

## Technical Appendix 1.7

### Shadow Flicker

#### 1. Introduction

This Technical Appendix reports the potential shadow flicker effects resulting from the Proposed Development on nearby sensitive receptors. This Technical Appendix (together with its associated figures and annexes) is not intended to be read as a standalone document and reference should be made to Chapter 2: Project Description of the Environmental Impact Assessment (EIA) Report.

The Update of UK Shadow Flicker Evidence Base (DECC, 2011) states that:

*“The term ‘shadow flicker’ refers to the flickering effect caused when rotating wind turbine blades periodically cast shadows over neighbouring properties as they turn, through constrained openings such as windows. The magnitude of the shadow flicker varies both spatially and temporally and depends on a number of environmental conditions coinciding at any particular point in time, including, the position and height of the sun, wind speed, direction, cloudiness, and position of the turbine to a sensitive receptor.”*

Any receptors which may be potentially affected by shadow flicker should be identified at the design stage of a proposed wind farm development and the potential occurrence of shadow flicker calculated.

The level of shadow flicker effects varies both spatially and temporally, and depends on a number of environmental conditions coinciding at a particular point in time, which include:

- time of day and year;
- wind direction;
- height of wind turbine and blade length;
- position of the sun in the sky;
- weather conditions;
- proportion of daylight hours in which the turbines operate;
- type and frequency of use of the affected space; and
- distance and direction of the wind turbine from the receptor.

The flickering effect caused by shadow flicker also has the potential to induce epileptic seizures in people with photosensitive epilepsy. The Epilepsy Society advises that around 1 in 100 people have epilepsy and up to 5% of these have photosensitive epilepsy (Epilepsy Society, 2024). The common rate of frequency at which photosensitive epilepsy might be triggered is between 3 and 30 hertz (Hz, flashes per second). Large commercial turbines rotate at low speeds resulting in less than 3 flashes per second and are therefore unlikely to cause epileptic seizures (Harding et al., 2008; Smedley et al., 2010). Therefore, there are not considered to be any health effects associated with the Proposed Development and this assessment will address the effects of shadow flicker related only to local amenity.

Turbines can also cause flashes of reflected light, which can be visible for some distance. It is possible to ameliorate the flashing, but it is not possible to eliminate it. Careful choice of blade colour and surface finish can help reduce the effect and



all modern turbine manufacturers use light grey semi-matt finishes to reduce this effect.

A wind development of more than one turbine can also result in more than one turbine affecting a specific receptor at any time, potentially increasing the overall shadow flicker intensity or frequency. This potential effect has been taken into account within this assessment as well as the cumulative effect with other operational and proposed wind turbines in the local area.

This Technical Appendix is supported by the following figures and annex:

- Annex A – Shadow Flicker Meteorological Data
- Annex B – Figures
  - o **Figure TA1.7.1** – Shadow Flicker Study Results – Real Case Scenario
  - o **Figure TA1.7.2** – Shadow Flicker Study Results – Worst Case Scenario
  - o **Figure TA1.7.3** – Cumulative Shadow Flicker Results

## 2. Consultation

East Ayrshire Council (EAC) responded to the EIA Scoping Report in March 2026, saying *“as noted in the report there is no level of shadow flicker which is deemed to be acceptable set out in guidance within the country, and the Planning Authority requires all shadow flicker, if a possible impact, will require to be mitigated”*.

On the study area, they note that *“The Planning Authority has experience of shadow flicker impacting on a property despite it being more than ten rotor diameters’ distance from the turbine in question. As such, if there are properties which are beyond such a distance but not too distant, consideration should be given as to the potential on such properties.”*

## 3. Assessment Methodology

### 3.1 Study Area

The Update of UK Shadow Flicker Evidence Base (DECC, 2011) recommends assessment of receptors located within 10 rotor diameters of a turbine and within 130 degrees either side of north. However, EAC’s Scoping comment noted previous experience of shadow flicker effects occurring beyond this distance. In response to this consultation feedback, the assessment was extended beyond the standard study area of ten rotor diameters and modelling was undertaken outwards from the site to where the model predicted no shadow flicker effects.

The shadow flicker assessment has been carried out for the proposed 14 turbines at the locations identified in **Chapter 2: Project Description**. The final turbine model has not been selected, and this will be based on the most advanced technology available at the time. Therefore, as a precaution this assessment is based on the worst-case scenario model (i.e. that with the largest proposed rotor area) that is being considered for the Proposed Development, within the envelope discussed in **Chapter 2**. Dimensions of the candidate models used for the purposes of the shadow flicker assessment can be found in **Table TA1.7-1**.



**Table TA1.7-1: Details of the Turbine Models Used for Shadow Flicker Modelling Purposes**

| Turbines                              | Hub Height | Rotor Diameter |
|---------------------------------------|------------|----------------|
| T2, T4, T5, T7, T8, T9, T10, T11, T12 | 119 m      | 162 m          |
| T1, T3, T6, T13, T14                  | 81.9 m     | 136 m          |

In accordance with East Ayrshire Council's Scoping Opinion, all residential receptors are treated as highly sensitive and any predicted shadow flicker effect is considered potentially significant unless mitigated. Accordingly, the assessment considers all receptors identified as potentially experiencing shadow flicker effects arising from the Proposed Development as sensitive receptors.

## 3.2 Desk Study

The desk study identified 35 residential receptors for assessment. Modelling subsequently predicted that shadow flicker effects could potentially occur at 31 receptors. As shown on Figures **TA1.7.1** and **TA1.7.2**, a number of receptors experiencing effects are located beyond the standard 10 rotor diameter study area, reflecting the extended assessment undertaken in response to consultation feedback. Four receptors within the wider study area were predicted to experience no shadow flicker effects on the basis of their location but have been retained within the full assessment for completeness.

**Table TA1.7-2** summarises the locations of the receptors and the distance from each property to the nearest turbine.

**Table TA1.7-2: Receptor Locations**

| ID | Property                 | Easting | Northing | Approximate Distance to Nearest Turbine (m) | Nearest Turbine |
|----|--------------------------|---------|----------|---------------------------------------------|-----------------|
| 1  | Dalfad Cottage           | 263545  | 624723   | 991                                         | 1               |
| 2  | Westbriggs               | 262417  | 623942   | 836                                         | 3               |
| 3  | Bellobank                | 262478  | 623966   | 834                                         | 3               |
| 4  | Stonebriggs              | 262493  | 623959   | 821                                         | 3               |
| 5  | Bellowbank               | 261103  | 622825   | 1,193                                       | 6               |
| 6  | Cronberry Schoolhouse    | 261006  | 622562   | 1,305                                       | 6               |
| 7  | Flat 1A Sharif House     | 260967  | 622559   | 1,344                                       | 6               |
| 8  | Flat 1 Rear Sharif House | 260972  | 622555   | 1,341                                       | 6               |
| 9  | Sharif House 2           | 260963  | 622552   | 1,350                                       | 6               |
| 10 | Sharif House 4           | 260954  | 622551   | 1,359                                       | 6               |
| 11 | Sharif House 5           | 260946  | 622544   | 1,367                                       | 6               |
| 12 | Sharif House 3           | 260952  | 622539   | 1,363                                       | 6               |
| 13 | Sharif House 6           | 260946  | 622535   | 1,369                                       | 6               |
| 14 | Sharif House 7           | 260944  | 622529   | 1,373                                       | 6               |



| ID | Property           | Easting | Northing | Approximate Distance to Nearest Turbine (m) | Nearest Turbine |
|----|--------------------|---------|----------|---------------------------------------------|-----------------|
| 15 | Field View 5A      | 260967  | 622530   | 1,349                                       | 6               |
| 16 | Field View 5B      | 260973  | 622525   | 1,344                                       | 6               |
| 17 | Sunnybrae          | 260918  | 622057   | 1,532                                       | 12              |
| 18 | Sunnyside          | 261027  | 621972   | 1,395                                       | 12              |
| 19 | Glenview           | 262374  | 620755   | 277                                         | 11              |
| 20 | Glenmuir Cottage   | 262510  | 620838   | 165                                         | 11              |
| 21 | Laigh Glenmuir     | 261717  | 620420   | 948                                         | 13              |
| 22 | Glenview Cottage   | 262357  | 620064   | 645                                         | 13              |
| 23 | Whiteholm Farm     | 262513  | 619922   | 521                                         | 14              |
| 24 | Springhill Farm    | 264176  | 619957   | 1,156                                       | 14              |
| 25 | Carbello Farm      | 261169  | 622876   | 1,130                                       | 6               |
| 26 | Nether Guelt       | 263616  | 619264   | 973                                         | 14              |
| 27 | Dornal Farm        | 263331  | 619496   | 621                                         | 14              |
| 28 | Low Garleffan Farm | 262453  | 619523   | 766                                         | 14              |
| 29 | Chestnut Cottage   | 264445  | 619273   | 1,614                                       | 14              |
| 30 | Darmalloch Farm    | 260976  | 620270   | 1,677                                       | 12              |
| 31 | Dalblair           | 264525  | 619239   | 1,701                                       | 14              |
| 32 | Wallaceton Farm    | 260303  | 621550   | 1,978                                       | 12              |
| 33 | Dalblair Bungalow  | 264505  | 619234   | 1,685                                       | 14              |
| 34 | Low Dalblair Farm  | 264569  | 619217   | 1,750                                       | 14              |
| 35 | Duncanziemere      | 261354  | 621761   | 1,010                                       | 12              |

## 4. Shadow Flicker Modelling

In assessing the effect of shadow flicker, the commercial software model WindPRO 4.2 was used to calculate the expected number of hours shadow flicker that could occur at each receptor. The model takes into account the movement of the sun relative to the time of day and time of year and predicts the time and duration of expected shadow flicker at a window of an affected receptor. The input parameters used in the model are as follows:

- the turbine locations;
- the turbine dimensions;
- the location of the receptors to be assessed; and
- the size of windows on each receptor and the direction that the windows face.

The WindPRO model is based upon a Zone of Theoretical Visibility (ZTV) analysis, which in this case was based upon a Digital Terrain Model (DTM) of 5 m resolution.



## 4.1 Worst-case Scenario

Calculations were undertaken for predicted shadow hours at each of the potential receptors for two scenarios: a theoretical (worst-case) and a real case scenario. For the worst-case scenario the following assumptions were made:

- each building façade of all receptors is modelled as a window ('greenhouse' approach);
- the turbine blades were assumed to be rotating for 365 days per year;
- there is a clear sky 365 days per year;
- the turbine blades were assumed to always be positioned towards each receptor;
- more than 20 % of the sun is covered by the blade; (in practice, at a distance, the blades do not cover the sun but only partly mask it, substantially weakening the shadow);
- the receptor is occupied at all times; and
- no screening is present (e.g. intervening vegetation).

The effect of shadow flicker was not calculated where the sun lies less than three degrees above the horizon due to atmospheric diffusion, low radiation (intensity of the sun's rays is reduced) and high probability of natural screening. It is generally accepted that below three degrees shadow flicker is unlikely to occur to any significant extent (Nordhein-Westfalen, 2002).

These assumptions result in a highly conservative assessment for the following reasons:

- the receptor may not directly face the turbines;
- the turbine blades will not turn for 365 days of the year, and will turn to face into the direction of the wind in order to maximise the energy generating potential from the wind, and therefore will not always face the receptor;
- it is unlikely that there will be clear skies 365 days a year;
- the receptor may not be occupied at the time that the shadow flicker impact is experienced; and
- screening, such as vegetation including the surrounding forestry, or curtains/blinds between the window and the turbine, is not accounted for within the model and, in practice, such screening will prevent any shadows from being cast onto the window and therefore prevent any flickering effect.

The assessment carried out is limited to the effects of shadows within buildings. Moving shadows will also be apparent out of doors; however, these do not result in flicker in the same manner or to the same extent, as the light entering windows. Therefore, shadow flicker effects outdoors have been scoped out of further assessment.

The modelling results for the theoretical scenario are typically considered to be a theoretical worst-case estimation of the actual impacts experienced, which would not arise in practice given the assumptions listed above.



## 4.2 Realistic Scenario

For much of the year weather conditions will be such that shadows will not be cast or will be weak and would therefore not give rise to shadow flicker effects. WindPRO calculations most likely overestimate the duration of effects as outlined in the theoretical scenario. Other factors such as the potential for screening by vegetation or structures will also reduce or prevent flicker incidence in practice. To create a more real case scenario for the potential impact of shadow flicker on receptors, it was necessary to identify the expected meteorological conditions at the site and take into account any significant shielding of receptors by buildings and vegetation between the receptor and the turbines.

In order to estimate the impact of cloud cover, information available from the Met Office (2024) was used to consider the likelihood of sunshine at different times of the year, and therefore allow calculations of the 'expected' values for shadow flicker occurrence. As part of the WindPRO calculation it is possible to upload data from a climatic station close to the Proposed Development.

In the case of the Proposed Development the closest weather station with available sunshine data is the Saughall weather station, located approximately 20 km north of the site.

The real case scenario represents a long-term average as it is based on long-term historic meteorological data. The variation between individual years can be significant and may lead to future observations differing from the predicted results.

A 16-degree sector wind rose was calculated for 7,446 hours of wind (assuming the Proposed Development is operational for 85 % of the year) based on Met Office data (see **Annex A**). The data is from Prestwick Airport weather station (approximately 24 km west of the site) over the period 1993-2021 as this was the closest weather station with sufficient wind data available.

The WindPro model also employs a slightly simplistic assumption that sunshine probability and turbine operational probability are independent parameters. The model therefore predicts slightly higher levels of shadow flicker than would actually occur as in reality there is correlation between bright and sunny weather conditions and low wind speeds.

There are a number of other assumptions in the real case scenario model which also lead to the model predicting higher levels of shadow flicker than are likely to be experienced, including:

- each building façade of all receptors is modelled as a window ('greenhouse' approach);
- the receptor is occupied at all times; and
- no screening is present.

## 5. Limitations to Assessment

All assumptions made by the WindPRO 4.2 model are noted above.

The real case scenario results represent an average as they are based on historic meteorological data from Saughall weather station (1991-2020) and Prestwick Airport (1993-2021) for sunshine and wind respectively. The variation between individual years can be significant and may lead to future observations differing from the predicted results.



As noted above, the historic meteorological data was taken from nearby Met Office weather stations and is not site-specific. Saughall weather station is approximately 20 km north of the site and Prestwick Airport weather station is approximately 24 km west of the site and there may be slight variation in using the historical data.

## 6. Baseline Conditions

A total of 35 residential receptors were identified for assessment based on their locations relative to the Proposed Development. Shadow flicker modelling determined that 31 receptors have the potential to experience shadow flicker effects under the assessment assumptions, while four receptors were predicted to experience no effects.

For the purposes of the assessment, each building façade of all receptors is modelled as a window ('greenhouse' approach) and no account has been taken of local screening such as vegetation, buildings, curtains or blinds. The assessment therefore represents a precautionary estimate of potential effects.

All receptors are considered to be of high sensitivity due to their residential nature.

## 7. Potential Effect

### 7.1 Construction

No shadow flicker will occur during the construction of the Proposed Development because the turbines would not yet be operational.

Given that any occurrence of shadow flicker during the short commissioning period would replicate itself during the operation of the Proposed Development, albeit more frequently, it is considered appropriate to consider the commissioning activities as part of the operational stage of the Proposed Development.

### 7.2 Operation

The modelling results presented in **Table TA1.7-3** below, present the theoretical worst-case scenario discussed in the previous section, in hours of shadow flicker per year for each potential receptor. Given that any level of shadow flicker effect is to be treated as significant and mitigated as such, it is shown that effects will potentially be experienced by 31 receptors in the worst-case scenario. It should be noted that this is theoretical modelling based on worst-case assumptions and, in reality, the duration of shadow flicker at each location would be considerably less than that indicated below, for the reasons outlined in **Section 4.1**.

**Table TA1.7-3: Shadow Flicker Assessment Summary of Results – Worst Case**

| Property ID | Property              | Total hours per year |
|-------------|-----------------------|----------------------|
| 1           | Dalfad Cottage        | 0:00                 |
| 2           | Westbriggs            | 95:48                |
| 3           | Bellobank             | 92:47                |
| 4           | Stonebriggs           | 94:15                |
| 5           | Bellowbank            | 32:14                |
| 6           | Cronberry Schoolhouse | 30:09                |
| 7           | Flat 1A Sharif House  | 27:54                |



| Property ID | Property                 | Total hours per year |
|-------------|--------------------------|----------------------|
| 8           | Flat 1 Rear Sharif House | 28:12                |
| 9           | Sharif House 2           | 27:55                |
| 10          | Sharif House 4           | 22:21                |
| 11          | Sharif House 5           | 22:03                |
| 12          | Sharif House 3           | 22:12                |
| 13          | Sharif House 6           | 21:50                |
| 14          | Sharif House 7           | 21:38                |
| 15          | Field View 5A            | 27:46                |
| 16          | Field View 5B            | 28:16                |
| 17          | Sunnybrae                | 43:32                |
| 18          | Sunnyside                | 53:08                |
| 19          | Glenview                 | 279:31               |
| 20          | Glenmuir Cottage         | 430:58               |
| 21          | Laigh Glenmuir           | 47:28                |
| 22          | Glenview Cottage         | 16:24                |
| 23          | Whiteholm Farm           | 107:21               |
| 24          | Springhill Farm          | 33:32                |
| 25          | Carbello Farm            | 34:44                |
| 26          | Nether Guelt             | 0:00                 |
| 27          | Dornal Farm              | 0:00                 |
| 28          | Low Garleffan Farm       | 0:00                 |
| 29          | Chestnut Cottage         | 5:26                 |
| 30          | Darmalloch Farm          | 20:37                |
| 31          | Dalblair                 | 4:13                 |
| 32          | Wallaceton Farm          | 3:34                 |
| 33          | Dalblair Bungalow        | 4:33                 |
| 34          | Low Dalblair Farm        | 3:46                 |
| 35          | Duncanziemere            | 86:23                |

The modelling results presented in **Table TA1.7-4** below represents the real case scenario. The inclusion of indicative wind data and average sunshine hours into the shadow flicker calculations has greatly reduced the potential of shadow flicker occurrence at all receptors, though given the recommended limits of zero, there are still significant effects.

**Table TA1.7-4: Shadow Flicker Assessment Summary of Results – Realistic Case**

| Property ID | Property       | Total hours per year |
|-------------|----------------|----------------------|
| 1           | Dalfad Cottage | 0:00                 |



| Property ID | Property                 | Total hours per year |
|-------------|--------------------------|----------------------|
| 2           | Westbriggs               | 10:00                |
| 3           | Bellobank                | 9:48                 |
| 4           | Stonebriggs              | 10:00                |
| 5           | Bellowbank               | 4:38                 |
| 6           | Cronberry Schoolhouse    | 5:00                 |
| 7           | Flat 1A Sharif House     | 4:41                 |
| 8           | Flat 1 Rear Sharif House | 4:44                 |
| 9           | Sharif House 2           | 4:41                 |
| 10          | Sharif House 4           | 3:37                 |
| 11          | Sharif House 5           | 3:36                 |
| 12          | Sharif House 3           | 3:38                 |
| 13          | Sharif House 6           | 3:34                 |
| 14          | Sharif House 7           | 3:33                 |
| 15          | Field View 5A            | 4:43                 |
| 16          | Field View 5B            | 4:49                 |
| 17          | Sunnybrae                | 7:21                 |
| 18          | Sunnyside                | 8:49                 |
| 19          | Glenview                 | 45:55                |
| 20          | Glenmuir Cottage         | 52:18                |
| 21          | Laigh Glenmuir           | 9:14                 |
| 22          | Glenview Cottage         | 3:13                 |
| 23          | Whiteholm Farm           | 21:39                |
| 24          | Springhill Farm          | 5:36                 |
| 25          | Carbello Farm            | 4:59                 |
| 26          | Nether Guelt             | 0:00                 |
| 27          | Dornal Farm              | 0:00                 |
| 28          | Low Garleffan Farm       | 0:00                 |
| 29          | Chestnut Cottage         | 1:01                 |
| 30          | Darmalloch Farm          | 4:17                 |
| 31          | Dalblair                 | 0:47                 |
| 32          | Wallaceton Farm          | 0:36                 |
| 33          | Dalblair Bungalow        | 0:51                 |
| 34          | Low Dalblair Farm        | 0:42                 |
| 35          | Duncanziemere            | 14:12                |

The model still does not take into consideration any local screening from vegetation, blinds or curtains, or true window orientation relative to the turbines, which in reality



will further reduce the potential time receptors could experience shadow flicker over the course of the year. This model also still assumes that each building façade of all receptors is a window ('greenhouse' approach) and that receptors are occupied at all times of the day that shadow flicker is predicted.

However, as requested by EAC, any potential impact on receptors is to be considered significant and will need to be mitigated as a result.

It is important to stress the theoretical and conservative nature of the model, and the absence of any consideration of screening in the model. For these reasons it is very unlikely the number of hours predicted in the 'realistic' scenario would actually occur at the potential receptors. In reality, the expected total shadow flicker hours will be less than modelled. Notwithstanding these points the Applicant is committed to provide a Shadow Flicker Mitigation Protocol to be activated, should any concerns in relation to shadow flicker effects be raised by residents, or shadow flicker subsequently be found to be causing nuisance in certain atmospheric conditions.

Any property that may be financially involved in the Proposed Development, will be subject to the same mitigation requirements, should they be assessed to potentially experience effects.

## 8. Cumulative Assessment

In order to assess the potential for cumulative impact from other wind developments in the surrounding area, all turbines that could feasibly affect receptors in conjunction with the Proposed Development were considered.

There are two developments that could feasibly contribute to cumulative shadow flicker impacts that overlap with the identified shadow flicker receptors for the Proposed Development. These developments are shown on **Figure TA1.7.3** and are:

- the in-planning Glen Water Wind Farm which lies approximately 2 km to the south of the site; and
- the in-planning The Drum Wind Farm which lies adjacent to the east of the site.

Specifications of the two wind farms are contained in **Table TA1.7-5**.

**Table TA1.7-5: Cumulative Wind Farm Developments**

| Cumulative Development | Number of Turbines | Max Rotor Diameter | Status      |
|------------------------|--------------------|--------------------|-------------|
| The Drum               | 8                  | 162                | In Planning |
| Glen Water             | 6                  | 170                | In Planning |

The two cumulative developments were added to the WindPRO model, and the model was rerun for the 'realistic' scenario. **Table TA1.7-6** details the calculated total combined 'realistic' hours of shadow flicker per year at the 35 potential receptors as a result of the three developments being simultaneously operational.

**Table TA1.7-6: Shadow Flicker Assessment Summary of Results – Cumulative**

| ID | Property       | Total Hours per year |
|----|----------------|----------------------|
| 1  | Dalfad Cottage | 0:00                 |



| ID | Property                 | Total Hours per year |
|----|--------------------------|----------------------|
| 2  | Westbriggs               | 10:56                |
| 3  | Bellobank                | 10:47                |
| 4  | Stonebriggs              | 10:59                |
| 5  | Bellowbank               | 4:37                 |
| 6  | Cronberry Schoolhouse    | 4:59                 |
| 7  | Flat 1A Sharif House     | 4:41                 |
| 8  | Flat 1 Rear Sharif House | 4:44                 |
| 9  | Sharif House 2           | 4:41                 |
| 10 | Sharif House 4           | 3:37                 |
| 11 | Sharif House 5           | 3:36                 |
| 12 | Sharif House 3           | 3:37                 |
| 13 | Sharif House 6           | 3:34                 |
| 14 | Sharif House 7           | 3:33                 |
| 15 | Field View 5A            | 4:43                 |
| 16 | Field View 5B            | 4:49                 |
| 17 | Sunnybrae                | 7:20                 |
| 18 | Sunnyside                | 8:48                 |
| 19 | Glenview                 | 52:17                |
| 20 | Glenmuir Cottage         | 59:54                |
| 21 | Laigh Glenmuir           | 9:32                 |
| 22 | Glenview Cottage         | 3:13                 |
| 23 | Whiteholm Farm           | 21:38                |
| 24 | Springhill Farm          | 5:36                 |
| 25 | Carbello Farm            | 4:59                 |
| 26 | Nether Guelt             | 4:02                 |
| 27 | Dornal Farm              | 0:02                 |
| 28 | Low Garleffan Farm       | 1:18                 |
| 29 | Chestnut Cottage         | 4:02                 |
| 30 | Darmalloch Farm          | 4:17                 |
| 31 | Dalblair                 | 3:36                 |
| 32 | Wallaceton Farm          | 0:36                 |
| 33 | Dalblair Bungalow        | 3:23                 |
| 34 | Low Dalblair Farm        | 1:53                 |
| 35 | Duncanziemere            | 16:28                |

The cumulative assessment demonstrates that limited additional hours or minutes of shadow flicker may arise at some receptors as a result of the proposed Glen



Water Wind Farm and The Drum Wind Farm operating concurrently with the Proposed Development. The greatest increases occur at receptors already identified as potentially experiencing shadow flicker from the Proposed Development alone.

Notwithstanding this, EAC's approach is that any shadow flicker effect should be mitigated. As mitigation is proposed through implementation of a Shadow Flicker Mitigation Protocol for the Proposed Development, the cumulative assessment does not alter the overall conclusions of the assessment. Should the cumulative developments also be consented and constructed, it is expected that similar mitigation protocols would be implemented as part of the conditions of their consent. Therefore, any potential cumulative shadow flicker effects would be appropriately reduced or avoided at all potentially affected receptors.

## 9. Mitigation

Although the real case scenario takes into consideration expected operational time for the turbines and average sunshine hours for the region, the results are likely to still be conservative due to local vegetation, dwelling orientation and internal screening from blinds, curtains or furniture that are not included in the model. Additionally, while shadow flicker may potentially occur at these locations it is possible that flicker will not be 'experienced' at all locations due to the time of day during which it may potentially occur and use of the properties.

Nevertheless, in the event of consent being granted, in order to ensure that potential shadow flicker effects do not occur at any property, the Applicant proposes that prior to the erection of the first turbine a written scheme (known as the 'Wind Farm Shadow Flicker Protocol') will be submitted to and approved in writing by East Ayrshire Council. This will set out mitigation measures to eliminate shadow flicker attributable to the Proposed Development as well as a protocol for addressing a complaint received from any potentially affected residence.

Operation of the turbines would be required to take place in accordance with the approved Shadow Flicker Protocol and any mitigation measures that have been agreed through the protocol would require to be implemented as appropriate.

Mitigation measures could include the provision of local screening to reduce or block shadow flicker affecting a receptor. Should screening provision not be possible, the most effective measure to mitigate shadow flicker is selective automatic turbine shutdown during the times of year when shadow flicker is predicted, if the weather conditions are such that shadow flicker would occur. The relevant technology which will allow for the automatic shutdown of the turbine would be fitted to the Proposed Development's turbines and details included within the 'Wind Farm Shadow Flicker Protocol'.

It is proposed that the provision and agreement of a Wind Farm Shadow Flicker Protocol is secured through an appropriately worded planning condition.

Similar shadow flicker mitigation protocols have been proposed or secured at other wind farm developments within the local area where the potential for shadow flicker effects has been identified. The Applicant considers that implementation of the proposed Wind Farm Shadow Flicker Protocol, including investigation of complaints and selective turbine shutdown where required, represents a robust and effective mitigation measure.



Through implementation of the approved Wind Farm Shadow Flicker Protocol, any shadow flicker effects attributable to the Proposed Development would be appropriately managed and either eliminated or reduced to an acceptable level.

## 10. Summary

This assessment considers whether the effect known as 'shadow flicker' is likely to be caused by the Proposed Development and assesses the impacts on nearby sensitive receptors. Shadow flicker is the effect of the sun passing behind the moving rotors of the turbines casting a flickering shadow through the windows of nearby properties. The effects can vary due to combinations of geographical position, time of day, time of year and specific weather conditions.

The assessment considered residential properties located within and beyond the standard shadow flicker study area in response to consultation feedback received from East Ayrshire Council. A total of 35 residential receptors were assessed.

Shadow flicker modelling identified that 31 of those receptors could potentially experience shadow flicker effects under the conservative assessment assumptions adopted. Predicted effects ranged from less than one hour per year to approximately 52 hours per year under the realistic assessment scenario.

The assessment demonstrates that shadow flicker effects are highly dependent on a combination of turbine operation, sunshine conditions, receptor orientation and occupancy. The modelling includes a number of conservative assumptions and does not take account of local screening effects, meaning actual shadow flicker experienced in practice is expected to be lower than predicted.

The cumulative assessment identified limited additional shadow flicker contributions from the proposed Glen Water Wind Farm and The Drum Wind Farm at some receptors.

In accordance with East Ayrshire Council's requirements, a Wind Farm Shadow Flicker Protocol would be prepared and agreed with the Council prior to operation of the Proposed Development. The protocol would include procedures for investigating complaints and implementing mitigation measures, including selective turbine shutdown where necessary. Subject to implementation of the protocol, shadow flicker effects would be appropriately managed (i.e. reduced or eliminated) throughout the operational life of the Proposed Development.



## 12. References

Department of Energy and Climate Change (DECC) (2011). Update of UK Shadow Flicker Evidence Base. Prepared by Parsons Brinckerhoff. London: Department of Energy and Climate Change.

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## Annex A – Shadow Flicker Meteorological Data

### Sunshine Hours – Saughall

**Table A-1** summarises the raw historical data for Saughall weather station.

**Table A-1: Summary of Meteorological Data for Saughall from 1991-2020**

| Month     | Number of Days in Month | Average Sunshine Hours per Month | Hours per Day |
|-----------|-------------------------|----------------------------------|---------------|
| January   | 31                      | 38.16                            | 1.23          |
| February  | 28                      | 65.3                             | 2.33          |
| March     | 31                      | 103.08                           | 3.33          |
| April     | 30                      | 147.94                           | 4.93          |
| May       | 31                      | 196.49                           | 6.34          |
| June      | 30                      | 164.47                           | 5.48          |
| July      | 31                      | 158.89                           | 5.13          |
| August    | 31                      | 155.02                           | 5.00          |
| September | 30                      | 116.96                           | 3.90          |
| October   | 31                      | 83.38                            | 2.69          |
| November  | 30                      | 54.32                            | 1.81          |
| December  | 31                      | 38.67                            | 1.25          |

### Wind Parameters – Prestwick Airport

**Table A-2** outlines the wind parameters used within the WindPRO model for the Proposed Development. It summarises data for 16 directional sectors and assumes the Proposed Development would be operational for 7,446 hours per year (i.e. 85% of the year). Wind distribution data for the site is taken from the historical weather station data for Prestwick Airport.

**Table A-2: Wind Distribution at Prestwick Airport from 1993-2021**

| Direction | Wind Distribution | Hours of Wind / year | Operational Hours (85%) |
|-----------|-------------------|----------------------|-------------------------|
| N         | 1.637%            | 143.40               | 121.89                  |
| NNE       | 2.149%            | 188.25               | 160.01                  |
| NE        | 4.478%            | 392.27               | 333.43                  |
| ENE       | 5.018%            | 439.58               | 373.64                  |
| E         | 7.740%            | 678.02               | 576.32                  |
| ESE       | 5.532%            | 484.60               | 411.91                  |
| SE        | 5.047%            | 442.12               | 375.80                  |
| SSE       | 4.904%            | 429.59               | 365.15                  |
| S         | 10.639%           | 931.98               | 792.18                  |



| Direction | Wind Distribution | Hours of Wind / year | Operational Hours (85%) |
|-----------|-------------------|----------------------|-------------------------|
| SSW       | 6.777%            | 593.67               | 504.62                  |
| SW        | 9.036%            | 791.55               | 672.82                  |
| WSW       | 11.493%           | 1006.79              | 855.77                  |
| W         | 12.206%           | 1069.25              | 908.86                  |
| WNW       | 6.573%            | 575.79               | 489.43                  |
| NW        | 4.871%            | 426.70               | 362.69                  |
| NNW       | 1.899%            | 166.35               | 141.40                  |

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## Annex B – Figures

