10.0 SHADOW FLICKER

10.1 INTRODUCTION

This assessment addresses the potential shadow flicker impacts of the proposed adjusted Yellow River wind farm on the surrounding dwellings in terms of:

- Predicting and assessing the extent of shadow flicker experienced by all houses within 10 diameters (1.13km) of the proposed adjusted Yellow River wind farm

- Specifying mitigation measures, where deemed necessary.

10.2 STATEMENT OF AUTHORITY

This report has been prepared by Mr David Kiely, Mr James Conlon and Mr Sean Molloy, Director and Project Engineers of Jennings O'Donovan & Partners Consulting Engineers respectively.

Mr Kiely is a Chartered Civil Engineer, a Fellow of Engineers Ireland and has a Masters Degree in Environmental Protection. Mr Kiely has some 29 years professional experience of which the last 14 years has been in the wind energy industry. Mr. Kiely has acted either as Project Manager or Project Director in all of the firm's wind energy projects of which 18 have been fully constructed.

Mr Conlon is a Chartered Engineer with six years' experience in the design and environmental assessment of wind farm projects. Mr Molloy is an engineer with three years' experience in the design and environmental assessment of wind farm projects.

10.3 SHADOW FLICKER

Wind turbines, like other tall structures will cast a shadow on the neighbouring area when the sun is visible. Shadow flicker occurs under a special set of conditions when the sun passes behind the hub of a wind turbine and casts a shadow over neighbouring properties. When the blades rotate, shadows pass over the same point causing an effect called 'shadow flicker'. Shadow flicker effects occur in various situations: travelling by road through a tunnel or under overhanging trees (dappled shadow effects), or standing within the shadowed area of wind turbine blades.

Although there is no agreed standard for shadow flicker impact in Ireland, the Department of Environment, Community and Local Government in its Wind Energy Development Guidelines for Local Authorities considers that the potential for shadow flicker is very low beyond ten rotor diameters, in this case 1.13km, from a property. It should be noted that 195 houses are located within 1.13km of the proposed Yellow River wind farm development.

It is also recommended that shadow flicker at neighbouring offices and dwellings within 500m should not exceed either 30 hours per year or 30 minutes per day. It should be noted that there are 2 houses within 500 metres of Yellow River wind farm (H210 & H226). Both of these of which are associated with the wind farm development. Both houses consent to the turbines being located within 500 metres of the development. Two consent letters were included in the original planning application. The closest dwelling which is referenced as H210, is located at a distance of 452 metres from the nearest turbine (T32), the occupants of H210 will experience 8.17 actual hours of shadow flicker per year. This will be further reduced by the fact that the dwelling in question is surrounded by a mature forest plantation. The next closest house, H226 (located 485 metres from T19), will experience 2.32 hours per year of actual shadow flicker.

Shadow flicker within a house occurs if a wind turbine is close enough and of a specific orientation with the house and the sun. It will not happen where there is vegetation or other obstructions between the turbines and the house. It will not happen if windows facing a turbine are fitted with blinds or shutters. It will not happen if the sun is not shining brightly enough to cause shadows from a turbine. Shadow flicker is more often experienced as a minor short-term nuisance than as a health and safety issue.

The shadow-flicker frequency is related to the rotor speed and number of blades on the rotor. Most turbines operate at a rotor speed of between 10 – 25 revolutions per minute (RPM), which translates to a blade pass frequency of less than 1 Hz (less than 1 alternation per second). For the purposes of modelling the characteristics of the Siemens S113 turbine model, with a hub height of 110m and 100m (T13-T25) and a rotor diameter of 113m, has been chosen to represent the effect of shadow flicker on the Yellow River site. It is likely that the model selected will operate at an RPM of 6-18.5. The Department of Energy and Climate Change for England stated in its report Update of UK Shadow Flicker Evidence Base (2011) that *it is considered that the*

frequency of the flickering caused by the wind turbine rotation is such that it should not cause a significant risk to health. Frequencies higher than 3 Hz but below 10 Hz are widely used in discotheques and the Epilepsy Foundation has made a statement that frequencies below 10 Hz are not likely to trigger epilepsy seizures.

According to the Danish Wind Industry Association – "*If you are farther away from a wind turbine rotor than about 500-1000 meters, the rotor of a wind turbine will not appear to be chopping the light*[1]*, but the turbine will be regarded as an object with the sun behind it. Therefore, it is generally not necessary to consider shadow casting at such distances"*.

The distance and direction between the turbine and habitation or observer is of great significance because:

- The duration of the shadow will be shorter the greater the distance.
- The shadow flicker effect will be reduced the further a dwelling is from an operating turbine.
- Shadow flicker effects may be experienced within ten blade diameters distance from the nearest turbine (i.e. in this case within 1.13km). Beyond this shadow flicker effects will not be significant.

The shadow flicker is more likely to occur on sunny winter days, when the sun is lower in the sky and shadows are then cast over a larger distance. Shadow flicker is more likely to take place where turbines are sited to the east, south east, west or south west of dwellings.

Shadow flicker is generally not regulated explicitly by planning authorities. Offaly County Development Plan, 2009-2015 recommends that wind farms be developed in accordance with the Wind Energy Development Guidelines 2006, by the Department of the Environment, Community and Local Government which requests that neighbouring dwellings within 500 m should not exceed 30 hours per year or 30 minutes a day.

[1] http://www.windpower.org/en/tour//env/shadowr.htm

10.3.1 Methodology

House Survey

House surveys were undertaken in May 2013. This was to make certain that all houses were included in the assessment. All inhabitable and uninhabitable houses were recorded as well as any holiday / mobile homes. Furthermore, a search was completed for all houses that have been granted planning permission but have not been constructed. One additional houses was added to the list, H237.

Locations were recorded using a GPS and subsequently refined using Ordnance Survey 1:5,000 maps. Co-ordinates represent the closest gable of the house to any turbine location. The survey covered all houses within 1.2km which equated to 243 houses. However, as it is only necessary to assess the houses within 10 rotor diameters, i.e. 1.13km, this number was reduced to one hundred and ninety five houses. Please note that the identifiers used for the houses have not been renumbered to account for this reduction. Please refer to **Figures 9.25 – 9.29** - House Locations Maps.

Shadow Flicker Calculation

This shadow flicker calculation is undertaken for all houses / buildings i.e. 195 houses located within approximately 1.13km of the Yellow River turbines.

The seasonal timing and duration of this effect has been accurately calculated from the geometry of each machine, its orientation relative to nearby houses and the latitude of the potential site, using WindFarm© computer software. Any properties, which may potentially be effected, can be identified and the risk calculated.

The computerised modelling calculates a theoretical worst case scenario, providing the highest possible shadow flicker for each house in a situation where the sun is shining all day from sunrise to sunset, the turbines are always moving, the wind direction is always perpendicular to the line from the turbine to the sun, a person is always home to view the moving turbines, and there are no vegetation or structures in between the moving turbines blades and the receptor.

The shadow flicker analysis was completed for the proposed Yellow River wind farm development using WindFarm© software as outlined above. Co-ordinates taken in relation to the houses approximate the middle of the houses within 1.13km of the proposed development. The ground contours, the coordinates of the wind turbines, latitude, and seasonal fluctuation of daylight/night time, rotor diameter, and hub height of the proposed wind farm development were input and the calculations run by the computer. The model utilises a 3º angle for the sun above the horizon.

Generic windows of 1 m squared of which the centre is 2 m above ground are applied to each side of the house. These windows represent an approximation of the existing windows on the house and provide an estimate of potential shadow flicker to a window on each side of the house. The software determines the times of year when the sun will be in line with the rotational components of the turbine, thereby casting intermittent shadows. The software outputs details of potential shadow flicker, in this case by mean and maximum duration of the shadow flicker events, days per year and times of occurrence and maximum hours per year of shadow flicker.

10.3.2 Shadow Flicker Analysis

Summarised details of the shadow flicker times for each house location can be found in Table 10.1**.**

Table 10.1 provides details on the maximum hours per day, the shadow days per year and the total hours per year in constant sunlight that shadow flicker is predicted to occur.

10.3.3 Assessment of Worst Case Shadow Flicker Impact

One hundred and ninety five houses could potentially experience an impact from shadow flicker as they are within ten rotor diameters of the proposed Yellow River wind farm. This figure is based on a "worst case" scenario and assumes the sun is always shining, that there is no cloud cover and the dwelling is always occupied. This calculation is also based on topography alone and excludes vegetation, buildings and other man made buildings. The existing forestry plantation that covers Yellow River is also not accounted for which in a "real" context would screen the flickering effect of the wind turbines.

It has been determined through the calculation completed that forty three of the houses would theoretically experience greater than 30 hours of shadow flicker per year. All of these houses are outlined in Table 10.1. No shadow flicker is experienced at some dwellings due to the orientation of these dwellings with respect to the proposed turbines. Impacts from shadow flicker occur within 130 degrees either side of north from a turbine.

It should be noted that the calculation of nearest turbine to each house and the distance to each respective house are as calculated in the software. This also applies to the days of shadow flicker per year and the maximum and mean hours per year of shadow flicker experience.

10.3.4 Assessment of Actual Shadow Flicker Impact

Reduction of Shadow Flicker due to absence of Sunlight

However, the shadow flicker experienced can be greatly affected by the probability of sunshine occurrence. Ireland normally gets between 1100 and 1600 hours of sunshine each year. The sunniest months are May and June. During these months, sunshine duration averages between 5 and 6.5 hours per day over most of the country. The extreme southeast gets most sunshine, averaging over 7 hours a day in early summer. December is the dullest month, with an average daily sunshine ranging from about 1 hour in the north to almost 2 hours in the extreme southeast. Over the year as a whole, most areas get an average of between 3 1/4 and 3 3/4 hours of sunshine each day.

Historical met data is utilised to apply a reductive factor to be applied to the worst case total hours per year shadow flicker occurrence. The closest climatic station to the proposed Yellow River Wind Farm site is located in Birr. Data collected and analysed from this station revealed that the area received only 3.2 hours of average sunshine per day as recorded by between 1981 and 2008. The shadow flicker reduction factor can be calculated based on the following information:

- 4,500 hours of daylight per year at Birr.
- 1,169 hours of actual sunshine per year (based on 3.2 hours of average sunshine per day as recorded by Met Eireann at Birr between 1981 and 2008).

The actual hours of sunlight at Yellow River Wind Farm represents 26% of the total hours of daylight, therefore, shadow flicker will only potentially occur for 26% of the predicted worst case time.

Reduction of Shadow flicker due to non-operation during low wind conditions

As discussed, shadow flicker can only occur when the blades are rotating. The type of wind turbine proposed for this application will not operate below a wind speed of 3m/s or above a wind speed of 25m/s. According to the wind rose for the proposed Yellow River wind farm, wind speeds are in the range of 3 to 25m/s for 86% of the year. Therefore turbine will only potentially be operational 86% on average.

Reduction of Shadow flicker due to non-operation as a result of technical issues

Other factors including forced outage, planned maintenance and grid availability will result in down time for turbine operation up to 10%. A conservative estimate of 7% has been adopted in this assessment.

Reduction of Shadow flicker due to non-directional orientation of the turbine

The predicted values of shadow flicker assume that the wind direction is always the same direction as the angle of the sun to the receptor window. Wind turbines operate at right angles to the wind, therefore, they will not always be orientated at right angles to houses. The orientation is determined by the predicted wind rose for the site. An alternative assumption of a random rotor position leads to a reduction to approximately 61% of the theoretical results.

These factors were then combined to obtain an overall reduction factor to the shadow flicker occurrence:

26% (Absence of sunlight) x 86% (Non operation of turbines due to low wind) x 93% (non-operation due to technical issues) x 61% (Non-directional orientation of the turbines) = 12.68%

By applying this reduction factor to the shadow flicker hours experienced by houses it has been determined that none of the houses / buildings experience greater than 30 hours of shadow flicker per year. Please refer to Table 10.1 for a list of the projected hours of shadow flicker experienced by the dwellings within 1.13km of the proposed development.

A Shadow Flicker Contour Map for the projected shadow occurrence has been included in Figures 10.5-10.8. The area shaded in blue illustrates areas that will experience 30 hours or greater of shadow flicker occurrence a year. **There are no house within this area.**

It should also be noted that the actual shadow flicker hours experienced by houses listed in Table 10.1 will be significantly reduced further by the presence of existing vegetation and sheds and barns between the proposed turbines and the existing houses. **This reduction factor has not been applied in this assessment.**

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
1	248567	235952	87	7	787	0.00	0.00	0.00	0.00	0.00
2	253125	234854	90	13	769	84.00	0.64	0.57	48.00	6.09
3	252847	235075	88	13	961	41.00	0.49	0.38	15.70	1.99
4	252814	235059	88	13	996	40.00	0.48	0.37	14.80	1.88
5	253151	234776	87	13	789	53.00	0.56	0.46	24.30	3.08
6	253312	234330	86	13	1024	0.00	0.00	0.00	0.00	0.00
7	253317	234312	86	13	1037	0.00	0.00	0.00	0.00	0.00
8	253320	234292	86	13	1054	0.00	0.00	0.00	0.00	0.00
9	253351	234320	86	13	1015	0.00	0.00	0.00	0.00	0.00
10	253352	234300	86	13	1032	0.00	0.00	0.00	0.00	0.00
11	253375	234293	86	13	1029	0.00	0.00	0.00	0.00	0.00
12	253399	234292	86	13	1020	0.00	0.00	0.00	0.00	0.00
13	253412	234315	86	13	994	0.00	0.00	0.00	0.00	0.00
14	253443	234315	86	13	983	0.00	0.00	0.00	0.00	0.00
15	253446	234304	86	13	992	0.00	0.00	0.00	0.00	0.00
16	248662	235946	86	7	722	0.00	0.00	0.00	0.00	0.00
17	247686	235439	88	2	1038	0.00	0.00	0.00	0.00	0.00
18	253533	234720	91	13	576	0.00	0.00	0.00	0.00	0.00
19	254679	235250	92	14	549	137.00	0.87	0.64	88.10	11.17
20	257540	239043	73	19	1108	79.00	0.45	0.36	28.10	3.56

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
21	257278	239056	74	19	957	48.00	0.48	0.39	18.50	2.35
22	251645	237031	87	11	1065	61.00	0.45	0.30	18.30	2.32
23	254330	242124	81	32	697	36.00	0.48	0.38	13.80	1.75
25	255208	235063	92	14	1109	48.00	0.44	0.34	16.40	2.08
26	255206	236003	89	15	854	42.00	0.54	0.42	17.50	2.22
29	255168	236052	87	15	825	42.00	0.55	0.44	18.50	2.35
30	255056	235079	98	14	963	67.00	0.51	0.39	26.20	3.32
32	253325	234255	88	13	1085	0.00	0.00	0.00	0.00	0.00
33	253325	234232	88	13	1105	0.00	0.00	0.00	0.00	0.00
36	255179	236937	77	16	778	0.00	0.00	0.00	0.00	0.00
37	255061	236912	76	16	738	0.00	0.00	0.00	0.00	0.00
41	247997	236211	89	4	662	109.00	0.58	0.43	46.60	5.91
42	253233	236099	77	13	1032	43.00	0.44	0.36	15.30	1.94
43	253451	234289	86	13	1004	0.00	0.00	0.00	0.00	0.00
44	253462	234280	86	13	1009	0.00	0.00	0.00	0.00	0.00
45	253470	234276	86	13	1010	0.00	0.00	0.00	0.00	0.00
46	253484	234274	87	13	1008	0.00	0.00	0.00	0.00	0.00
47	253493	234279	86	13	1000	0.00	0.00	0.00	0.00	0.00
48	253504	234288	86	13	988	0.00	0.00	0.00	0.00	0.00
49	253505	234299	86	13	977	0.00	0.00	0.00	0.00	0.00

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
50	253508	234312	86	13	964	0.00	0.00	0.00	0.00	0.00
51	253506	234321	86	13	956	0.00	0.00	0.00	0.00	0.00
52	253537	234323	87	13	945	0.00	0.00	0.00	0.00	0.00
53	253540	234316	87	13	951	0.00	0.00	0.00	0.00	0.00
54	253536	234301	87	13	967	0.00	0.00	0.00	0.00	0.00
55	253539	234294	87	13	973	0.00	0.00	0.00	0.00	0.00
56	253535	234280	87	13	987	0.00	0.00	0.00	0.00	0.00
57	253538	234274	87	13	992	0.00	0.00	0.00	0.00	0.00
58	253239	234858	89	13	670	68.00	0.68	0.55	37.20	4.72
59	256033	237147	75	18	809	56.00	0.45	0.38	21.20	2.69
60	252914	235036	90	13	902	46.00	0.52	0.41	18.80	2.38
61	252938	235015	91	13	884	48.00	0.54	0.42	20.10	2.55
62	253240	235150	91	13	561	80.00	1.21	0.80	63.90	8.10
63	253230	234878	90	13	667	74.00	0.73	0.63	46.40	5.88
64	253206	234827	88	13	715	57.00	0.63	0.51	29.10	3.69
65	254072	234708	91	13	593	0.00	0.00	0.00	0.00	0.00
66	253659	241041	81	30	622	124.00	0.72	0.56	68.90	8.74
67	247805	235869	87	2	772	0.00	0.00	0.00	0.00	0.00
68	251228	237472	106	11	1098	0.00	0.00	0.00	0.00	0.00
69	253243	234926	91	13	631	84.00	0.83	0.75	63.10	8.00

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
74	257892	238120	88	19	1127	34.00	0.42	0.33	11.20	1.42
75	257889	238079	89	19	1130	36.00	0.42	0.32	11.40	1.45
77	254061	238638	79	24	580	110.00	0.61	0.48	52.80	6.70
79	255853	237190	76	18	679	18.00	0.21	0.17	3.10	0.39
80	254136	234300	87	13	993	0.00	0.00	0.00	0.00	0.00
81	254085	234740	91	13	571	0.00	0.00	0.00	0.00	0.00
82	253241	235118	91	13	565	78.00	1.25	0.87	67.50	8.56
83	253107	235469	82	13	727	83.00	0.63	0.43	35.70	4.53
85	251205	237399	100	11	1023	0.00	0.00	0.00	0.00	0.00
86	250527	237235	84	11	764	16.00	0.21	0.17	2.60	0.33
87	251976	235986	79	12	852	87.00	0.55	0.41	35.90	4.55
88	255053	235825	96	15	696	93.00	0.66	0.47	43.60	5.53
89	255277	236775	76	16	967	0.00	0.00	0.00	0.00	0.00
90	255188	236882	76	16	829	0.00	0.00	0.00	0.00	0.00
91	255992	236980	76	18	930	0.00	0.00	0.00	0.00	0.00
92	256000	237349	74	18	633	86.00	0.50	0.36	30.90	3.92
93	256150	237164	74	18	871	0.00	0.00	0.00	0.00	0.00
94	256553	237273	73	18	995	85.00	0.45	0.35	29.30	3.72
95	256613	237376	73	19	882	0.00	0.00	0.00	0.00	0.00
98	255304	235274	86	15	1126	64.00	0.45	0.40	25.70	3.26

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
99	255275	235286	87	15	1095	99.00	0.47	0.38	37.70	4.78
100	254979	235261	91	14	828	56.00	0.57	0.44	24.60	3.12
102	255190	235126	94	14	1069	46.00	0.45	0.35	16.20	2.05
103	255140	235061	96	14	1047	56.00	0.47	0.36	20.20	2.56
104	254117	238648	78	24	597	74.00	0.56	0.50	37.20	4.72
105	254035	238637	78	24	570	102.00	0.60	0.46	46.90	5.95
106	255252	239287	79	21	920	84.00	0.76	0.55	46.30	5.87
107	255119	239662	81	22	1264	0.00	0.00	0.00	0.00	0.00
108	255299	239972	79	31	1443	0.00	0.00	0.00	0.00	0.00
110	255240	240390	78	31	1088	0.00	0.00	0.00	0.00	0.00
111	254501	240623	85	31	521	32.00	0.43	0.34	10.90	1.38
112	254300	240602	84	31	561	40.00	0.51	0.40	16.00	2.03
113	255670	239696	79	21	1098	0.00	0.00	0.00	0.00	0.00
114	256175	239631	81	21	1052	0.00	0.00	0.00	0.00	0.00
115	256157	239657	81	21	1073	0.00	0.00	0.00	0.00	0.00
119	257812	237829	87	19	1120	46.00	0.44	0.34	15.80	2.00
120	257738	237877	85	19	1034	49.00	0.47	0.37	18.10	2.30
121	257427	237822	76	19	780	60.00	0.60	0.50	29.80	3.78
122	257348	237814	74	19	719	27.00	0.34	0.27	7.30	0.93
123	257388	237816	75	19	750	46.00	0.53	0.42	19.40	2.46

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
124	257308	237806	74	19	692	0.00	0.00	0.00	0.00	0.00
125	256922	237544	75	19	716	0.00	0.00	0.00	0.00	0.00
126	253134	235422	84	13	687	88.00	0.66	0.44	38.70	4.91
127	253014	234962	92	13	826	59.00	0.58	0.45	26.60	3.37
129	251194	237368	98	11	990	21.00	0.24	0.19	4.00	0.51
130	252967	234994	91	13	861	51.00	0.55	0.43	22.10	2.80
131	252992	234975	92	13	843	55.00	0.56	0.44	24.30	3.08
132	255432	235683	89	15	1092	37.00	0.44	0.34	12.70	1.61
133	254782	235295	92	14	629	125.00	0.75	0.51	63.40	8.04
134	254751	235282	91	14	604	155.00	0.78	0.54	83.60	10.60
135	255271	236950	77	16	825	0.00	0.00	0.00	0.00	0.00
136	256580	237359	73	19	905	54.00	0.44	0.34	18.40	2.33
137	256764	237362	74	19	882	0.00	0.00	0.00	0.00	0.00
138	254349	238723	76	22	510	121.00	0.88	0.56	67.80	8.60
139	254521	238947	76	22	563	154.00	0.79	0.60	93.10	11.81
140	254550	238960	76	22	562	140.00	0.79	0.59	82.60	10.47
141	254905	239054	77	22	622	116.00	0.58	0.39	44.90	5.69
142	254929	239108	79	22	680	96.00	0.45	0.33	31.60	4.01
143	253136	235891	77	13	931	118.00	0.53	0.36	42.50	5.39
144	253157	235988	77	13	988	72.00	0.50	0.42	30.00	3.80

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
145	255399	236884	76	17	930	0.00	0.00	0.00	0.00	0.00
146	253043	234909	92	13	818	75.00	0.59	0.45	33.60	4.26
147	250459	237281	85	11	828	4.00	0.04	0.03	0.10	0.01
150	247773	235882	87	2	739	0.00	0.00	0.00	0.00	0.00
151	253250	234967	91	13	606	97.00	0.94	0.81	78.40	9.94
152	255344	236871	75	17	927	0.00	0.00	0.00	0.00	0.00
153	255467	237058	75	18	749	48.00	0.48	0.39	18.70	2.37
154	255198	235218	91	14	1050	70.00	0.46	0.30	21.30	2.70
155	255096	235307	90	14	931	71.00	0.51	0.35	24.50	3.11
156	255078	239295	78	22	901	55.00	0.47	0.36	19.70	2.50
157	255440	239556	80	21	1037	0.00	0.00	0.00	0.00	0.00
158	257511	237922	77	19	807	102.00	0.60	0.44	44.80	5.68
162	255219	240255	79	31	1171	0.00	0.00	0.00	0.00	0.00
163	255322	239896	79	21	1395	0.00	0.00	0.00	0.00	0.00
164	255524	239623	80	21	1066	0.00	0.00	0.00	0.00	0.00
165	255485	239615	80	21	1073	0.00	0.00	0.00	0.00	0.00
166	255217	239886	78	21	1432	0.00	0.00	0.00	0.00	0.00
167	255254	239573	80	21	1143	0.00	0.00	0.00	0.00	0.00
168	255200	239475	80	21	1096	56.00	0.46	0.38	21.30	2.70
169	255210	239184	80	22	856	105.00	0.55	0.45	46.80	5.93

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
170	255025	239163	79	22	759	68.00	0.47	0.33	22.40	2.84
171	254949	239125	79	22	701	61.00	0.45	0.31	19.10	2.42
172	254551	239015	77	22	613	119.00	0.68	0.53	63.20	8.01
173	254312	238769	76	22	566	118.00	0.80	0.52	61.70	7.82
175	255714	239696	79	21	1090	0.00	0.00	0.00	0.00	0.00
176	255247	240361	78	31	1113	0.00	0.00	0.00	0.00	0.00
177	255291	239603	80	21	1149	0.00	0.00	0.00	0.00	0.00
178	255096	239603	80	22	1201	0.00	0.00	0.00	0.00	0.00
179	254989	239163	78	22	748	56.00	0.46	0.31	17.30	2.19
181	257086	237641	78	19	680	0.00	0.00	0.00	0.00	0.00
182	257093	237687	77	19	643	0.00	0.00	0.00	0.00	0.00
185	256204	239568	80	21	1001	0.00	0.00	0.00	0.00	0.00
186	255785	239548	81	21	934	0.00	0.00	0.00	0.00	0.00
187	255615	239684	79	21	1098	0.00	0.00	0.00	0.00	0.00
188	255448	239926	79	21	1378	0.00	0.00	0.00	0.00	0.00
190	256750	239334	76	19	1090	48.00	0.44	0.34	16.50	2.09
191	256307	239403	78	21	890	40.00	0.45	0.36	14.50	1.84
192	256185	239484	79	21	915	0.00	0.00	0.00	0.00	0.00
193	254620	240381	83	31	779	0.00	0.00	0.00	0.00	0.00
194	254652	240610	86	31	568	0.00	0.00	0.00	0.00	0.00

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
195	254095	238602	80	24	627	109.00	0.65	0.48	52.20	6.62
196	254092	238643	78	24	589	118.00	0.64	0.50	59.10	7.49
197	253684	238390	82	25	771	33.00	0.43	0.34	11.30	1.43
198	253409	238094	82	25	992	0.00	0.00	0.00	0.00	0.00
199	254170	238194	76	22	656	232.00	0.73	0.50	117.10	14.85
200	251779	235993	79	12	656	114.00	0.70	0.53	60.00	7.61
203	251043	237236	89	11	805	39.00	0.47	0.37	14.40	1.83
204	251006	237187	88	11	746	47.00	0.53	0.43	20.20	2.56
205	250489	237255	84	11	794	16.00	0.20	0.15	2.30	0.29
207	253953	239994	83	30	718	123.00	0.55	0.38	46.10	5.85
208	254079	240060	84	30	780	103.00	0.60	0.44	45.60	5.78
209	254261	240143	83	30	907	65.00	0.53	0.41	26.80	3.40
210	253804	241176	82	32	452	117.00	0.69	0.50	58.70	7.44
211	254181	240585	83	31	619	45.00	0.59	0.46	20.80	2.64
212	254232	234223	89	13	1100	0.00	0.00	0.00	0.00	0.00
213	251956	235813	79	10	844	105.00	0.55	0.42	44.30	5.62
214	247785	235857	87	2	765	0.00	0.00	0.00	0.00	0.00
216	255108	240498	79	31	918	0.00	0.00	0.00	0.00	0.00
217	255281	240592	79	31	994	52.00	0.48	0.40	20.60	2.61
218	255460	240830	75	31	1054	46.00	0.46	0.36	16.40	2.08

House No.	Easting I.N.G. (m)	Northing I.N.G (m)	Altitude (m)	Nearest Turbine	Distance (m)	Days per year (worst case)	Max hours per day (worst case)	Mean hours per day (worst case)	Total hours (worst case)	Projected Hours Based on 12.68% reduction factor
219	255285	241036	78	31	838	47.00	0.55	0.44	20.60	2.61
220	255608	240886	77	31	1183	0.00	0.00	0.00	0.00	0.00
221	255523	241106	80	31	1070	36.00	0.44	0.34	12.10	1.53
222	255330	241212	82	31	879	40.00	0.52	0.42	16.70	2.12
223	255322	241490	82	31	936	39.00	0.50	0.39	15.30	1.94
224	255299	241806	80	31	1075	46.00	0.45	0.35	16.10	2.04
226	256380	237956	73	19	485	68.00	0.55	0.39	26.30	3.33
227	255224	235079	92	14	1118	46.00	0.44	0.34	15.80	2.00
228	251226	237475	106	11	1100	0.00	0.00	0.00	0.00	0.00
229	252058	235989	80	12	933	79.00	0.50	0.38	30.20	3.83
230	255275	236764	76	16	975	0.00	0.00	0.00	0.00	0.00
233	253711	238425	82	24	747	34.00	0.44	0.35	11.90	1.51
234	253140	237956	80	25	1148	0.00	0.00	0.00	0.00	0.00
236	255319	241508	82	31	940	40.00	0.49	0.38	15.40	1.95
237	254470	238988	77	22	623	186.00	0.72	0.54	99.50	12.62

Table 10.1 – Shadow Flicker Analysis of all houses within 1.13km

10.3.5 Mitigation Measures

The Shadow Flicker analysis presented is an indicative computer analysis that provides a measure of potential shadow flicker for the proposed adjusted Yellow River wind farm development. If the proposed Yellow River wind farm development is constructed and shadow flicker occurs in such a way that it is deemed to have an impact on the health and safety of nearby residents, mitigation measures will be put in place. To limit these effects, the developer will be responsible for implementing such mitigation measures, upon agreement with the house occupiers. This could involve the installation of appropriately designed blinds or screens to prevent any flicker nuisance. Furthermore vegetative screening could also be employed including treelines or hedgerows to limit or prevent shadow flicker occurrence.

In the unlikely event that shadow flicker does occur, the developer proposes to install a Shadow Flicker Management System, as a component of the turbine's SCADA (Supervisory Control and Data Acquisition) software. In brief, the system assesses the potential for shadow flicker to affect properties and shuts them down until the period with potential for shadow flicker has passed. The photocell (Light Sensor) is mounted on top of the turbine nacelle. Although the developer have yet to appoint a turbine supplier, a key aspect of the tender is the inclusion of a Shadow Flicker Management System. For further information, we have enclosed details of the 'Shadow Control Description' employed by Siemens in their wind turbines. As the turbine supplier has yet to be selected for the proposed Yellow River Wind Farm, this is an example only.

In brief, where adverse shadow flicker has been identified the monitoring / remediation procedure as agreed with Offaly County Council will be implemented and the impacted turbines will be shut down for the period of shadow flicker incidence.

10.4 CONCLUSION

Shadow Flicker is unlikely to cause a nuisance to nearby inhabited dwellings as there are only 2 houses located within 500 metres and these houses are located in areas where the levels of shadow flicker experience is below the limit of 30 hours per year. If it does become a nuisance appropriate mitigation measures can be implemented by the developer.

There are no significant shadow flicker impacts on dwellings in the vicinity of the proposed Yellow River Wind Farm development.