Cush Wind Farm

Environmental Impact Assessment Report

Annex 12.2: Cush Wind Farm Shadow Flicker Prediction Model

Cush Wind Limited

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Calculated:
09/08/2023 15:36/3.6.366

SHADOW - Main Result

Calculation: Shadow Flicker Predictions

Assumptions for shadow calculations

Maximum distance for influence
Calculate only when more than 20 % of sun is covered by the blade
Please look in WTG table

Minimum sun height over horizon for influence	3 °
Day step for calculation	1 days
Time step for calculation	1 minutes

Sunshine probability S (Average daily sunshine hours) [BIRR]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.57	2.08	2.82	4.36	5.20	4.37	4.15	3.90	3.54	2.68	1.94	1.23

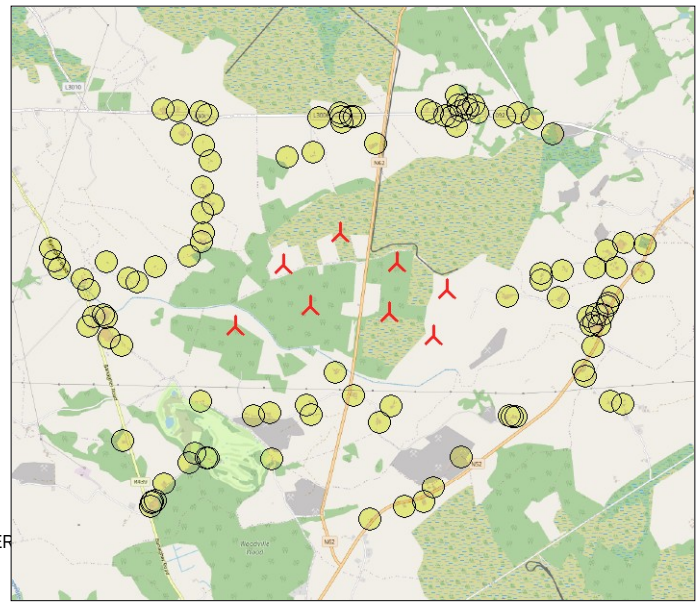
Operational time

N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW
297	221	328	510	236	166	281	856	1,081	898	1,029	889

W	WNW	NW	NNW	Sum
735	495	400	338	8,760

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:
Height contours used: Elevation Grid Data Object: Cush Wind Farm_(SHADOW FLICKER
Receptor grid resolution: 1.0 m

All coordinates are in
Irish ITM-IRENET95 (IE), geocentric, GRS80



Scale 1:75,000
New WTG Shadow receptor

WTGs

	Easting	Northing	Z [m]	Row data/Description	WTG type Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Shadow data Calculation distance [m]	RPM [RPM]
1	606,797	710,446	47.0	T1	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	114.0	1,788	0.0
2	606,312	709,829	46.7	T2	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	114.0	1,788	0.0
3	607,351	710,753	48.5	T3	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	114.0	1,788	0.0
4	607,060	710,033	46.9	T4	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	114.0	1,788	0.0
5	607,922	710,465	46.9	T5	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	114.0	1,788	0.0
6	607,844	709,967	49.0	T6	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	114.0	1,788	0.0
7	608,286	709,735	52.1	T7	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	114.0	1,788	0.0
8	608,427	710,195	50.9	T8	Yes	VESTAS	V172-7.2-7,200	7,200	172.0	114.0	1,788	0.0

Shadow receptor-Input

No.	Name	Easting	Northing	Z [m]	Width [m]	Height [m]	Elevation a.g.l. [m]	Slope of window [°]	Direction mode	Eye height (ZVI) a.g.l. [m]
A	H1	604,473	710,611	53.0	1.5	1.5	0.5	90.0	"Green house mode"	2.0
B	H2	604,513	710,481	51.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
C	H3	604,560	710,397	49.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
D	H4	604,793	710,300	50.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
E	H5	604,868	710,199	49.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
F	H6	605,037	710,465	51.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
G	H7	605,253	710,310	49.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
H	H8	605,337	710,277	48.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
I	H9	605,512	710,429	52.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
J	H10	605,848	710,529	54.5	1.5	1.5	0.5	90.0	"Green house mode"	2.0
K	H11	605,980	710,676	57.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
L	H12	606,002	710,762	55.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
M	H13	605,991	710,967	56.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
N	H14	606,089	711,041	56.5	1.5	1.5	0.5	90.0	"Green house mode"	2.0
O	H15	605,992	711,219	59.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
P	H16	606,072	711,473	57.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
Q	H17	605,999	711,625	59.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
R	H18	605,781	711,736	55.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
S	H19	605,597	711,988	54.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
T	H20	605,735	711,966	55.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
U	H21	605,958	711,958	59.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0

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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

...continued from previous page

No.	Name	Easting	Northing	Z	Width	Height	Elevation a.g.l.	Slope of window	Direction mode	Eye height (ZVI) a.g.l.
				[m]	[m]	[m]	[m]	[°]		[m]
V	H22	606,031	711,938	60.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
W	H23	606,821	711,514	58.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
X	H24	607,091	711,562	60.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
Y	H25	607,141	711,906	58.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
Z	H26	607,355	711,953	61.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AA	H27	607,369	711,920	61.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AB	H28	607,377	711,858	61.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AC	H29	607,458	711,911	61.5	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AD	H30	607,501	711,911	60.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AE	H31	607,709	711,650	61.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AF	H32	608,211	711,989	64.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AG	H33	608,276	711,954	66.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AH	H34	608,399	711,924	65.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AI	H35	608,462	711,916	64.7	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AJ	H36	608,510	711,820	61.0	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AK	H37	608,516	712,123	61.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AL	H38	608,533	712,036	62.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AM	H39	608,552	711,973	62.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AN	H40	608,602	712,041	59.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AO	H41	608,622	711,992	59.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AP	H42	608,682	712,035	57.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AQ	H43	608,717	711,950	60.5	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AR	H44	608,993	711,913	62.5	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AS	H45	609,115	711,957	60.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AT	H46	609,273	711,896	66.0	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AU	H47	609,461	711,748	60.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AV	H48	610,385	710,654	69.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AW	H49	610,174	710,669	71.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AX	H50	610,370	710,379	64.7	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AY	H51	610,101	710,420	67.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
AZ	H52	610,007	710,586	73.0	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BA	H53	609,898	710,417	70.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BB	H54	609,568	710,399	63.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BC	H55	609,356	710,359	62.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BD	H56	609,348	710,291	61.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BE	H57	609,016	710,126	66.7	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BF	H58	609,526	710,119	61.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BG	H59	610,067	710,128	64.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BH	H60	610,030	710,061	64.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BI	H61	610,018	710,045	64.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BJ	H62	609,974	709,951	63.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BK	H63	609,911	709,957	62.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BL	H64	609,820	709,935	58.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BM	H65	609,879	709,876	61.7	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BN	H66	609,858	709,846	59.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BO	H67	609,939	709,852	62.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BP	H68	609,872	709,638	60.0	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BQ	H69	609,779	709,404	58.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BR	H70	609,799	709,337	58.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BS	H71	610,049	709,089	58.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BT	H72	610,169	709,063	60.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BU	H73	609,109	708,940	66.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BV	H74	609,072	708,937	67.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BW	H75	609,042	708,947	67.7	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BX	H76	608,569	708,536	64.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BY	H77	608,285	708,227	67.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
BZ	H78	608,198	708,088	66.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CA	H79	608,005	708,038	67.7	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CB	H80	607,662	707,913	68.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CC	H81	607,865	709,036	53.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CD	H82	607,751	708,884	55.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CE	H83	607,490	709,143	59.5	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CF	H84	607,310	709,373	55.7	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CG	H85	607,027	709,054	55.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CH	H86	606,680	708,508	58.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0

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Calculated:
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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

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No.	Name	Easting	Northing	Z	Width	Height	Elevation a.g.l.	Slope of window	Direction mode	Eye height (ZVI) a.g.l.
				[m]	[m]	[m]	[m]	[°]		[m]
CI	H87	606,657	708,968	52.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CJ	H88	606,500	708,943	59.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CK	H89	606,051	708,521	56.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CL	H90	606,024	708,520	56.4	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CM	H91	605,909	708,570	54.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CN	H92	605,851	708,477	52.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CO	H93	605,608	708,265	47.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CP	H94	605,525	708,100	46.6	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CQ	H95	605,497	708,087	46.2	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CR	H96	605,482	708,080	45.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CS	H97	605,473	708,043	45.0	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CT	H98	605,197	708,689	48.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CU	H99	605,962	709,085	59.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CV	H100	605,189	709,640	51.3	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CW	H101	605,060	709,718	50.5	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CX	H102	605,034	709,921	48.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CY	H103	604,999	709,941	48.9	1.5	1.5	0.5	90.0	"Green house mode"	2.0
CZ	H104	604,907	709,932	50.1	1.5	1.5	0.5	90.0	"Green house mode"	2.0
DA	H105	604,855	709,831	49.5	1.5	1.5	0.5	90.0	"Green house mode"	2.0
DB	H106	607,073	708,957	54.8	1.5	1.5	0.5	90.0	"Green house mode"	2.0

Calculation Results

Shadow receptor

		Shadow, worst case			Shadow, expected values
No.	Name	Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]
A	H1	0:00	0	0:00	0:00
B	H2	0:00	0	0:00	0:00
C	H3	0:00	0	0:00	0:00
D	H4	7:23	30	0:23	1:03
E	H5	8:48	32	0:26	1:15
F	H6	16:12	60	0:28	2:19
G	H7	25:52	75	0:35	3:52
H	H8	36:49	110	0:37	5:31
I	H9	50:39	132	0:42	7:04
J	H10	105:17	193	0:52	13:47
K	H11	70:41	172	0:47	9:57
L	H12	60:10	139	0:47	8:31
M	H13	55:55	131	0:43	7:21
N	H14	70:06	153	0:45	8:45
O	H15	51:56	125	0:38	6:15
P	H16	31:05	85	0:32	3:30
Q	H17	16:00	62	0:24	1:49
R	H18	12:56	41	0:23	1:18
S	H19	0:00	0	0:00	0:00
T	H20	0:00	0	0:00	0:00
U	H21	0:00	0	0:00	0:00
V	H22	8:59	43	0:22	1:05
W	H23	64:43	78	1:03	7:13
X	H24	30:21	48	0:57	3:09
Y	H25	0:00	0	0:00	0:00
Z	H26	0:00	0	0:00	0:00
AA	H27	0:00	0	0:00	0:00
AB	H28	0:00	0	0:00	0:00
AC	H29	0:00	0	0:00	0:00
AD	H30	0:00	0	0:00	0:00
AE	H31	17:30	40	0:41	2:01
AF	H32	6:02	26	0:17	0:40
AG	H33	13:55	41	0:25	1:36
AH	H34	19:34	58	0:26	2:23
AI	H35	17:24	64	0:25	2:11
AJ	H36	12:45	52	0:26	1:45
AK	H37	0:00	0	0:00	0:00

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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

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No.	Name	Shadow, worst case			Shadow, expected values
		Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow hours per year [h/year]
AL	H38	15:22	56	0:23	1:52
AM	H39	14:00	65	0:23	1:47
AN	H40	0:00	0	0:00	0:00
AO	H41	10:54	54	0:22	1:27
AP	H42	0:00	0	0:00	0:00
AQ	H43	0:00	0	0:00	0:00
AR	H44	0:00	0	0:00	0:00
AS	H45	0:00	0	0:00	0:00
AT	H46	0:00	0	0:00	0:00
AU	H47	0:00	0	0:00	0:00
AV	H48	0:00	0	0:00	0:00
AW	H49	0:00	0	0:00	0:00
AX	H50	0:00	0	0:00	0:00
AY	H51	5:00	25	0:19	0:46
AZ	H52	5:19	25	0:20	0:47
BA	H53	11:47	54	0:23	1:46
BB	H54	32:10	110	0:34	4:57
BC	H55	51:33	133	0:42	7:56
BD	H56	56:20	135	0:43	8:52
BE	H57	152:42	205	1:35	25:15
BF	H58	42:08	119	0:40	6:53
BG	H59	5:47	27	0:21	0:59
BH	H60	10:51	52	0:22	1:47
BI	H61	11:01	50	0:22	1:48
BJ	H62	12:28	54	0:23	2:02
BK	H63	14:14	58	0:24	2:19
BL	H64	18:00	66	0:27	2:55
BM	H65	15:40	62	0:25	2:32
BN	H66	16:46	65	0:26	2:43
BO	H67	13:45	58	0:24	2:13
BP	H68	17:21	68	0:24	3:00
BQ	H69	32:16	110	0:26	5:08
BR	H70	29:52	101	0:25	4:42
BS	H71	0:00	0	0:00	0:00
BT	H72	0:00	0	0:00	0:00
BU	H73	0:10	9	0:02	0:01
BV	H74	0:00	0	0:00	0:00
BW	H75	0:00	0	0:00	0:00
BX	H76	0:00	0	0:00	0:00
BY	H77	0:00	0	0:00	0:00
BZ	H78	0:00	0	0:00	0:00
CA	H79	0:00	0	0:00	0:00
CB	H80	0:00	0	0:00	0:00
CC	H81	10:08	43	0:22	1:43
CD	H82	16:30	61	0:23	2:29
CE	H83	44:23	79	0:50	7:08
CF	H84	83:43	120	1:13	14:30
CG	H85	27:06	87	0:29	4:45
CH	H86	0:00	0	0:00	0:00
CI	H87	0:00	0	0:00	0:00
CJ	H88	4:17	35	0:10	0:43
CK	H89	0:00	0	0:00	0:00
CL	H90	0:00	0	0:00	0:00
CM	H91	0:00	0	0:00	0:00
CN	H92	0:00	0	0:00	0:00
CO	H93	0:00	0	0:00	0:00
CP	H94	0:00	0	0:00	0:00
CQ	H95	0:00	0	0:00	0:00
CR	H96	0:00	0	0:00	0:00
CS	H97	0:00	0	0:00	0:00
CT	H98	0:00	0	0:00	0:00
CU	H99	0:00	0	0:00	0:00
CV	H100	19:25	49	0:35	3:20
CW	H101	14:15	41	0:32	2:29

To be continued on next page...

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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

...continued from previous page

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]
CX	H102	12:54	38	0:31	2:01
CY	H103	12:02	38	0:30	1:51
CZ	H104	10:01	33	0:28	1:32
DA	H105	9:19	33	0:27	1:32
DB	H106	24:37	67	0:30	4:09

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

No.	Name	Worst case [h/year]	Expected [h/year]
1	T1	210:29	28:19
2	T2	248:53	34:55
3	T3	187:59	24:23
4	T4	89:14	11:18
5	T5	72:18	10:11
6	T6	26:00	4:01
7	T7	160:34	26:33
8	T8	174:53	28:48

Total times in Receptor wise and WTG wise tables can differ, as a WTG can lead to flicker at 2 or more receptors simultaneously and/or receptors may receive flicker from 2 or more WTGs simultaneously.

The calculation of the total expected values for a given receptor assumes a weighted average directional reduction for all WTGs contributing to shadow flicker within the same day. In the case where shadow flicker from different WTGs is not concurrent within the day, the total expected time at a given receptor may deviate marginally from the individual flicker time caused by each turbine separately.