8. SHADOW FLICKER

Additional information relevant to Section 8 is presented in Appendix E in Volume 2 of 3 of the EIS.

8.1 RECEIVING ENVIRONMENT

Wind turbines, as with trees or any other tall structure, can cast long shadows when the sun is shining and is low in the sky. A phenomenon known as shadow flicker, which could be considered a nuisance, even though the effect would be very short-lived, could occur under certain conditions. This is where the blades of a wind turbine cast a shadow over a window in a nearby house. The rotation of the blades might cause a shadow to be cast about once per second or two in the room whose window is affected.

The shadow flicker effect lasts for just a short period and depends for its occurrence on the following factors:

- The sun not being obscured and being at a low angle in the sky.
- The turbine being directly between the sun and the affected property.
- There being enough wind for the turbines to be in operation.

It is part of the nature of long shadows that they pass any particular point relatively quickly and, due to the movement of the sun across the sky, the effect, if present, lasts for only a short period of time. It is generally only observed in the period after dawn and before sunset as the sun is rising and setting.

Potential occurrence of shadow flicker requires that the disc outlined by the rotating turbine blades be located in the path between the sun and a possible receptor. Each latitude on the globe has its own shadow signature. In the northern hemisphere the sun stays in the southern part of the sky in winter and shadows are distributed in a V-shaped area to the north of a turbine. In summer the sun rises to the northeast and sunset is in the northwest, meaning that summer shadows are distributed in an A-shaped area, with the turbine in the tip of the A. In the northern hemisphere, there is no potential shadow flicker occurrence at receptors located due south of a wind turbine because the arc of the sun's movement is such that sunshine from the north does not occur.

Concerns about shadow flicker have largely arisen in continental countries where wind turbines are located much closer to dwellings than is the practice in Ireland and where in summer months there is a high frequency of sunshine at dawn and before sunset.

Shadows that are cast outdoors are not considered a nuisance any more than shadows from trees moving in the wind.

8.2 IMPACT OF THE DEVELOPMENT

Where a window in a property is sufficiently far away from a wind turbine, the blades of the turbine will not appear to be chopping the light.

The DoEHLG Windfarm Planning Guidelines (Section 5.12) note as follows:

> *At distances greater than 10 rotor diameters from a turbine, the potential for shadow flicker is very low.*

Shadow flicker analysis was carried out for 44 residences around the perimeter of the site (see Figure 8.1), residences of landowners having a financial interest in the project being excluded, using the computer programme WindPRO. This uses the exact locations of the wind turbines and of the residences to calculate times throughout the year when the disc outlined by a rotating turbine blade viewed from the window of a house is in line with the sun and therefore a potential for shadow flicker occurrence exists. A zone of visual influence calculation is performed before the flicker calculation to ensure that all visible wind turbines contribute to calculated flicker values.

Shadow flicker calculations were conducted based on a notional window measuring 2 m wide x 1 m high and facing directly toward the closest turbine. The bottom of each window was assumed to be 4 m above ground level, being an equivalent height to a window in a two-storey house.

Further to the above the following was assumed in the analysis:

- All residences have a window that is oriented in such manner that it could potentially be affected.
- There is no intervening vegetation between turbines and receptors.

8.2.1 Predicted Impact

There are a number of candidate wind turbines being considered for deployment at Grousemount and, while the extent of shadow casting is determined principally by the size of the turbine's rotor blade diameter, i.e. longer blades cast longer shadows, calculations were undertaken for candidate turbines at either end of the range of turbine blade length being considered. They are the Nordex N80 (85 m tower height and 40 m long blades) and the Vestas V112 (70 m tower height and 56 m long blades).

In accordance with accepted based on the advise of the DoEHLG Windfarm Planning Guidelines, the extent of shadow casting was limited to a distance of 10 x the rotor blade diameter. Additionally, cumulative impacts were incorporated in the analysis by considering the presence of the adjacent wind farms.

Results, which are presented in Appendix E.4, are summarised in Table 8.1, where Annual Shadow Days, Maximum Daily Hours and Expected Annual Hours are presented for those residences where the presence of Grousemount Wind Farm contributes to potential shadow flicker occurrence.

Table 8.1: Expected Potential Shadow Flicker Occurrence

House	Nordex N80			Vestas V112		
	Annual Shadow Days	Max. Daily Hours	Expected Annual Hours	Annual Shadow Days	Max. Daily Hours	Expected Annual Hours
H7	26	0:14	0:23	26	0:17	0:28
H8	46	0:19	0:58	46	0:25	1:16
H9	51	0:20	1:11	52	0:27	1:35
H28	144	0:44	7:26	245	1:00	16:15

As expected, while the height of the turbine tower is a contributory factor, as shown in a comparison of the results shown in Appendices E.2 & E.4, the extent of shadow casting is determined principally by the size of the turbine's rotor blade diameter.

In the above, the expected annual hours have been automatically calculated by applying three factors to theoretical values, namely the rotor plane factor, the sunshine hours factor and the operational hours factor.

- It is unlikely that the wind and thus the rotor will track the sun, so there will be occasions when the rotor plane is in line with the sun direction and no flicker will occur. (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 63% of the theoretical results.)
- The sun will not be shining during all daylight hours. (The long-term mean value is typically less than 30% of daylight hours, but evidently this varies from month to month. Records from the nearest meteorological station for which such records are available indicate average daily sunshine hours ranging from 1:01 hours in December to 5:45 hours in May.)
- Long-term wind speed records from the nearest meteorological station are applied to take account of periods when wind speed is below the turbine cut-in wind speed. (Typical values are the range 80% - 85%.)

The combined effect of the above, which is reflected in the results in Table 8.1, is to reduce the expected annual values to approximately 15% of theoretical worst case values. Whereas it is unlikely to happen in practice, no correction to maximum shadow hours is applied, since the worst case scenario could still theoretically occur, despite the reduction to approximately 15% of cumulative hours annually.

Further to the above, turbines will be unavailable for operation at certain times, due for instance to routine and emergency maintenance, substation outages, etc. These factors also reduce potential shadow occurrence, but they are not reflected in the results.

The calculations indicate that, in addition to the four residences identified, houses H10, H11, H23, H24 and H25 also have potential shadow flicker occurrence. However, comparing the results presented in Appendix E.3 (Grousemount turbines only) and Appendix E.4 (all turbines) shows that there is no contribution attributable to the turbines at Grousemount Wind Farm.

8.2.2 Assessment

The predicted maximum expected shadow flicker occurs at house H28, which is not permanently occupied.

The DoEHLG Windfarm Planning Guidelines (Section 5.12) recommends that shadow flicker should not exceed 30 hours annually. The predicted maximum expected annual occurrence is 16:15 hours, which is slightly in excess of 50% of the recommended limit value.

The DoEHLG Windfarm Planning Guidelines (Section 5.12) recommends that shadow flicker should not exceed 30 minutes daily. Whereas the predicted maximum daily shadow hours is 1:00 hours, given that the number of annual days on which shadow could occur is 237, it is highly unlikely that the expected annual occurrence of 15:43 hours would be reached by a number of isolated instances of exceeding the 30 minute limit. Further to this, house H28 is occupied only on a part-time basis.

The Guidelines suggest that this limit should apply at neighbouring offices and dwellings within 500 m. At Grousemount all residences at which shadow flicker was analysed, including H28, are more than 500 m from the nearest turbine and in that context the predicted expected annual hours and maximum daily hours above are evidently low.

The following factors, of which no account has been taken in the analysis, also arise:

- The rooms whose windows are potentially affected will not be in use at all times that shadow flicker could occur.
- Occupants in rooms that are potentially affected will not be awake at all times that shadow flicker could occur.
- The impact of internal light levels and the presence of blinds or curtains on the potentially affected windows will have a mitigating effect.
- The presence of natural features such as trees and hedges, which will reduce or eliminate shadow flicker occurrence, has not been taken into account.

In relation to the latter, it will be obvious from Figure 8.2 that house H28 is surrounded by high vegetation, which renders it highly unlikely that it will be potentially impacted.

Shadow flicker analysis is based on the potential for even faint, partial shadows to be cast by the blades of a turbine. However, because of the distance of all houses from the turbines, at most only some of the sun’s light can ever be blocked out. A sharp shadow will never be cast on a residence by a blade.

The combined effect of many factors pertaining to the geometry of shadows and the dimensions and geometry of wind turbine blades is to greatly reduce the effect and impact of shadow flicker. It will actually be imperceptible for a significant amount of the time that blades are passing between the clear sun and a window of a residence.

The flickering frequency of any shadow occurring depends on the rate of rotation and the number of blades. It has been recommended that the critical flickering frequency should not be above 2.5 Hz, so as to avoid any possible potential to impact upon sufferers of a condition known as photosensitive epilepsy. (The UK National Society for Epilepsy identifies this threshold criteria as being 3 Hz). For a three bladed wind turbine this is equivalent to a rotational speed of 50 revolutions per minute (rpm). The turbines are likely to operate at a maximum of 19 rpm. Therefore, the health impact of flicker frequency is not considered further in this assessment

8.3 MITIGATION

The principal means of reducing the potential for shadow flicker is by turbine siting and maintaining a suitable turbine exclusion zone around sensitive receptors.

It is evident that, without operational constraints, the actual potential occurrence of shadow flicker at Grousemount will be very low and will be well below the accepted annual limit of tolerance.

However, in the highly unlikely event of validated records indicating a significant shadow flicker impact, the developer will consider suitable mitigation, which would include the following:

- Pre-programming turbines to prevent their operation on the dates and times when shadow flicker could cause a nuisance.
- Planting of vegetation close to the receptor in order to shield it from shadow flicker.

8.4 CONCLUSIONS

It is considered that significant impact from shadow flicker will not arise.

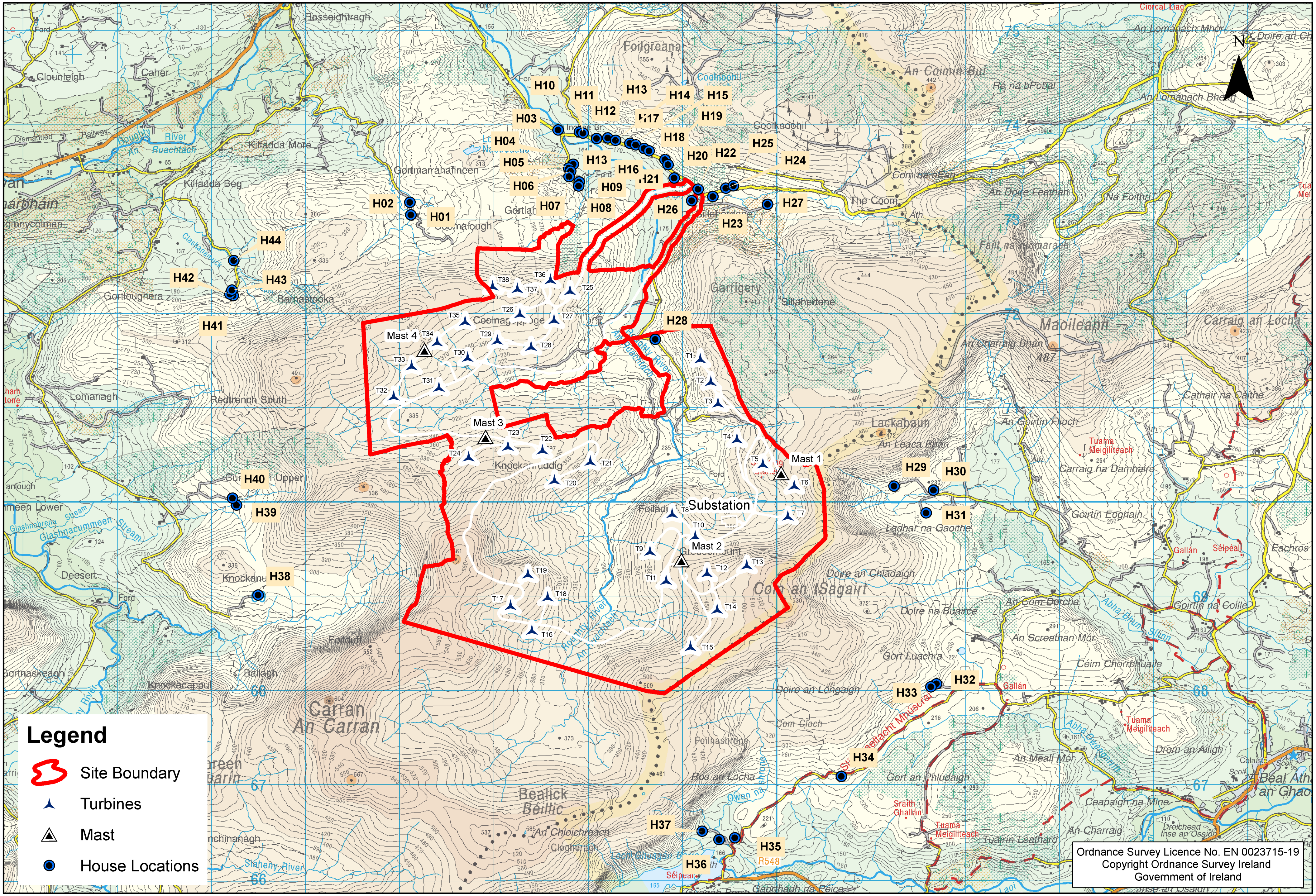

Figure 8.1 - House Locations - Shadow Flicker Analysis