to 78.1%, with the overall mean 68.4% and the dropout fairly equally distributed over sound categories. The distribution of age in the study population was similar to that of the demographic data for the area, but the proportions of women were somewhat higher than expected, especially in the lower sound categories. It has previously been shown that annoyance is not related to gender (Miedema and Vos, 1999) and as this study found no differences between men and women regarding noise annoyance and attitude to wind turbines, the higher proportion of women in the study population presumably had no impact on the results. A rather high proportion, 50%, of respondents self-reported as rather or very sensitive to noise. Other field studies in Sweden on annoyance due to road traffic noise in urban areas have found a lower proportion of noise-sensitive persons; for example, Matsumura and Rylander (1991) reported 25% of the respondents as noise sensitive in a road traffic survey ($n=805$). The difference might reflect preference of living environment, indicating that noise sensitive individuals prefer a more rural surrounding or that people living in areas with low background noise levels might develop a higher sensitivity to noise.

The calculated A-weighted SPL reflected downwind conditions assuming a wind speed of 8 m/s. Over a larger period of time, the direction and speed of the wind will vary and hence affect the actual SPL at the respondent's dwelling. It is likely that these variations, seen as an average over a longer period of time, in most cases will result in lower levels than the calculated SPL. Several unreliabilities related to the calculations might have led to an over- or underestimation of the dose levels. However, this error would not invalidate the comparison between respondents living at different SPL. Another source of error is that no account was taken of the physical environment around the respondent's house (e.g., location of patio or veranda, presence of bushes and trees in the garden). The actual SPL that the respondent experienced in daily life might therefore differ from the calculated, leading in most cases to an overestimation of the calculated dose.

B. Results

The results suggest that the proportions of respondents annoyed by wind turbine noise are higher than for other community noise sources at the same A-weighted SPL and that the proportion annoyed increases more rapidly. A comparison between established estimations of dose–response relationships for annoyance of transportation noise (Schultz, 1978; Fidell *et al.*, 1991; Miedema and Voss, 1998; Miedema and Oudshoorn, 2001; Fidell, 2003) and an estimation of a dose–response relationship for wind turbine noise, based on the findings in this study, are shown in Fig. 3. All curves are third order polynomials. The established curves describing annoyance from transportation noise are based on a large amount of data, and the wind turbine curve on only one study, so interpretations should be done with care. An important difference between studies of transportation noises and wind turbine noise is however where the main annoyance reaction is formed. For most studies of transportation noises

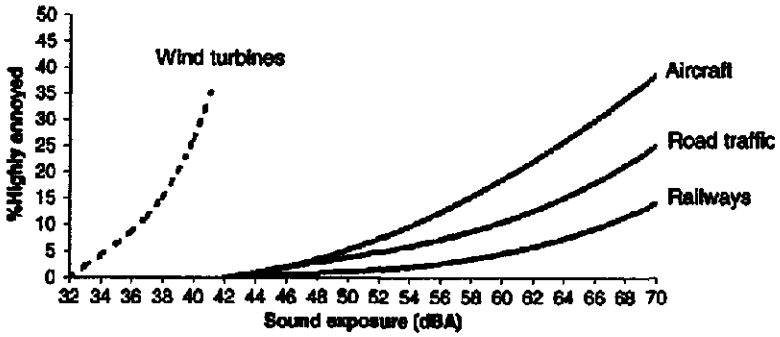

FIG. 3. A comparison between the dose–response relationship for transportation noise estimated by third order polynomials suggested by Miedema and Oudshoorn (2001) and wind turbine noise (dotted line). The latter ($\%HA = 4.38*10^{-2}(LEQ-32)^3 - 2.413*10^{-1}(LEQ-32)^2 + 2.4073(LEQ-32)$) were derived using regression based on five points interpolated from sound categories used in this study and the assumption that "very annoyed" in this study equals "highly annoyed" (Miedema and Voss, 1998).

it can be assumed that annoyance is formed mainly as a reaction to the sound pressure levels perceived indoors, and hence the actual noise dose should be reduced by the attenuation of the façade. For wind turbine noise the main annoyance reaction is formed when spending time outdoors. The actual difference in noise dose could therefore, at least partly, explain the comparatively higher prevalence of noise annoyance due to wind turbines. However, this factor does not explain the steep gradient.

Another factor that could be of importance for explaining the seemingly different dose–response relationships is that the wind turbine study was performed in a rural environment, where a low background level allows perception of noise sources even if the A-weighted SPL are low. Wind turbine noise was perceived by about 85% of the respondents even when the calculated A-weighted SPL were as low as 35.0–37.5 dB. This could be due to the presence of amplitude modulation in the noise, making it easy to detect and difficult to mask by ambient noise. This is also confirmed by the fact that the aerodynamic sounds were perceived at a longer distance than machinery noise.

Data obtained in this study also suggest that visual and/or aesthetic interference influenced noise annoyance. Support for this hypothesis can be found in studies evaluating auditory-visual interactions (Viollon *et al.*, 2002). In one field-laboratory study, subjects evaluating annoyance due to traffic noise were less annoyed if a slide of a visually attractive street was presented together with the noise, as compared to the same noise level presented together with a visually unattractive street. The difference in noise annoyance amounted to as much as 5 dBA (Kastka and Hangartner, 1986). The hypothesis was also supported by the logistic multiple regression analyses in the present study, where the visual variable attitude to visual impact had a significant impact on the model. However, although the inclusion of the variable increased the pseudo-R^2, the influence of noise exposure was still a significant factor for noise annoyance. A general prediction of the visual influence on noise annoyance, however, can not yet be made with any certainty as both attenuating (Kastka and Hangartner, 1986) and amplifying effects (e.g., Watts *et al.*, 1999) have been detected.

The high prevalence of noise annoyance could also be due to the intrusive characteristics of the aerodynamic sound. The verbal descriptors of sound characteristics related to the aerodynamic sounds of swishing, whistling, pulsating/throbbing, and resounding were—in agreement with this hypothesis—also reported to be most annoying. The results for the sounds of swishing and whistling agree well with results from previous experimental studies (Persson Waye *et al.*, 2000; Persson Waye and Agge, 2000; Persson Waye and Öhrström, 2002), while pulsating/throbbing in those studies was not significantly related to annoyance.

Most respondents who were annoyed by wind turbine noise stated that they were annoyed often, i.e., every day or almost every day. The high occurrence of noise annoyance indicates that the noise intrudes on people's daily life. The survey was performed during May and June when people could be expected to spend time outdoors, and the results therefore reflect the period that is expected to be most sensitive for annoyance due to wind turbine noise.

A low number of respondents were annoyed indoors by wind turbine noise. Some of the respondents also stated that they were disturbed in their sleep by wind turbine noise, and the proportions seemed to increase with higher SPL. The number of respondents disturbed in their sleep, however, was too small for meaningful statistical analysis, but the probability of sleep disturbances due to wind turbine noise can not be neglected at this stage.

Noise annoyance was also related to other subjective factors such as attitude and sensitivity. These results correspond well with the results from other studies regarding community noise (e.g., noise from aircraft, railways, road traffic, and rifle ranges). In a summary of 39 surveys performed in ten different countries, the correlation was 0.42 between dose and response, 0.15 between exposure and attitude, 0.41 between annoyance and attitude, −0.01 between exposure and sensitivity, and 0.30 between annoyance and sensitivity (Job, 1988). Corresponding numbers from this study are presented in Table VII and show a noteworthy similarity.

Two aspects of attitude were explored in the present study. Attitude to the visual impact of wind turbines on the landscape scenery was more strongly correlated to annoyance than the general attitude to wind turbines. The four most supported adjectives queried in the survey were environmentally friendly, necessary, ugly, and effective, thus giving the picture of a phenomenon that is accepted, but not regarded as a positive contribution to the landscape.

Previous studies of community noise have found that people who tend to be consistently negative could be predicted to be more annoyed by a new source of noise (Weinsten, 1980). More recent studies on community noise have included additional aspects and suggest conceptual models describing individual differences in the terms of stress, appraisal, and coping (Lercher, 1996). In the case of annoyance due to wind turbine noise, the findings suggest that individual differences others than attitude and sensitivity could influence the variation of noise annoyance. Respondents annoyed by wind turbine reported negative changes in their neighborhood to a higher degree than those not annoyed and stated that they had little perceived opportunity to influence local government. The importance of these parameters for noise annoyance due to wind turbines should be further studied.

C. Conclusions

A significant dose–response relationship between calculated A-weighted SPL from wind turbines and noise annoyance was found. The prevalence of noise annoyance was higher than what was expected from the calculated dose. It is possible that the presence of intrusive sound characteristics and/or attitudinal visual impacts have an influence on noise annoyance. Further studies are needed, including a larger number of respondents especially at the upper end of the dose curve, before firm conclusions could be drawn. To explore attitude with regard to visual impact, some of these studies should be performed in areas of different topography where the turbines are less visible. There is also a need to further explore the influence of individual and contextual parameters.

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APPENDIX: QUESTIONNAIRE

Key questions from the questionnaire used in the study. Questions with the main purpose to mask the intention of the questionnaire and standard questions on socio-economic status and health are not shown here. Translated from Swedish.

Section I

—How satisfied are you with your living environment? (very satisfied, satisfied, not so satisfied, not satisfied, not at all satisfied)

—Have there been any changes to the *better* in your living environment/municipality during the last years? (no, yes) State which changes.

—Have there been any changes to the *worse* in your living environment/municipality during the last years? (no, yes) State which changes.

—State for each nuisance below if you notice or are annoyed when you spend time *outdoors* at your dwelling: odor from industries, odor from manure, flies, noise from hay fans, noise from wind turbines, railway noise, road traffic noise, lawn mowers. (do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed)

—State for each nuisance below if you notice or are annoyed when you spend time *indoors* in your dwelling: odor from industries, odor from manure, flies, noise from hay fans, noise from wind turbines, railway noise, road traffic noise, lawn mowers. (do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed)

—How would you describe your sensitivity to the following environmental factors: air pollution, odors, noise, littering? (not sensitive at all, slightly sensitive, rather sensitive, very sensitive)

Section II

—Can you see any wind turbine from your dwelling or your garden? (yes, no)

—What is your opinion on the wind turbines' impact on the landscape scenery? (very positive, positive, neither positive nor negative, negative, very negative)

—Are you affected by wind turbines in your living environment with regard to: shadows from rotor blades, reflections from rotor blades, sound from rotor blades, sound from machinery, changed view? (do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed)

—If you are annoyed by noise, shadows and/or reflections from wind turbines, how often does this happen? (never/almost never, some/a few times per year, some/a few times per month, some/a few times per week, daily/almost daily)

—If you hear sound from wind turbines, how would you describe the sound: tonal, pulsating/throbbing, swishing, whistling, lapping, scratching/squeaking, low frequency, resounding? (do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed)

—Have you noticed if sounds from wind turbines sound different at special occasions: when the wind blows from the turbine towards my dwelling, when the wind blows from my dwelling towards the turbine, when the wind is low, when the wind is rather strong, warm summer nights? (less clearly heard, more clearly heard, no differences, do not know)

—Are you annoyed by sound from wind turbines during any of the following activities: relaxing outdoors, barbecue nights, taking a walk, gardening, other outdoor activity? (do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed)

—Do you own any wind turbines? (no, yes I own one or more turbines, yes I own shares of wind turbines)

—What is your general opinion on wind turbines? (very positive, positive, neither positive nor negative, negative, very negative)

—Please mark the adjectives that you think are adequate for wind turbines: efficient, inefficient, environmentally friendly, harmful to the environment, unnecessary, necessary, ugly, beautiful, inviting, threatening, natural, unnatural, annoying, blends in.[1]

[1]Developed by Karin Hammarlund, Department of Human and Economic Geography, Göteborg University, Sweden, and used with her permission.

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ORIGINAL ARTICLE

Wind turbine noise, annoyance and self-reported health and well-being in different living environments

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Objectives: To evaluate the prevalence of perception and annoyance due to wind turbine noise among people living near the turbines, and to study relations between noise and perception/annoyance, with focus on differences between living environments.

Methods: A cross-sectional study was carried out in seven areas in Sweden across dissimilar terrain and different degrees of urbanisation. A postal questionnaire regarding living conditions including response to wind turbine noise was completed by 754 subjects. Outdoor A-weighted sound pressure levels (SPLs) were calculated for each respondent. Perception and annoyance due to wind turbine noise in relation to SPLs was analysed with regard to dissimilarities between the areas.

Results: The odds of perceiving wind turbine noise increased with increasing SPL (OR 1.3; 95% CI 1.25 to 1.40). The odds of being annoyed by wind turbine noise also increased with increasing SPLs (OR 1.1; 95% CI 1.01 to 1.25). Perception and annoyance were associated with terrain and urbanisation: (1) a rural area increased the risk of perception and annoyance in comparison with a suburban area; and (2) in a rural setting, complex ground (hilly or rocky terrain) increased the risk compared with flat ground. Annoyance was associated with both objective and subjective factors of wind turbine visibility, and was further associated with lowered sleep quality and negative emotions.

Conclusion: There is a need to take the unique environment into account when planning a new wind farm so that adverse health effects are avoided. The influence of area-related factors should also be considered in future community noise research.

Wind power is a relatively new form of electricity generation that has a low impact on the environment compared with other power sources[1] and is also favoured by the public, at least by those who do not have a wind turbine project in their own community.[2] One disadvantage is the noise that inevitably emits from the rotor blades. Typically, sound power levels of a modern wind turbine range from 98–104 dB(A) at a wind speed of 8 m/s, which result in 33–40 dB(A) at a dwelling 500 m away, though this depends on meteorological and ground conditions. Sound pressure levels (SPLs) of this low magnitude are not considered a problem when it comes to other sources of community noise, such as road traffic and aircraft, but two circumstances increase the risk of negative perception of the sound from wind turbines: the sound character and the localisation. The sound is amplitude modulated by the pace of the rotor blades, which gives a rhythmical swishing sound. Such sounds are known to be more easily perceived than an even sound[3] and possibly also are more negatively appraised. In a rural environment the turbines are prominent and, because the rotor blades move in an otherwise fairly still environment, they are likely to draw visual attention.

We do not know the prevalence of perception and possible effects of wind turbine noise at a generalised level because only a few studies have been carried out. In an investigation of the impact of wind turbines on people living near them in a flat landscape, a dose-response relation between A-weighted SPL and annoyance due to wind turbine noise was found.[4] The relation was, however, moderated by the respondents' attitude to the visual impact of the turbines on the landscape. In a Danish study, also carried out in a flat landscape, the angle from the subject to the hub of the wind turbine was more correlated to perception of the noise than SPL was.[5] There are therefore reasons to believe that the prevalence of noise annoyance may be influenced by the variation in visibility of the wind turbines between different landscapes, such as a flat landscape and a hilly ground.

In one study, interviews with 15 subjects revealed additional possible associations between landscape and perception of wind turbine noise.[6] The subjects' personal values relating to the living environment appeared to influence how the noise from the wind turbines was perceived. Some, who considered the countryside as a place for economic growth and technical achievements, were indifferent to noise exposure from the wind turbines. Others, who emphasised that the countryside should be a quiet and peaceful place for relaxation, felt that the noise intruded their privacy and hence had a negative impact on their quality of life. People in the latter category would presumably seek living environments consistent with their needs, and may therefore be overrepresented in areas they perceive as quiet and peaceful. It could therefore be hypothesised that exposure from wind turbines would be more negatively appraised in an area that is perceived as unspoiled than in an area where several human activities take place.

AIMS

The objectives of this study were to evaluate the prevalence of perception and annoyance due to wind turbine noise among people living in the vicinity of one or more turbines, and to study relations between noise and perception/annoyance with focus on differences between different living environments.

METHODS

General outline

For this cross-sectional study, we selected seven wind turbine areas in Sweden that represented different types of landscapes

Abbreviations: LSD, least significant difference; SPL, sound pressure level

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with regard to terrain and urbanisation. To assess the prevalence of perception of and annoyance with wind turbine noise, a questionnaire was sent to a sample of people living near the wind turbines. The questionnaire was masked to give the impression of investigating general living conditions in the countryside. Outdoor A-weighted SPL was calculated for each respondent to estimate the exposure to wind turbine noise outside their dwelling. Perception of and annoyance with wind turbine noise were analysed in relation to exposure and with regard to possible variables of influence on the relation.

Study areas and study samples

Areas with different terrain and a population density large enough to meet the criteria of the power calculations were sought among all areas in Sweden containing wind turbines with a nominal power of more than 500 kW (n = 478 in 2004). Areas with offshore wind turbines, and turbines placed close to noisy industries and highways were excluded. Of the seven areas selected, three had flat ground (Areas V–VII) and four had complex ground (Areas I–IV)—that is, the ground was rocky and/or the altitude of the base of the wind turbine differed considerably from that of the dwellings nearby. Areas I, IV and VII were classified as suburban; areas II, III, V and VI as rural. Some of the areas also contained wind turbines with a nominal power less than 500 kW. We included two areas with few inhabitants (Areas II and III) as it was difficult to find areas with complex ground and a higher population density.

Addresses with coordinates of people living within a preliminary calculated isobar of 30 dB(A) from a wind turbine were bought from a postal delivery company and a sample of one randomised person in each household was constructed. In areas with a study population of more than 500 (Areas I, IV and VII), the sample was further reduced by randomly excluding half of the households among those living at SPL <35 dB(A) to avoid unnecessary costs. In total, 1309 questionnaires were sent out (table 1).

Questionnaires were satisfactorily completed and returned by 754 subjects (57.6%). Respondents were statistically significantly older than non-respondents (mean age 51 vs 47 years; Student's t test, $p<0.001$) and an insignificantly greater number of respondents compared with non-respondents were female (55% vs 47%; Mann–Whitney U test, $p = 0.131$). The distribution of age and sex between the respondents and the non-respondents was approximately the same in all seven areas.

The study was carried out in accordance with the requirements of the national and regional ethics committees in Sweden.

Subjective variables assessed by the questionnaire

The questionnaire consisted of questions on living conditions, reaction to possible sources of annoyance in the living environment, sensitivity to environmental factors, health and well-being. The questionnaire has been used and evaluated in a previous study.[4] Perception of and annoyance with wind turbine noise were assessed (together with other environmental stressors) by the question, "Specify for each of the inconveniences below whether you notice it or are annoyed by it outside your dwelling", with a five-point verbal rating scale (VRS), where 1 = "do not notice"; 2 = "notice but not annoyed"; 3 = "slightly annoyed"; 4 = "rather annoyed"; and 5 = "very annoyed". Noise sensitivity was assessed with a four-point VRS ranging from 1 = "not sensitive at all", to 4 = "very sensitive". The questionnaire also comprised specific questions about wind turbines, related to the respondent by the recent development of wind turbines in the community. Attitudes to wind turbines in general and to their impact on the landscape were assessed with a five-point VRS ranging from 1 = "very positive", to 5 = "very negative".

General coping was assessed by 15 items originally developed by Lercher,[7] and in our study translated and slightly modified to Swedish conditions. Questions on coping with wind turbines (11 items) and the respondents' descriptions of their living environment (10 items) were derived from a previous study based on 15 in-depth interviews with people living near wind turbines[4] (five-point VRS ranging from 1 = "do not agree at all", to 5 = "completely agree"). Respondents were also asked about their emotions when thinking about wind turbines, their set of values of their living environment, and their status of health (chronic disease, eg, diabetes or cardiovascular disease), well-being and sleep.

Noise exposure assessment

For each wind turbine, the sound power levels (dB) in octave bands were obtained from the manufacturers. The standard model of sound propagation proposed by the Swedish Environmental Protection Agency[8] was then used to estimate the noise emission outside each respondent's dwelling as equivalent continuous A-weighted SPL (dB). The model is based on downwind conditions ($\pm 45°$) with a wind speed of 8 m/s at 10 m height. The distance between the respondent and the nearest wind turbine was calculated using geographical coordinates. For those respondents in Area I who lived on the far side of a small bay from the wind turbine, 1.5 dB(A) were added to the calculated A-weighted SPL (personal communication with Sten Ljunggren, developer of the used sound propagation algorithm). The same was done for respondents living in Area II where there were large differences in altitude between the wind turbine and the respondents, which is known to enhance sound propagation.[9] In areas with several wind turbines, the A-weighted SPLs received by the respondent were added logarithmically.

Vertical visual angle

To study the influence of a tall object near the dwelling, the vertical visual angle was calculated for each respondent. "Vertical visual angle" in this study was defined as the angle between the horizontal plane and an imaginary line from a respondent's house to the hub of the nearest wind turbine, expressed in degrees.

Subjective background sound

Using principal component analysis the variable "subjective background sound" was derived from three items in the questionnaire. Respondents were asked to agree or not agree on a five-point VRS to the following statements: (1) "when outside on a calm summer morning, I can hear only bird song and other nature sounds"; (2) "a background noise from road traffic is almost always present outdoors"; and (3) "it is never really quiet in the area". The mean values of the factor scores differed between the areas ($F = 4.137$, $p<0.001$). Three quiet areas (Areas IV, VI and VII) and two not quiet (Areas I and V) were identified in a post hoc test (least significant difference (LSD)). Areas II and III were excluded as they did not significantly differ from areas in either group.

Statistical treatment of data

The relation between A-weighted SPL and response to wind turbine noise did not fulfil the proportional odds assumption required for ordinal logistic regression. Perception and annoyance were therefore analysed separately using binary logistic regression. The depending variable—that is, response to wind turbine noise, was dichotomised: perception into "do not notice" and "notice" (1/2–5) and annoyance into "not

Table 1 Study population, sample, respondents and response rate, and descriptive data of respondents and exposure related to area

Area	I	II	III	IV	V	VI	VII	Total
Study population	1085	40	48	672	311	217	1098	3471
Sample	396	24	23	221	148	112	385	1309
Respondents	206	16	12	141	87	70	222	754
Response rate (%)	52.0	66.7	52.2	63.8	58.8	62.5	57.7	57.6
Description of respondents and exposure								
Age (years), mean (SD)	52 (15)	51 (18)	54 (15)	52 (14)	49 (16)	49 (15)	51 (15)	51 (15)
Sex (% male)	40	53	58	47	48	38	46	44
Occupation (% employed)	54	33	58	57	61	58	62	58
(% retired)	28	53	33	24	22	21	23	25
Housing type (% detached)	70	93	100	70	89	93	82	79
Length of time in current dwelling (years), mean (SD)	14 (14)	16 (10)	16 (15)	15 (13)	15 (15)	15 (16)	16 (12)	15 (13)
Distance to nearest wind turbine (m), mean (SD)	862 (164)	636 (254)	670 (284)	812 (151)	834 (266)	1014 (245)	605 (160)	780 (233)
Sound pressure level (dB(A)), mean (SD)	31.4 (2.3)	38.2 (4.7)	33.8 (4.5)	33.2 (1.4)	34.6 (3.2)	31.9 (2.3)	35.0 (2.9)	33.4 (3.0)
Visual angle (degree), mean (SD)	3.5 (0.9)	10.8 (3.9)	8.4 (4.3)	2.5 (0.4)	2.7 (1.3)	3.5 (1.7)	3.8 (0.8)	3.5 (1.7)
Visibility (% of respondents who could see at least one wind turbine)	64	75	67	60	91	88	71	71
Noise sensitivity (% sensitive)	54	50	42	59	39	56	48	51
Self-rated health (% chronic disease)	36	33	67	35	21	26	32	33
Self-rated sleep (% not good)	9	0	0	6	5	4	5	6

annoyed" and "annoyed" (1–3/4–5). Factors related to the differences of the areas and possible moderating factors were analysed one by one in the regressions, always keeping A-weighted SPL in the model as the main factor of impact. Though age and sex are not known to have any influence on response to community noise,[10] these factors were included in the analyses to exclude bias from observed differences between areas. Several parameters were hypothesised to have an influence on perception: terrain, degree of urbanisation, subjective background noise level, employment (not employed spending more time at home), housing (residents in detached houses spending more time outside) and visibility (respondents seeing at least one wind turbine from their dwelling, meaning there are no barriers between the noise source and the receiver). Some of these parameters were also hypothesised to influence noise annoyance, in addition to factors of how long the respondents had lived at their current address, noise sensitivity,[11] attitude to the source,[12 13] and respondents' description of their living environment.[6] Noise sensitivity was dichotomised into "not sensitive" and "sensitive" (1–2/3–4), and attitude into "not negative" and "negative" (1–3/4–5).

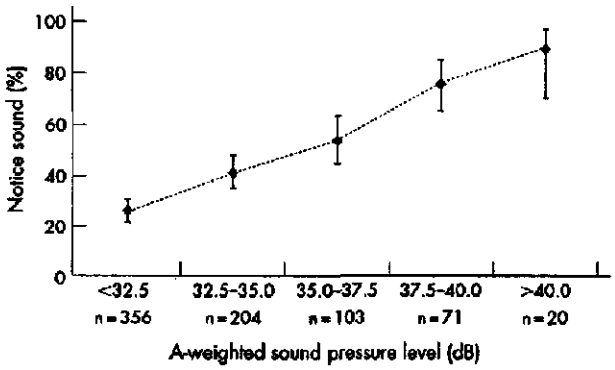

Figure 1 Proportion of respondents who noticed sound from wind turbines outside their dwelling, in relation to A-weighted sound pressure levels in 2.5-dB intervals. Vertical bars indicate 95% confidence intervals; n, the total number of respondents in each interval.

Odds ratios (ORs) with 95% confidence intervals (CIs) not including 1.0 were considered statistically significant.

Two models predicting noise perception were derived by simultaneously entering variables associated with perception into a binary logistic regression and then excluding no longer significant variables one by one. The models were tested using the Hosmer and Lemshow test (a high p value indicates a good fit). Modelling with more than two factors was not possible for annoyance, because of the low incidence.

Principle component analysis with Varimax was used for deriving factors from the 11 items assessing coping with wind turbines. Items were excluded if they did not fulfil the following criteria suggested by Hair *et al*:[14] extraction communality <0.5, measure of sampling adequacy >0.5, not loading more than 0.2 on two factors. Derived factors with Cronbach's alpha <0.6 for the included items were rejected.

Correlations were tested using Spearman's rank test. Differences in distribution between groups were tested with Mann–Whitney's U test for variables with ordinal scales, using the χ test[2] for dichotomous variables, and one-way analysis of variance (ANOVA) for continuous variables. The tests were two-sided. p Values <0.05 were considered statistically significant. The 95% CIs for proportions were calculated using the Wilson's method in accordance with Altman.[15]

RESULTS

Descriptive data of respondents and exposure

Table 1 shows the demographic characteristics of respondents in each area and in total. The mean age was approximately the same for all areas, but the proportion of men differed (range 38–58%). Most of the respondents were employed (58%) or retired (25%); Area III had the lowest proportion of employed and the highest proportion of retired respondents, but this area only contributed 14 respondents. "Not employed" comprised unemployed individuals (4% of all respondents), respondents on parental leave (3%), respondents on sick leave (2%) and home workers (1%). Most people lived in single-family detached houses, but Areas I and IV also featured rented or tenant-owned apartments.

The largest mean vertical visual angles were found in Areas II (10.8°) and III (8.4°) where the wind turbines were situated on top of a hill. The highest proportions of respondents who could

Table 2 Association between perception of noise from wind turbines (dependent variable "do not notice" (n = 457) or "notice" (n = 307)) and variables hypothesised to influence the perception, expressed as odds ratio (OR), with 95% confidence intervals (CIs)

Sound pressure level (dB(A))	Other variables hypothesised to influence perception	
OR (95% CI)	Variable of interest (ref; tested category)*	OR (95% CI)
1.3 (1.25 to 1.40)		
	Demographic and socioeconomic factors	
1.3 (1.26 to 1.41)	Age (years; + 1 year)	1.0 (0.99 to 1.01)
1.3 (1.25 to 1.41)	Sex (male; female)	1.0 (0.83 to 1.16)
1.3 (1.26 to 1.41)	Employment (employed; not employed)	0.7 (0.48 to 0.91)
1.3 (1.26 to 1.41)	Housing (apartment; detached house)	1.6 (1.04 to 2.33)
	Area-related factors	
1.3 (1.24 to 1.40)	Terrain (complex; flat)	1.1 (0.81 to 1.56)
1.3 (1.25 to 1.41)	Urbanisation (suburban; rural)	1.8 (1.27 to 2.64)
1.3 (1.24 to 1.41)	Terrain and urbanisation	
	Suburban and flat ground (n = 222)	1.0
	Suburban and complex ground (n = 347)	1.0 (0.65 to 1.48)
	Rural and flat ground (n = 157)	1.6 (1.01 to 2.53)
	Rural and complex ground (n = 28)	4.8 (1.65 to 13.72)
1.3 (1.22 to 1.38)	Subjective background noise (not quiet; quiet)	1.8 (1.25 to 2.51)
	Visual factors	
1.3 (1.22 to 1.37)	Visibility (no; yes)	2.2 (1.47 to 3.18)
Model 1†‡ (Hosmer and Lemshow test: 0.703)		
Sound pressure level (dB(A))		1.3 (1.21 to 1.39)
Employment (employed; not employed)		0.6 (0.40 to 0.83)
Terrain (complex; flat)		0.6 (0.38 to 0.97)
Urbanisation (suburban; rural)		2.3 (1.34 to 3.88)
Subjective background noise (not quiet; quiet)		2.6 (1.72 to 3.95)
Visibility (no; yes)		2.3 (1.51 to 3.47)
Model 2†‡ (Hosmer and Lemshow test: 0.703)		
Sound pressure level (dB(A))		1.3 (1.21 to 1.39)
Employment (employed; not employed)		0.6 (0.40 to 0.83)
Terrain and urbanisation		
Suburban and flat ground (n = 222)		1.0
Suburban and complex ground (n = 347)		1.6 (1.03 to 2.63)
Rural and flat ground (n = 157)		2.2 (1.34 to 3.89)
Rural and complex ground (n = 28)		13.8 (4.24 to 45.14)
Subjective background noise (not quiet; quiet)		2.6 (1.72 to 3.95)
Visibility (no; yes)		2.3 (1.51 to 3.47)

*Variables were entered one by one into a binary logistic regression, always keeping SPL in the regression as the main factor of importance for perception.
†Models 1 and 2 comprise several variables simultaneously entered into a binary logistic regression.
‡Adjusted for age and sex.

see at least one wind turbine from their dwelling were found in Areas V (91%) and VI (88%), characterised as rural areas with flat ground. The highest proportions of noise-sensitive respondents were found in Areas IV (59%) and VI (56%), both areas that had been classified as quiet.

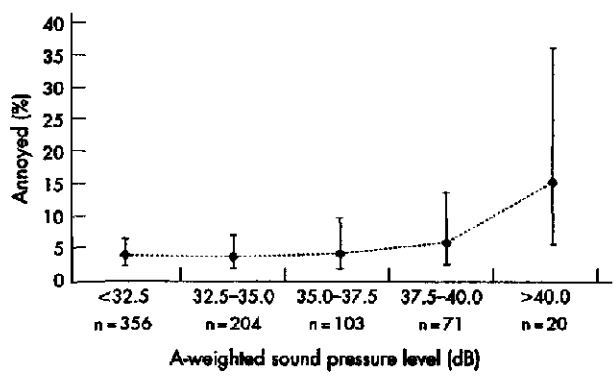

Figure 2 Proportion of respondents who were annoyed by sound from wind turbines outside their dwelling, in relation to A-weighted sound pressure levels in 2.5-dB intervals. Vertical bars indicate 95% confidence intervals; n, the total number of respondents in each interval.

Perception

Perception of and annoyance with wind turbine noise were correlated with A-weighted SPL ($p<0.001$). Of all the respondents, 39% (n = 307) noticed sound from wind turbines outside their dwelling. The proportion of respondents who noticed sound increased almost linearly with increasing SPL (fig 1). At 37.5–40.0 dB(A), 76% of the 71 respondents within that category of sound level reported that they noticed sound from the wind turbines while at >40.0 dB(A), 90% of 20 did. Respondents who slept with an open window in the summer or in the winter did not perceive the noise to a higher degree than did other respondents within the same category of sound level, as presented in figure 1 (p values in the range of 0.067–1.00; p values <0.3 were all related to lower perception if sleeping with the window open).

Table 2 shows the association between SPL and perception of noise from wind turbines; the odds of noticing sound increased by 30% for each dB(A) increase. Perception was not associated with sex or age. Being employed, living in a detached house, living in an area with low subjectively rated background noise and seeing at least one wind turbine from the dwelling increased the odds of noticing the sound. Terrain did not statistically significantly influence the perception, but the OR for noticing sound from wind turbines in rural areas compared with suburban areas was 1.8. When further exploring this finding, we found that respondents living in rural areas with complex ground were more likely to notice the sound than others.

Table 3 Association between annoyance with noise from wind turbines (dependent variable "not annoyed" (n=723) or "annoyed" (n=31)) and variables hypothesised to influence annoyance, expressed as odds ratio (OR), with 95% confidence intervals

Sound pressure level (dB(A))	Other variables hypothesised to influence perception	
OR (95% CI)	Variable of interest (ref; tested category)*	OR (95% CI)
1.1 (1.01 to 1.25)		
Demographic and socioeconomic factors		
1.1 (1.03 to 1.27)	Age (years; + 1 year)	1.0 (0.99 to 1.04)
1.1 (1.02 to 1.26)	Sex (male; female)	0.9 (0.50 to 1.64)
1.1 (1.01 to 1.25)	Employment (employed; not employed)	1.3 (0.61 to 2.60)
1.1 (1.01 to 1.25)	Housing (apartment; detached house)	2.5 (0.75 to 8.40)
1.1 (1.01 to 1.25)	Length of time in current dwelling (years, + 1 year)	1.0 (1.00 to 1.05)
Area related factors		
1.1 (1.02 to 1.26)	Terrain (complex; flat)	0.8 (0.39 to 1.76)
1.1 (0.99 to 1.21)	Urbanisation (suburban; rural)	3.8 (1.80 to 7.83)
1.1 (0.98 to 1.23)	Terrain and urbanisation	
	Suburban and flat ground (n=222)	1.0
	Suburban and complex ground (n=347)	2.1 (0.63 to 7.28)
	Rural and flat ground (n=157)	5.2 (1.62 to 16.65)
	Rural and complex ground (n=28)	10.1 (2.46 to 41.61)
1.1 (0.91 to 1.21)	Subjective background noise (not quiet; quiet)	3.6 (1.21 to 10.67)
Noise sensitivity and attitude to source		
1.1 (1.02 to 1.26)	Noise sensitivity (not sensitive; sensitive)	2.5 (1.14 to 5.63)
1.1 (1.00 to 1.25)	Attitude to wind turbines in general (not negative; negative)	13.4 (6.03 to 29.59)
1.1 (1.01 to 1.25)	Attitude to the visual impact of the wind turbine on the landscape (not negative; negative)	14.4 (6.37 to 32.44)
Valuation of the current living environment†		
1.1 (1.01 to 1.25)	"I live in a place where I can restore myself and gain strength" (disagree; agree)	0.3 (0.13 to 0.74)
1.1 (1.02 to 1.25)	"I have renovated my dwelling" (no; yes)	2.6 (1.03 to 6.33)
Visual factors		
1.0 (0.88 to 1.16)	Vertical visual angle (degrees; + 1 degree)	1.2 (1.03 to 1.42)
1.1 (0.97 to 1.21)	Visibility (no; yes)	10.9 (1.46 to 81.92)

*Variables were entered one by one into a binary logistic regression, always keeping sound pressure level (SPL) in the regression as the main factor of importance for perception.
†Only items that were positively or negatively associated with noise annoyance are shown.

Model 1 (table 2) predicts perception of wind turbine noise. Housing was no longer statistically significant and was therefore excluded. All other variables were still associated with perception; urbanisation and subjective background noise to a higher degree than when tested one by one. Living in an area with flat ground now decreased the likeliness of hearing the sound. In Model 2 (table 2) the more differentiated variable of "terrain and urbanisation" was examined. Living in an area with complex ground increased the likeliness of noise perception both in a rural and suburban setting.

Annoyance

The total number of respondents who were annoyed by wind turbine noise in this study was 31. The proportion of respondents who were annoyed at low SPL varied from 3% to 4%, but at 37.5–40 dB(A) the proportion increased slightly to 6% of the 71 respondents within that category of sound level, and at SPL >40 dB(A) it further increased to 15% of 20 respondents, as shown in figure 2. The increase was not statistically significant, largely because of the low numbers of respondents living at SPL >40 dB(A).

The odds of being annoyed by noise from wind turbines increased significantly with A-weighted SPL (table 3). Age, sex, employment, type of housing and length of time in current dwelling were not associated with annoyance. Living in a rural area, living in an area with low subjectively rated background noise, being noise-sensitive, and having a negative attitude to wind turbines in general or to their visual impact on the landscape were factors positively associated with annoyance. Of the 10 items measuring the respondents' description of the living environment, the following two were associated with annoyance: (1) having renovated the dwelling was positively associated with noise annoyance; while (2) looking upon the current living environment as a place for recovery and gaining strength was negatively associated with noise annoyance. Having renovated the dwelling was not correlated to coping with wind turbines by changing the living environment, as asked about later in the questionnaire ($p = 0.730$). Both the objective variable "vertical visual angle" and the subjective report of visibility of wind turbines increased the odds of being annoyed.

Subjective ratings of health and well-being

A-weighted SPL was not correlated to any of the health factors or factors of well-being asked for in the questionnaire. However, noise annoyance was associated with sleep quality and negative emotions. Of those 31 respondents who were annoyed by wind turbine noise, 36% reported that their sleep was disturbed by a noise source, compared with 9% among those 733 not noise annoyed ($p<0.001$). Respondents who were annoyed by wind turbine noise felt more tired ($p = 0.05$) and tense ($p<0.05$) in the morning. When thinking about wind turbines, they also felt resigned (29%), violated (23%), strained (19%) and tired (19%) to a statistically significantly higher degree compared with those who were not annoyed (all p values <0.001). These feelings were not related to self-reported health status, except for feeling violated, which was associated with bad sleep ($p<0.01$).

Coping

Several of the 11 items measuring coping specific to wind turbine noise were correlated with noise annoyance. Two factors, which explained 72% of the variance in the original variables, were derived: (1) taking active steps to avoid the negative impact ("I have changed my living environment because of the wind turbines"; "I have changed my behaviour

because of the wind turbines"; "I would consider moving if more wind turbines are erected"); and (2) discussing and seeking information ("I have gathered information about wind power"; "I discuss wind power with people around me"). Both factors were positively correlated to noise annoyance (for (1), p<0.001; for (2), p<0.01). "Taking active steps to avoid the negative impact" was not correlated with any of the questions assessing well-being. "Discussing and seeking information" was negatively correlated with three out of five items assessing stress or strain (unhappiness/depression, irritability, feelings of hopelessness; all p values <0.05), indicating that this group of respondents were less under strain than others. None of the 15 items measuring general coping were correlated to annoyance with wind turbine noise.

DISCUSSION

Living in a rural landscape in contrast with an urbanised area enhanced the risk of perceiving wind turbine noise and, furthermore, the risk of annoyance. Type of terrain had no major influence on perception in urbanised areas; however, in a rural landscape, complex terrain substantively increased the risk. These results suggest, together with the higher risk of perception in areas rated as quiet, that there is a need to take the special features of an environment into account when assessing the risk of nuisance for people living in the area.

The findings of our study could in part be explained by differences in levels of background sound between rural and urbanised areas. However, not just perception but also annoyance was associated with type of landscape, indicating that the wind turbine noise interfered with personal expectations in a less urbanised area. Having renovated the dwelling was another variable that was positively associated with annoyance, pointing towards a personal factor related to the living environment, which affects response to an environmental stressor. Theories used in studies of residential environments have revealed that people choose environments that harmonise with their self-concept and needs, and that they remain in places that provide a sense of continuity.[16] When a new environmental stressor occurs, the individual's relationship with her or his place of residence is disrupted.[17] Such a distortion could possibly predispose for an increased risk of annoyance such as measured in our study.

The increased risk of perception of wind turbine noise in a rural landscape with a complex terrain compared with a flat terrain could be due to shelter effects decreasing the background noise at the respondent's dwelling, where the houses are located in a valley and the turbine on a hill. Also, it cannot be excluded that the model used for calculating the sound propagation underestimates the A-weighted SPL at the respondent's dwelling more than compensated for in this study, in cases where there are large differences in altitude between the source and the receiver.[9]

The association between perception of wind turbine noise and A-weighted SPL was statistically significant and consistent (OR 1.3) even when several moderating variables were tested. The association between noise annoyance and sound level (OR 1.1) was also consistent for most moderating variables, even though it was not always statistically significant, largely owing to the low number of annoyed persons. However, when the vertical visual angle was tried in a logistic regression, the association between annoyance and sound decreased (OR 1.0). Both A-weighted SPL and vertical visual angle were calculated from the distance between the respondent and the wind turbine, so the decrease may be due to the dependence of the variables. The decrease could also be seen as an indication of the visual influence that wind turbines have on noise annoyance. Seeing one or more turbines increased not just the odds of perceiving the sound, but also the odds of being annoyed, suggesting a multimodal effect of the audible and visual exposure from the same source leading to an enhancement of the negative appraisal of the noise by the visual stimuli. This effect has previously been observed in a field study where traffic noise was found to be more annoying if the source of the noise (moving road traffic) could be seen.[18] On the other hand, the increased odds of being annoyed, observed among respondents with a negative attitude to the wind turbine's visual impact on the landscape, point to a more aesthetic explanation: respondents who think of wind turbines as ugly are more likely to appraise them as not belonging to the landscape and therefore feel annoyed, also by the noise. Experimental studies have shown that the same noise level of traffic generates a higher degree of noise annoyance when pictures of an urban setting rated as not pleasant are shown as compared with pictures of a more pleasant area.[20]

Annoyance is an adverse heath effect.[21] Community noise has in some studies also been linked to other non-auditory health effects, for example in a recently published study on aircraft noise and hypertension.[22] However, these studies have mainly explored sound levels >50 dB(A) and the results are therefore not relevant for effects of wind turbine noise.[23] In our study no adverse health effects other than annoyance could be directly connected to wind turbine noise. Reported sleep difficulties, as well as feelings of uneasiness, associated with noise annoyance could be an effect of the exposure, but it could just as well be that respondents with sleeping difficulties more easily appraise the noise as annoying. Wind turbine noise as a hindrance to psycho-physiological restoration could, however, not be excluded. Being employed was, contrary to the hypothesis, associated with higher prevalence of perceiving wind turbine noise, possibly because individuals who leave the house for work are more observant of stressors that could interfere with their psycho-physiological restoration needs when at home. Furthermore, respondents who were annoyed by the noise did not think of their living environment as a place for gaining strength. The need for restorative environments in order to

Main messages

- The risk for being annoyed by wind turbine noise increased with increasing A-weighted sound pressure levels. Dose-response relationships for noise levels as low as these have not earlier been derived.
- Living in a rural environment, in comparison with a suburban area, increases the risk of perceiving and being annoyed by sound from nearby wind turbines.
- Noise annoyance with wind turbine noise could lead to hindrance of human restoration.
- Seeking information and discussing wind turbines as a coping strategy could decrease adverse health effects.

Policy implications

- To avoid annoyance, the characteristics of a geographical area should be taken into account when establishing new wind farms.
- Dose-response relations between exposure to community noise and noise annoyance should be assessed not just on a general level, but for different living environments.

maintain health and well-being, especially for vulnerable groups, has been frequently pointed out, by such authors as Kaplan.[24] The fact that a non-urbanised setting has been linked to restorative properties such as "not being distracted"[25] suggests that audio and visual distractions caused by wind turbines could change a rural environment from restorative to non-restorative.

Of the coping strategies identified, discussing and seeking information appeared to be most successful as this was correlated with less strain. This finding should be acknowledged in the planning of wind turbines, by giving people living in intended wind farm areas relevant information and possibilities to communicate with the developers and authorities.

Our study had some limitations, apart from the difficulties in assessing the exposure mentioned above. Participation was incomplete (response rate 57.6%), but response bias would only explain the influence of urbanisation and terrain if people in one type of area perceiving the noise would be more willing to answer the questionnaires than people in another. This seems unlikely, and similar associations were found when examining those who responded to the questionnaire at the first invitation and those who required one or two reminders (data not presented). It can also not be excluded that differences between the areas, other than terrain and degree of urbanisation, could have influenced the results, for instance local opinion groups and media discussions. Using seven different areas located in different parts of southern Sweden reduced this risk.

The findings of this study are probably relevant for other sources of community noise, such as road traffic and airports. There has been a tradition of focusing on synthesised dose-response relations for a specified noise source irrespective of environment, even though the results of the studies often differ.[27] Difficulties in accurately predicting noise annoyance of particular communities from modelled dose-response curves has also been reported.[28] A recent study of annoyance with noise in an alpine valley, in which data were separately analysed for neighbouring communities, found differences in dose-response relation between areas; however, the authors do not explain the reasons for the observed differences.[29]

Future research should not only take into account individual factors already known to moderate the dose-response relation, such as noise sensitivity and attitude to the source, but should explore the influence of dissimilar environments, in our study associated with perception of and annoyance with wind turbine noise.

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