



Wind Power Aviation Consultants Ltd

Wind Farm Aviation Lighting and Mitigation Report for Mynydd Fforch Dwm Wind Farm -V3.0

Our Reference: WPAC 076/22

Your Reference: Mynydd Fforch Dwm Energy Park Ltd 59698 dated Apr 2022

Authors: Commander John Taylor, RN (Ret)

Squadron Leader Mike Hale MBE MSc CFS RAF (Ret)

Light Modelling, GIS and Mapping – Sam Taylor BA (Hons) MSc

Wind Power Aviation Consultants Ltd, Company No.: 6811887
e-mail: enquiries@wpac.co.uk Tel.: +44 (0)2380767345 Mob.: +44 (0)7949234440
www.wpac.co.uk

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Reference Documents

- A. Civil Aviation Publication (CAP) 764 Civil Aviation Authority (CAA) Policy and Guidance on Wind Turbines Version 6, Feb 2016
- B. CAP 764 Version 7 (Draft) issued for comment in June 2020 (to be released shortly)
- C. Air Navigation Order (ANO) Article 222
- D. CAA Policy Statement: Lighting of Onshore Wind Turbine Generators in the United Kingdom with a maximum blade tip height at or in excess of 150m Above Ground Level dated 01/06/17
- E. International Civil Aviation Organisation (ICAO) Annex 14 Vol 1 Chapter 6
- F. CAA SARG Approval letter dated 2 December 2022 Mynydd Fforch Dwm Wind Farm (Appendix C to this report)

Scope

1. This report is divided into two parts. Part 1 proposes a lighting design that is compliant with existing and draft (but soon to be ratified) regulations and guidance contained within References A to E as discussed with the CAA and the MOD. It explains the rationale behind the lighting design taking into account the requirement to minimise the number of turbines illuminated with aviation obstruction lights whilst maintaining flight safety and provides a detailed assessment of the brilliance of the lighting when viewed from a number of viewpoints provided by the LVIA consultant after consultation with the relevant stakeholders including the Local Planning Authority. Part 2 of the report identifies and explains those mitigation measures that can be utilised to minimise the environmental effect of the lights including an assessment of the historical meteorological data from which to predict the luminous intensity requirements for the lights. The entire report can be considered to fulfil the requirements for an Aviation Lighting Landscape and Visual Impact Mitigation Plan.

Part 1 Turbine Lighting Layout Design

Introduction

2. WPAC have designed a number of CAA and MOD compliant lighting layouts for wind farms and have also been in constant dialogue with the CAA regarding the proposed change to CAP 764 in terms of aviation lighting requirements. Whilst Reference A is technically the current publication for policy and guidance on this issue, Reference B was released for comment and is already being used by the CAA as the current *de facto* policy. Discussions with the CAA have clarified that the draft regulations will not be changing in terms of the overarching policy but the wording may be slightly amended in the interests of clarity.

Proposed Mynydd Fforch Dwm Wind Turbine Site

3. Naturalis Energy Development Ltd has proposed a wind farm located in the Welsh Valleys 7km to the east of Neath Castell-Nedd. The proposed site sits on two hills, Mynydd Fforch Dwm and Mynydd Blaenafon and straddles the Nant Blaenpelenna River. Taking the name Mynydd Fforch Dwm (MFD) the turbine site has 6 turbines laid out in an approximately east-west configuration.

4. This proposed turbine site is within MOD Low Flying Area (LFA) 7. At night this area converts to Night Allocated Region (NRR) 7S an area primarily reserved for low flying helicopters in the hours of darkness. MFD is located in an area where fixed-wing aircraft (fast jet and tactical transport) are limited by 'flow control' measures that limit both their routing and altitude. This restricts the utility of this airspace and therefore the presence of such fixed-wing aircraft.

5. Conversely, the hilly and built-up nature of the Welsh Valleys dictates that this is an active helicopter operating region. Emergency Helicopters operating in the area at night will include: Police, Ambulance, Coast Guard and various Military formations down to 30ft (9m) on occasion. Due to the density of MOD and civilian helicopters operating in the airspace, the development will require a comprehensive obstruction lighting arrangement that includes both visible and infra-red obstruction lights.

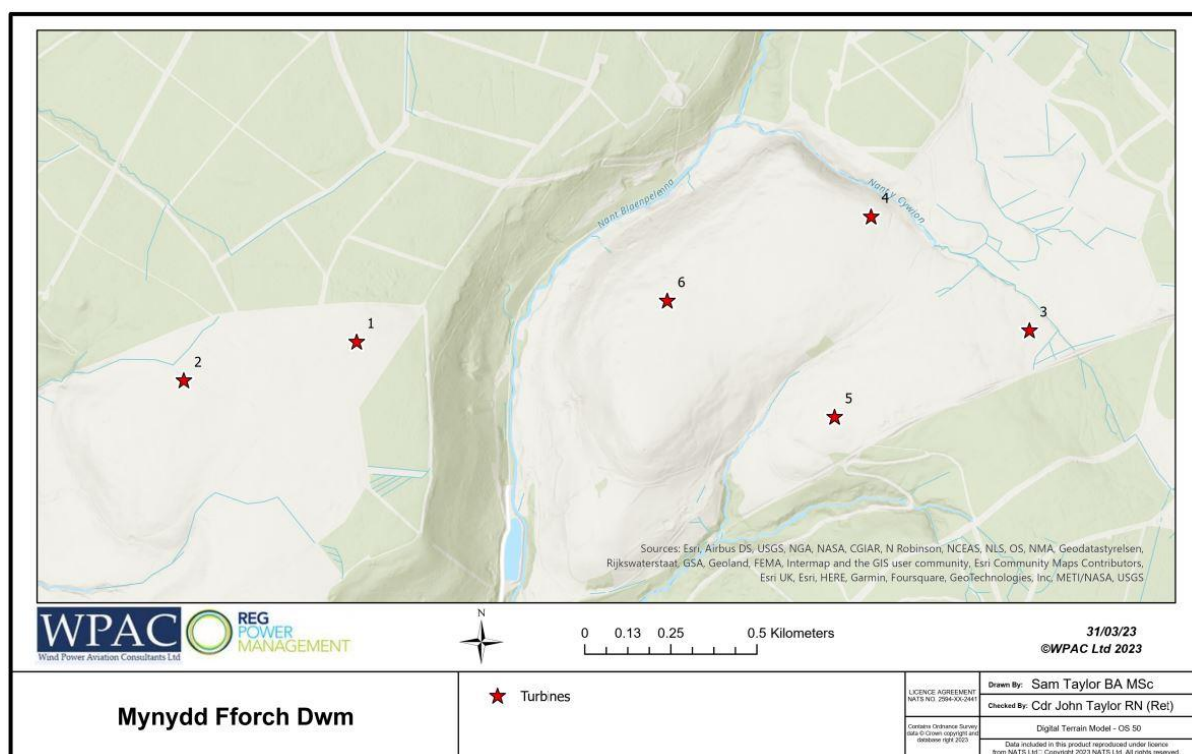


Figure 1 Mynydd Fforch Dwm

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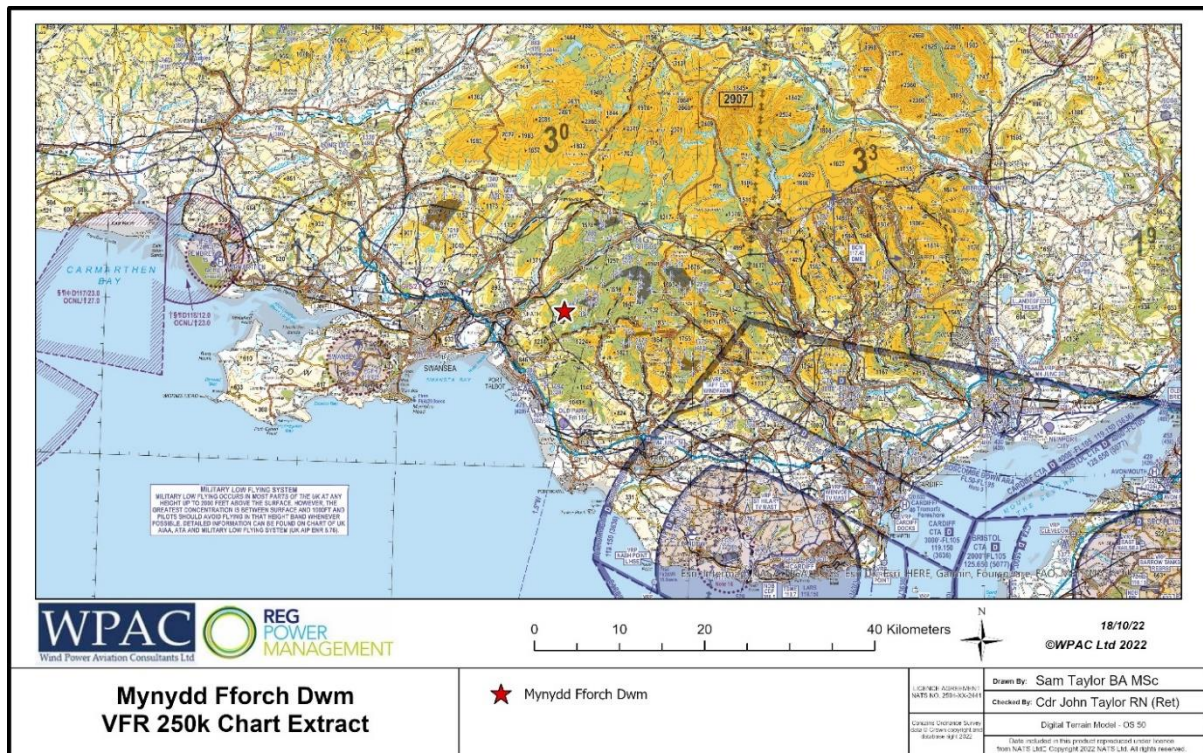


Figure 2 Mynydd Fforch Dwm Wind Farm location on an aviation chart

Lighting Assessment Overview

- From a CAA perspective, MFD is sited outside the Cardiff Airport Control Zone (CTZ) and Control Area (CTA), so will be assessed for visible lighting in accordance with Class G 'en-route' airspace requirements as detailed in CAP 764 advice.
- To accommodate MOD requirements, the site will be assessed for NVG compatible lighting in accordance with MOD published obstruction lighting specifications.
- Where possible, the recommended final lighting configuration has been optimised to reduce light impact on the local area.
- The MFD wind turbine proposal is for 6 turbines: between 180 and 200m to tip.

CAA-ANO Red 2000/200cd Lighting (In compliance with CAA CAP 764 - Draft)

6. In accordance with the CAP 764 (draft) conditions, the CAA requires:
 - That all perimeter turbines be lit unless removing a light will leave a gap of less than 900m total between the remaining lit turbines.



- That any turbine within 200m of a 'string perimeter' be lit unless the distance between adjacent turbines is less than 900m total. Note a 10% additional dispensation is sometimes available.
- That any unlit turbine does not exceed a 10° up-slope from adjacent lit turbines.

Applying these criteria dictates that all turbines of the MFD site will require ANO visible red lighting.

Note: Whilst it might have been possible to apply for no light on T1, it and T6 will be the closest turbines to the Nant Blaenpelenna valley which may be used by helicopters in poor (low cloud) weather.

Turbines with 2000/200cd Lights: T1, T2, T3, T4, T5 and T6

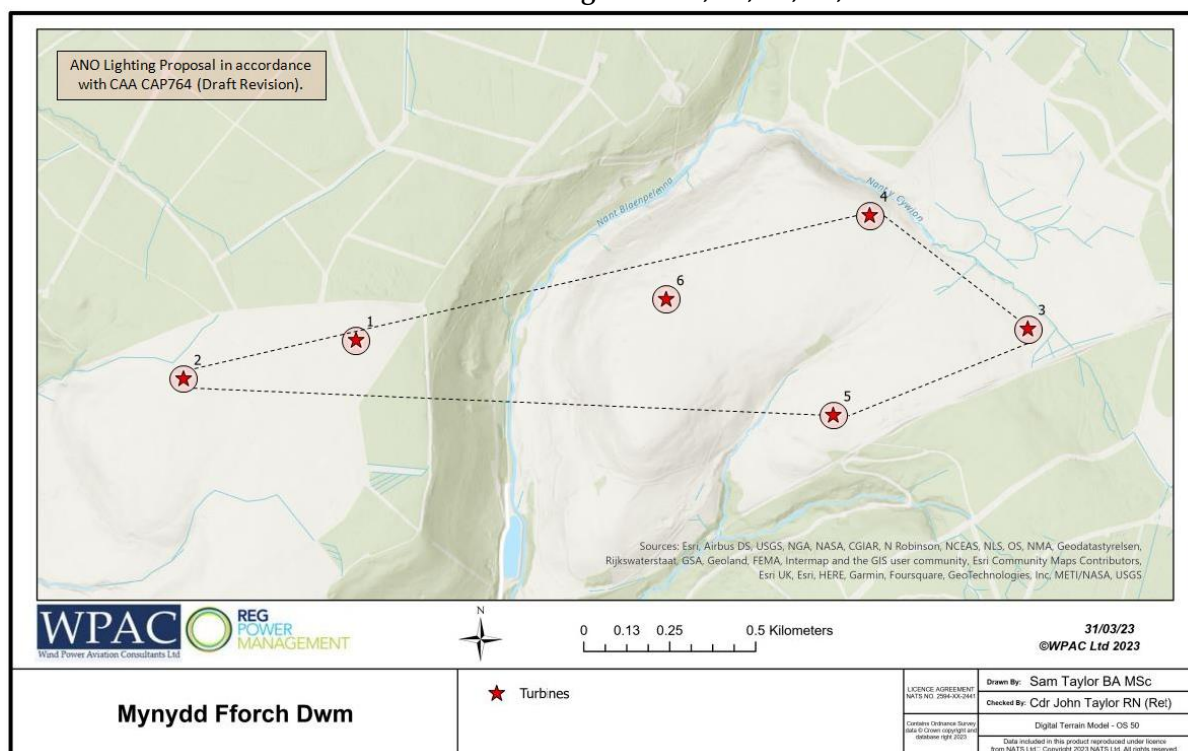


Figure 3 CAA-ANO CAP764 Compliant Lighting Arrangement

CAA-ANO Red 2000/200cd Lighting. (Reduced Lighting Proposal)

7. The CAP compliant visible lighting proposal at Figure 3 results in a significant number of lights for a small 6 turbine site.

8. When considering how to reduce the effects of lighting, in this specific case the only opportunity is to reduce lighting intensity instead of light numbers, therefore, whilst maintaining terrain specific safe lighting, the following was proposed.

- That all dominant corner turbines be lit by ANO 2000cd lights (T2, T3, T4).

- That the remaining turbines (T1, T5 and T6), that sit inside the area defined by the dominant corner turbines, be lit with ANO 200cd lights. These lights would adequately mark the turbines closest to the Nant Blaenpelenna valley for slower moving craft (helicopters). Note: faster fixed-wing aircraft would not use such a small valley and, indeed, will not be expected to be low flying at the heights of the turbines in this area.

Turbines with 2000/200cd Lights: T2, T3, and T4

Turbines with 200cd Lights: T1, T5 and T6

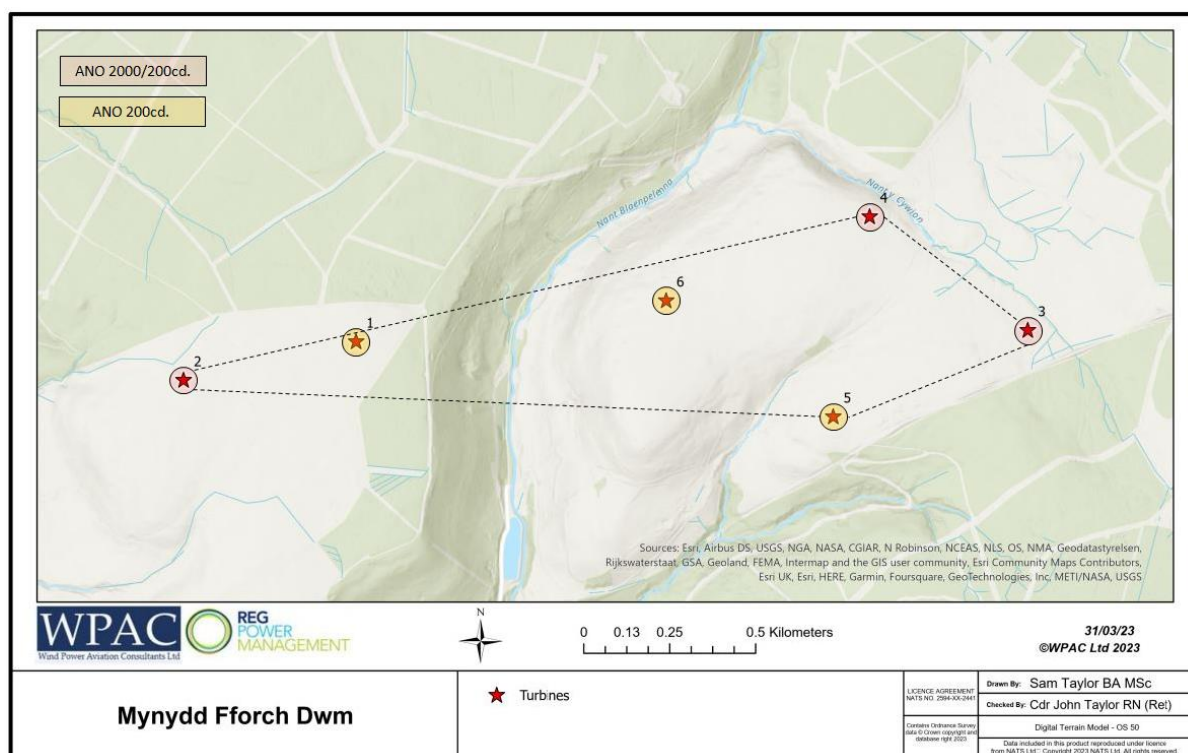


Figure 4 CAA-ANO CAP 764 Modified Lighting Arrangement

MOD Lighting Requirements

9. Early detection is important especially if the aircraft is manoeuvring hard and the air temperature profile causes the turbines to blend into the background. Suitable lighting is necessary for flight safety.

10. MOD IR lights have been developed to be invisible to the public at large but very detectable to aircrew night vision aids. As such the MOD IR lights can have a wide beam width and flash continuously without disturbing the environment.

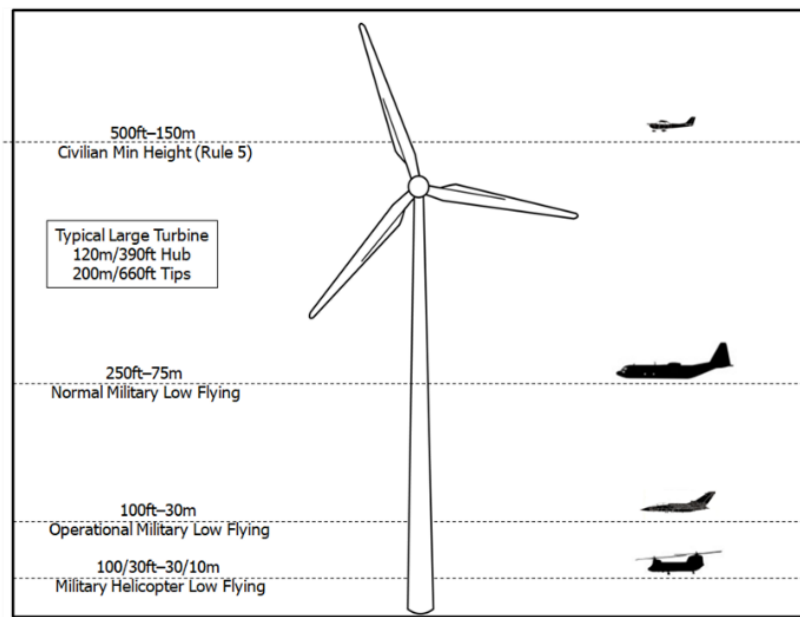


Figure 5 Wind turbine in context with MOD Low Flying

MOD Infra-Red Lighting Layout

11. The MOD requires:

- That all 'compound-perimeter' (see diagram) turbines be lit unless removing a light will leave a gap of less than 500m between the remaining perimeter lit turbines. Note: at this site, the 'CAA string' and 'MOD compound' perimeters are quite similar.
- That any dominant turbine, by location or height, be lit. Note: here, all turbines are lit.

Applying these criteria dictates that all of the turbines of the MFD site will require IR lighting.

Turbines with Infra-Red: T1, T2, T3, T4, T5 and T6

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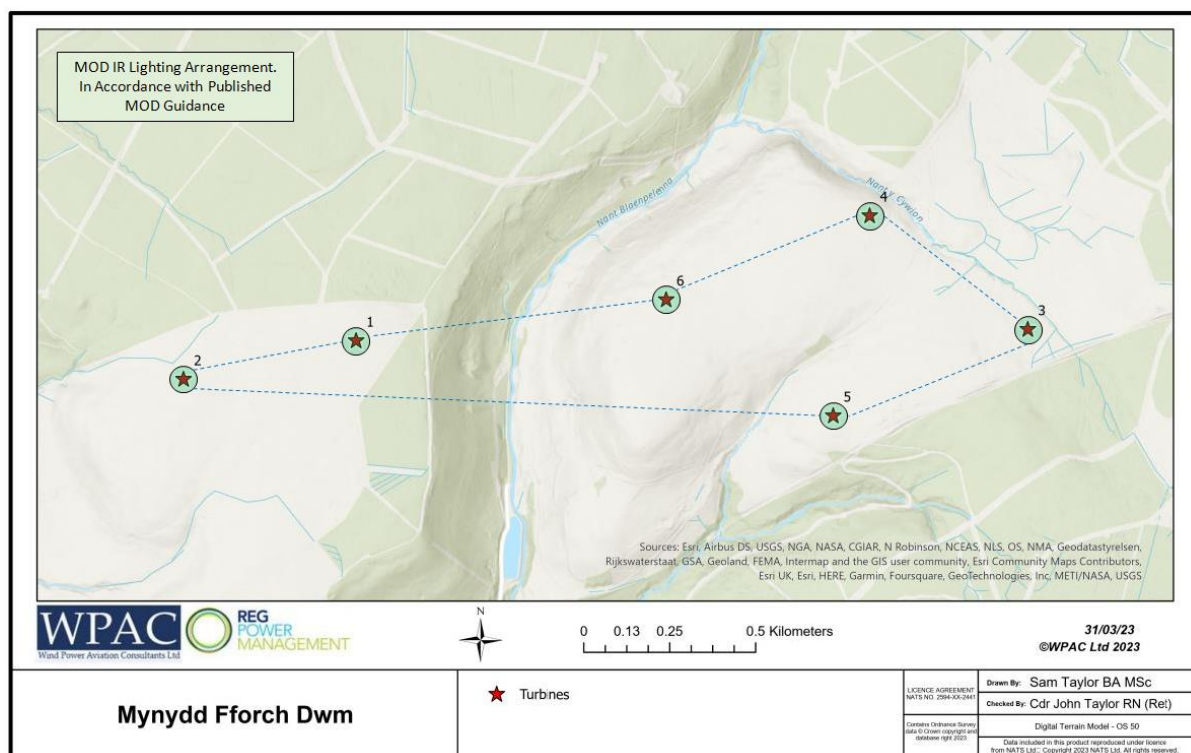


Figure 6 Proposed MOD Infra-Red Lighting Arrangement

Combined CAA Visible Lighting and MOD Infra-Red Lighting

Mynydd Fforch Dwm – Turbine Lighting Table							
Turbine	Easting	Northing	Tip Ht	Rotor Dia	Hub Ht	CAA ANO	MOD IR
1	281131	197711	180	150	105	200cd	600mW/sr
2	280629	197599	180	150	105	2000/200cd	600mW/sr
3	283088	197744	200	150	125	2000/200cd	600mW/sr
4	282628	198074	200	150	125	2000/200cd	600mW/sr
5	282522	197493	200	150	125	200cd	600mW/sr
6	282036	197830	200	150	125	200cd	600mW/sr

Table 1 Proposed CAA and MOD Lighting Arrangement



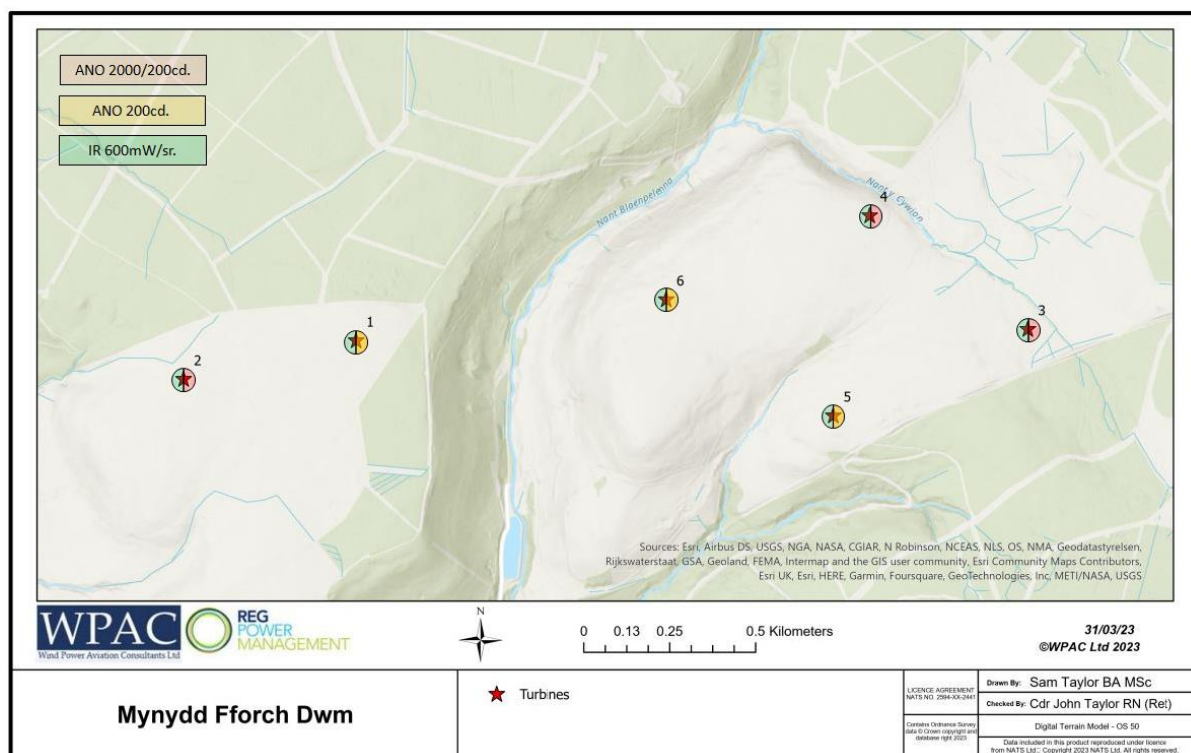


Figure 7 Combined CAA/MOD Lighting Arrangement

12. Many airports accept 200cd lights (as opposed to 2000/200cd lights) in the vicinity of the airfield. The proposal to use 200cd lights on MFD simply applies this option.

ANO Light Specifications

13. The ANO 2000/200cd Lights will conform to the ICAO specification as set out in Annex 14 Table 6-3. The lights will also be controlled such that when the met visibility is greater than 5km in all directions from all turbine hubs, the 2000cd lights will be reduced to 200cd (10% of normal power). This reduction in power will not apply to MOD IR Lights.

ICAO Annex 14 Table 6-3 (excerpt)

Benchmark intensity	Minimum requirements					Recommendations				
	Vertical elevation angle (b)			Vertical beam spread (c)		Vertical elevation angle (b)			Vertical beam spread (c)	
	0°		-1°			0°	-1°	-10°		
	Minimum average intensity (a)	Minimum intensity (a)	Minimum intensity (a)	Minimum beam spread	Intensity (a)	Maximum intensity (a)	Maximum intensity (a)	Maximum intensity (a)	Maximum beam spread	Intensity (a)
2000	2000	1500	750	3°	750	2500	1125	75	N/A	N/A

a) 360° horizontal. All intensities are expressed in Candela. For flashing lights, the intensity is read into effective intensity, as determined in accordance with the Aerodrome Design Manual (Doc 9157), Part 4.

b) Elevation vertical angles are referenced to the horizontal when the light unit is levelled.

c) Beam spread is defined as the angle between the horizontal plane and the directions for which the intensity exceeds that mentioned in the "intensity" column.

Table 2 ICAO Annex 14 Table 6-3 Medium Intensity Lighting Specifications.

14. **Low Intensity Mid Mast Lights** – Mid mast lighting was originally intended to give an attitude/range reference (horizon indication) to pilots flying at night in the days before NVGs. Tip/hub and mid lights will give a vertical reference (from which a horizontal reference can be gauged) when fitted to a single vertical structure. In contrast, a single light will not be able to give a vertical or horizontal reference or indication of range and range-rate. However, a series of single tip/hub lights, on a group of structures, will provide a good horizon reference together with range and range-rate clues. Accordingly, the requirement for mid-masts lights is much diminished if not made redundant in the case of multiple vertical structures such as wind farms.

15. All of the current commercially available 32cd (supposedly focused) lights are over-engineered (up to 70cd between -30deg and +40deg to fit a multitude of aviation and marine applications) they induce a disproportionately large environmental impact, often significantly more than the focused hub 2000/200cd lights. WPAC requested that the CAA guidance requirement for 32cd (Type B) mid mast lights be removed for Mynydd Fforch Dwm which was approved in their response at Appendix C.

Table 6-2. Light distribution for low-intensity obstacle lights

	Minimum intensity (a)	Maximum intensity (a)	Vertical beam spread (f)	
			Minimum beam spread	Intensity
Type A	10 cd (b)	N/A	10°	5 cd
Type B	32 cd (b)	N/A	10°	16 cd
Type C	40 cd (b)	400 cd	12° (d)	20 cd
Type D	200 cd (c)	400 cd	N/A (e)	N/A

Note.— This table does not include recommended horizontal beam spreads. 6.2.1.3 requires 360° coverage around an obstacle. Therefore, the number of lights needed to meet this requirement will depend on the horizontal beam spreads of each light as well as the shape of the obstacle. Thus, with narrower beam spreads, more lights will be required.

Table 3 ICAO Annex 14 Table 6-2 Low Intensity Obstacle Lights.

IR Light Specifications

16. The IR lights will conform to the MOD specification as set out in MOD Lighting Guidance and shown below in Table 4.

MOD Specification IR.

IR wavelength – 750 to 900nm.

But ideally concentrated within 800 to 850nm for optimum detection by all military NVG types.

IR intensity – 600mW/sr minimum at peak flash but not above 1200mW/sr.

(Note: Typically a 300mW/sr steady burn LED IR light will generate 600mW/sr at peak flash)

This will generate a 7-8 nm NVG pick-up range - remaining above 5nm as the light ages.

Horizontal Pattern – unrestricted 360 deg.

Vertical Pattern – Minimum flash intensity of 600 mW/sr between +30 deg and -15 deg elevation.

– up to 50% reduction between +25 to +30 deg and -10 to -15 deg is acceptable.

– Maximum intensity of 1200 mW/sr for all angles of elevation.

– Vertical overspill is acceptable.

Flash Pattern – 60 flashes per min at 100-500 ms duration (ideally 250ms)

Synchronisation – all lights to be visually synchronised across a wind farm site

Table 4 MOD Specification for IR Obstacle Lights

Timings

17. The lights (IR and ANO) will be switched on between Evening Civil Twilight and Morning Civil Twilight in accordance with the UK Almanac; approximately 11 hours per day when averaged over the year.

Assessment of Aviation Lighting and Potential Mitigation Measures Designed into the Lights

18. Having defined a layout of turbines to be fitted with visible lighting, an assessment has been undertaken to calculate the brilliance of the lights when seen from a number of viewpoints. The standard aviation lights to be fitted to the nacelle of the turbines are required to fulfil certain design criteria in terms of brilliance and coverage as per Table 2. They are designated 'medium intensity obstruction lights' and have a minimum luminous intensity of 2000 candela¹ at horizontal and slightly above. The LED lights are also required to be able to shine a beam that reduces in intensity above and below the horizontal. One manufacturer of such obstruction lights, CEL, have tested their light, the CEL MI-2KR² in a calibration chamber and produced results showing precisely how much the beam reduces in brilliance at any specified elevation angle. The results are interpolated to every 0.1°. These lights are already fitted in a number of locations around the UK.

¹ Candela is the SI Unit of luminous intensity and refers to the amount of light emitted in a particular direction.

² The Technical Specification is at: <https://www.contarnex.com/led-obstruction-lighting/medium-intensity-led-obstacle-warning-lighting.php>

19. Figure 8 demonstrates the reduction in luminous intensity below the horizontal and also above 1° in elevation. The various coloured lines are the candela measured from different angles in the horizontal in order to measure the performance all around the light.

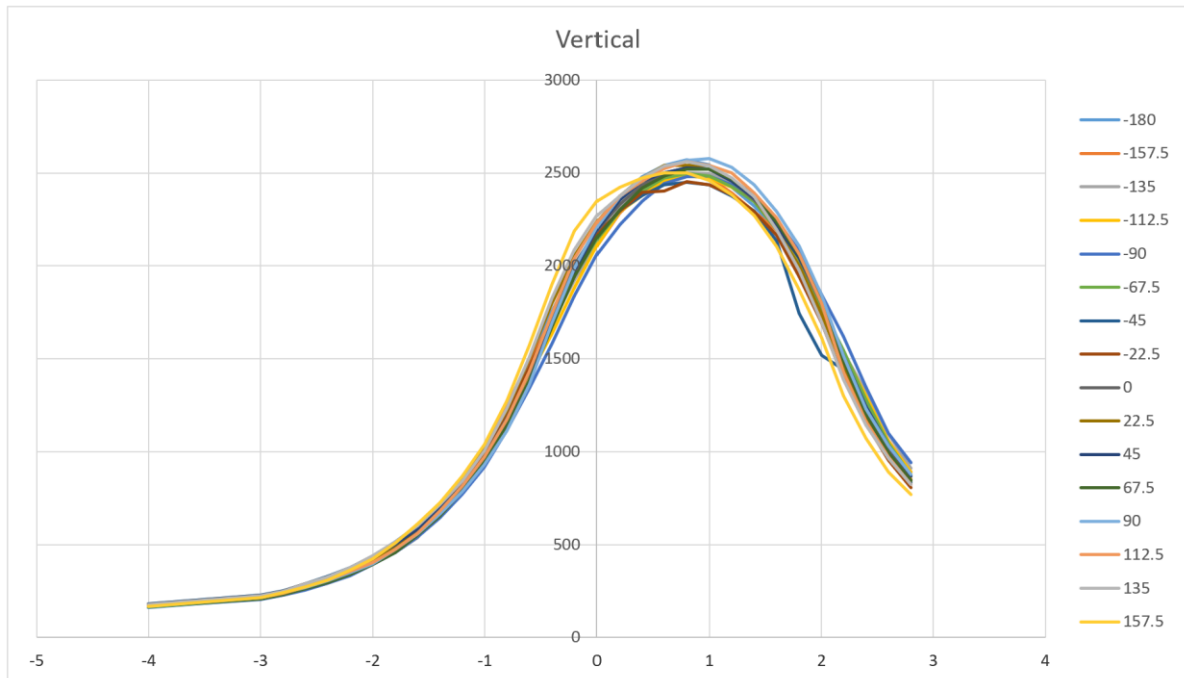


Figure 8 (MI GAM Light Measurement Results)

20. WPAC have utilised their propagation modelling system (Rview) to calculate the precise angle of elevation between the turbine light and a viewpoint assuming a height of eye of 1.5 metres and a turbine hub height of 105 and 125 metres as required. The system utilises a standard atmospheric model and an earth model that uses actual earth curvature between the turbine light and the viewpoint. Ordnance Survey OS50 DTM is used as the terrain model. The calculations have been undertaken for each designated lit turbine against all designated Mynydd Fforch Dwm Wind Farm viewpoints. The locations of the viewpoints are shown in Figure 9 and Table 5. The assessment has been undertaken utilizing the turbine lighting layout shown in Figure 4 and Table 1. It is possible that one or two viewpoint locations may be moved very slightly when the on site photography is undertaken, but for all practical considerations, the results for each point will remain the same.

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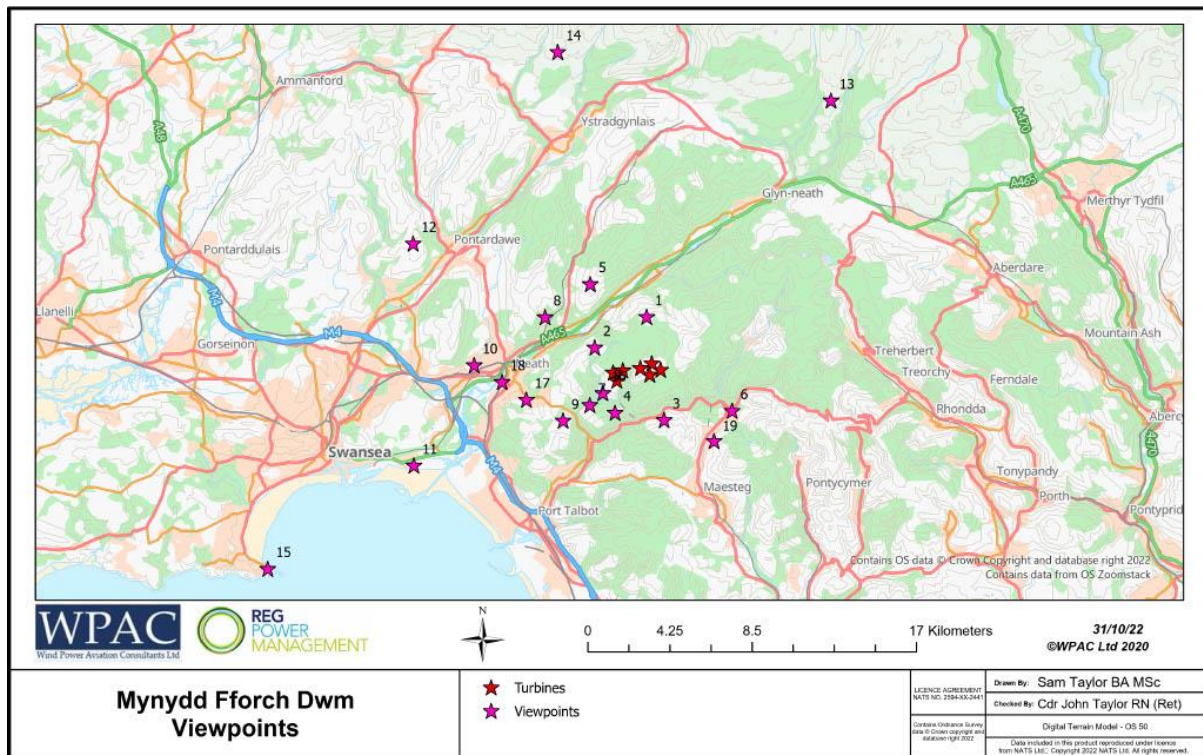


Figure 9 Viewpoint Locations



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Viewpoint Number	Viewpoint Name	Easting	Northing
1	St Illtyd's walk near Carn Caca	282364	200464
2	East of Tonna	279678	198885
3	By-way near Cynonville	283268	195153
4	Afan Bike Park	280726	195528
5	Sarn Helen	279445	202152
6	Heol-Y-Fedw, Croeserw	286786	195629
7	Tonmawr Road, Tonmawr	279422	195927
8	Cilfrew	277107	200451
9	Bridleway near Cimla Equestrian Centre	278039	195125
10	Heol Penlan, Neath Abbey	273439	197975
11	Beach Path, Swansea University Bay Campus	270319	192752
12	Cwn Clydach walk outside Pontardawe	270281	204297
13	National Park, above Pontneddfechan	291901	211671
14	National Park, above Ystalfera	277763	214168
15	Mumbles Head, (AONB: Gower)	262755	187428
16	John's Terrace, Tonmawr	280093	196543
17	Cimla Common	276140	196201
18	A474 flyover, Neath	274882	197111
19	Pleasant View, Caerau	285850	194012

Table 5 Viewpoints

21. The next stage in the process is to take the candela figures radiated towards a viewpoint and taking into account the distance, calculate the lumens per square metre (also known as Lux) that will be experienced by the human eye at the viewpoint. The figure produced is in micro-lumens per square metre or $\text{lumen}^{(10^{-6})}/\text{m}^2$ or $\text{lux}^{(10^{-6})}$. These are perfect clear-air figures and therefore worst case results from an LVIA perspective. Figures obtained by this method enable comparisons to be made with commonly understood light sources such as stars or planets. In practice the light intensity at the observation points will be further attenuated by scatter and absorption by airborne dust, droplets and aerosols in the atmosphere. This attenuation is typically in the order of 10 to 20% but can be as high as 75% at the more distant observation ranges. The results for every lit turbine from all of the viewpoints are shown in the results tables in Appendix A to this report. Viewpoints where lights are obstructed by terrain are shaded in green, when the viewpoint is too close to a turbine to get an accurate assessment it is shaded red. **To take into account any limitations within the terrain model we have highlighted in purple any viewpoints where the line of sight is under 10 metres above ground level but above 1.5 metres and should therefore, still be screened by terrain but may be visible within the vicinity of the viewpoint.**



Interpreting the Results

22. The results show that there is a significant decrease in the luminous intensity (candela) of the light emanating towards those viewpoints which are at lower angles of elevation in relation to the turbine hub, however, when considering the perception of the light from a viewpoint, in general the distance between the light and the viewpoint is the dominant factor and the resultant figure in microlumens is the most relevant figure to consider. This report provides the results and anticipates that the Landscape and Visual Impact Assessment (LVIA) consultants will be able to put them into the correct context for visualisations in terms of background environmental lighting and atmospheric conditions. Table 6 shows the turbine with the greatest potential perceived luminous intensity expressed in microlumens at each viewpoint. It should be noted that in this case a number of the selected viewpoints are significantly lower than the hub lights, down in a valley and are lower in terms of the angle between the light and the viewpoint than the calibrated results have been measured for. However, interpreting the results in Figure 8 show that it is likely in these cases the light seen at the viewpoint will be so dim as to be rendered almost invisible.

Viewpoint	Brightest Lit Turbine	Distance (km)	microlumens per m ² (lux ¹⁰⁻⁶)	Microlumens at 10%	Obscured
1	2	3.35	61.6	6.2	
2	2	1.60	29.3	2.9	
3	3	2.60	18.5	1.9	
4	2	2.07	30.6	3.1	
5	2	4.70	26.0	2.6	
6	3	4.26	11.7	1.2	
7	2	2.06	17.6	1.8	
8	2	4.53	8.8	0.9	
9	2	3.58	15.1	1.5	
10	2	7.20	4.9	0.5	
11	2	11.39	3.2	0.3	
12	2	12.33	7.8	0.8	
13	4	16.46	5.8	0.6	
14	2	16.82	6.1	0.6	
15	2	20.57	2.3	0.2	
16	2	1.18	53.5	5.4	M
17					X
18					X
19	5	4.82	0.9		

Table 6 Brightest Turbine Hub Light from each Viewpoint (measured in micro-lumens)

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23. In order to place the values in microlumens per m² (lux¹⁰⁻⁶) in context, Table 7 provides some examples of approximate values placed on a number of environmental comparators, however these are just an illustration to place the results in a real world environment. The actual perceived brightness will depend upon a number of factors including bulb manufacturer, bulb type, specific construction (single/multiple colour LEDs etc) atmospheric conditions, absorption spectrum, individual eye characteristics and capabilities.

Comparison Object	Approximate Illuminance (micro-lumens per m ²)
Car Halogen main beam approaching 1km	Up to 1,000,000 (can vary significantly between cars)
International Space Station (400km up)	1000 (depends upon relative position of sun)
Car Brake Light at 0.5km	400
Car Brake Light at 0.7km	200
Car Brake Light at 1.0km	100
Car Brake Light at 2.0km	25
Car Brake Light at 5.0km	4
Car Brake Light at 10km	1
Front Cycle Light at 0.5km	140 (Modern high power white LED)
Front Cycle Light at 0.7km	70
Front Cycle Light at 1.0km	35
Front Cycle Light at 2km	9
Front Cycle Light at 5km	2
White LED Street Light at 0.5km	500 (Viewed from the horizontal)
White LED Street Light at 0.7km	250
White LED Street Light at 1.0km	120
White LED Street Light at 2.0km	30
White LED Street Light at 5.0km	8
Sodium Street Light at 0.5km	300 (Viewed from the horizontal)
Sodium Street Light at 0.7km	150
Sodium Street Light at 1.0km	75
Sodium Street Light at 2.0km	20
Sodium Street Light at 5.0km	5
Brightest Star in the Sky (Sirius)	13
Airliner flying at 30,000ft)	Nav Lights 0.4 to 5; anti-collision lights 2 to 20
Typical bright star (e.g. Orion)	0.5 to 2.0
Faintest light visible from street lit area	0.4
Visible limit for fully dark-adapted eyes	0.02

Table 7 Comparisons of approximate micro-lumens values



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24. If there is a requirement to consider the brightest turbine in terms of emitted candela rather than micro-lumens, Table 8 provides data on which turbine emits the most candela towards each viewpoint but takes no account of the distance between light and viewpoint.

Viewpoint	Brightest Lit Turbine	Distance (km)	Candela	Candela at 10%	Obscured
1	2	3.35	690.6	69.1	
2	3	3.60	198.8	19.9	
3	3	2.60	125	12.5	
4	4	3.18	180.8	18.1	
5	2	4.70	576	57.6	
6	3	4.26	212.3	21.2	
7	2	2.06	75	7.5	
8	3	6.57	207.8	20.8	
9	4	5.46	239.3	23.9	
10	2	7.20	256.4	25.6	
11	4	13.41	448.4	44.8	
12	2	12.33	1192.2	119.2	
13	2	18.03	1721.2	172.1	
14	2	16.82	1721.2	172.1	
15	2	20.57	982	98.2	
16	2	1.18	75	7.5	M
17					X
18					X
19	5	4.82	21.68		

Table 8 Brightest Turbine Hub Light measured in Candela emitted towards a viewpoint



Part 2 Mitigation

Intensity Reduction (ANO Lighting: 2000cd down to 200cd)

25. The lights (IR and visible red lights) will be switched on between Evening Civil Twilight and Morning Civil Twilight in accordance with the UK Almanac; approximately 11 hours per day averaged over the year. The primary mitigation consideration in addition to the already described reduction in brilliance due to elevation angle, is taken from Reference D which states:

'If the horizontal meteorological visibility in all directions from every wind turbine generator in a group is more than 5 km, the intensity for the light positioned as close as practicable to the top of the fixed structure required to be fitted to any generator in the windfarm and displayed may be reduced to not less than 10% of the minimum peak intensity specified for a light of this type'.

26. It is therefore possible to take advantage of the CAA SARG Policy Statement dated 01/06/2017 and incorporate the option to reduce the hub height lighting to not less than 10% of the minimum peak intensity specified for the installation in good weather; in essence, reducing the 2000cd obstruction lights to 200cd in meteorological visibilities greater than 5km.

Note: This concession is not applicable to those lights already limited to a maximum brilliance of 200cd or to MOD specification IR lighting, which is covered separately.

27. It will be necessary to calculate how much time the lights would spend at 2000cd and at 200cd. To assess historical visibility in this South Wales region, the closest meteorological station to Mynydd Fforch Dwm is at Cardiff Airport. Although the visibility will not be identical at these locations it will be in the same air-mass for the majority of the time and will give similar observations. Table 9 is a Met Office table of visibilities throughout the year for Cardiff Airport which are averaged over a 30-year period.

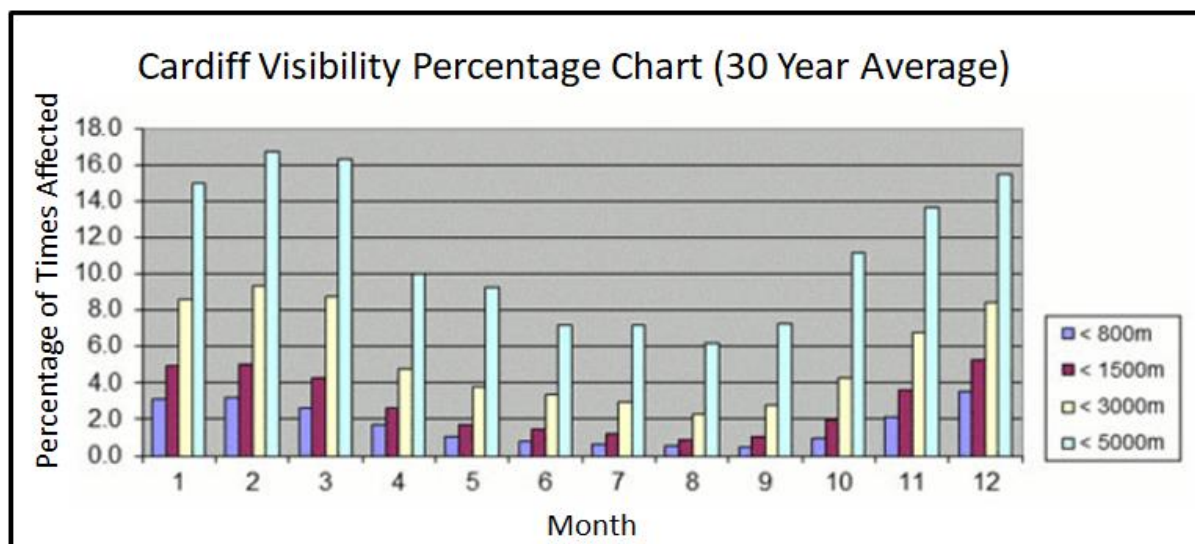


Table 9 Visibility Table for Cardiff Airport (Light Blue is 5km Indicator)

28. This Met Office table shows that the visibility is below 5km (light blue bar) for an average of 12% of the time at Cardiff Airport. This suggests that the lights at Mynydd Fforch Dwm will be set at **2000cd for 12% of the time (visibility below 5km) and set at 200cd (visibility below 5km) for 88% of the time.**

29. Whilst Cardiff Airport is not Mynydd Fforch Dwm, the figures can be expected to be remarkably similar. Indeed, met visibility improves with height since the concentration of particles (dust, haze) and liquid droplets (water) reduces with height and the air also becomes thinner. It could be argued that the Mynydd Fforch Dwm visibility, on a 300m hill, will be better than that at Cardiff Airport and the lights will spend less time at 2000cd higher setting.

Obstruction Light: Weather (Cloud) Obscuration.

30. On occasion, the visibility in the area will reduce significantly due to the presence of cloud on the hills. If the turbines are in cloud, then the obstruction lights will not be seen.

31. The average height of the turbine hubs (where the lights are mounted) will be around 400-500m amsl. (Note: turbine hub heights and terrain altitudes vary across the site). For aeronautical reasons, cloud bases are quoted in feet (ft) so measurements will now be given in feet. Converting 400 to 500m gives 1300 to 1650ft.

32. It is now possible to compare the average turbine hub/light heights of 1300-1650ft amsl with the actual cloud bases recorded by the Met Office at Cardiff Airport, again, over a 30-year period as shown in Figure 10. The maroon bars show when the cloud-base first drops below 1000ft and therefore low enough below the turbine red light for the light to be significantly obscured – even invisible to the human eye

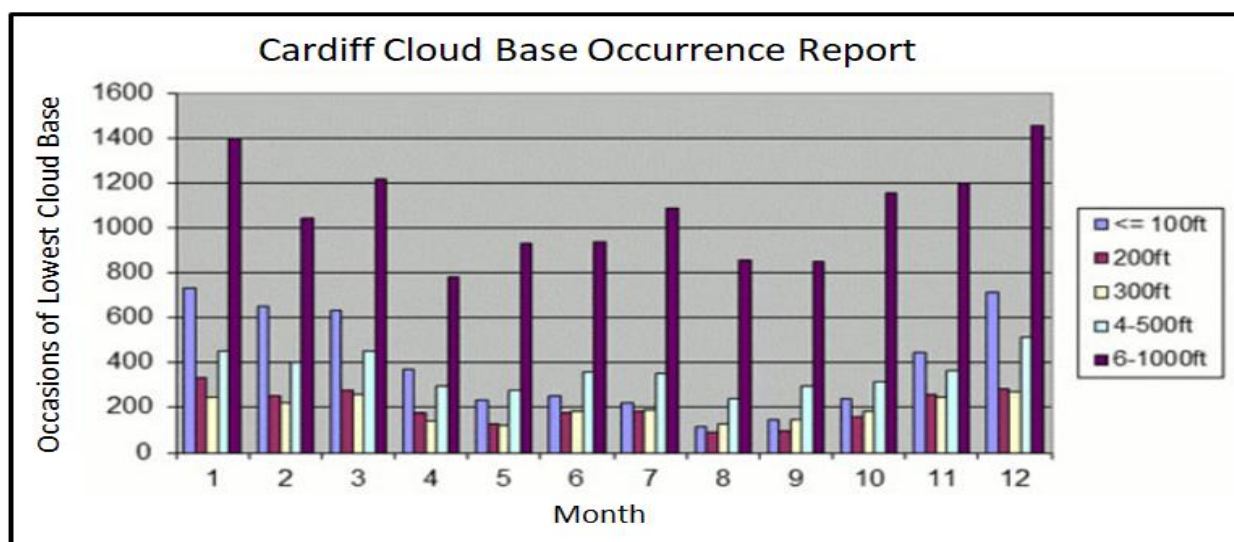


Table 10 Cardiff Cloud Base Table

33. The burgundy columns (600-1000ft) indicate that the cloud base will be comfortably below turbine hub heights on around 1000 occasions a month. At this distance below the turbine hubs the lights will be effectively obscured to the general public.

34. The other columns (light blue in particular 400-500ft) indicate that on a further 300-500 or more occasions a month the lights will be obscured by cloud. Note: met office statistics report cloud base in occurrences as opposed to total duration.

35. Again, whilst Cardiff Airport is not Mynydd Fforch Dwm, Met Office statistics show that the cloud-base reduces in the region of hills. It could be argued that located on a 300m hill, the cloud-base would be lower than at Cardiff thus providing even greater degree of obstruction light obscuration than calculated here.

Weather Obscuration Conclusion

36. It is most important not to try and combine the two different observations, visibility and cloud-base, into a single statement. Informal advice direct from Met Office and Airport forecasters indicate that the information so gathered, should be presented as follows:

Meteorological observations suggest that the turbine hubs will be obscured on more than a thousand occasions a month by cloud. (Obstruction lights not visible)

When not obscured by cloud, the visibility in the area of the turbines can be expected to exceed 5km for up to 88% of the time. (Obstruction lights switched down to 200cd)

Conclusion

37. The MFD site does not benefit appreciably from the concessions available in the latest CAA CAP 764 resulting in every turbine having to have a visible obstruction light. To reduce the overall intensity of the visible obstruction lights, and their impact on local populated areas, WPAC proposed a reduced lighting scheme which is in concert with extant CAA lighting approvals. This requires having the 3 dominant turbines fitted with 2000/200cd lights and 3 turbines fitted with 200cd lights whilst all turbines carry an Infra-Red light.

38. However, the site is in an area where it will positively benefit from the weather obscuration of its visible ANO lighting. This obscuration benefit is potentially quite significant. Moreover, when the lights are not obscured by cloud, they can all expect to be set at the lower 200cd for 88% of the time.

Technical Mitigation

39. One other form of potential mitigation commonly discussed is the installation of an Aircraft Detection Lighting System (ADLS). There are two possible methods of detecting an aircraft approaching a wind farm that will automatically turn on the aviation obstruction lights, firstly through the use of a suitable primary surveillance radar (PSR) or secondly, the use of aircraft installed Electronic Conspicuity (EC) equipment with a suitable receiver at the wind farm. There are some significant technical and regulatory issues to be overcome before any such system can be installed and operated in the UK.

40. In the case of PSR, this is already in use at wind farms in Europe; as an example the Terma Scanter 5002 radar is installed at a number of sites as shown in Figure 10. The main regulatory constraint is that although such systems are in use in Europe, in the UK, where airspace tends to be shared to a much greater extent between users, the CAA have yet to mandate the performance parameters that such a system must be capable of fulfilling. For example, the coverage requirement will need to be defined in terms of maximum range of detection and activation (which may vary depending upon the speed of the aircraft), base of cover (above ground level) and almost certainly a maximum height coverage to avoid unnecessary activations, which a PSR on its own cannot ascertain. An initial set of draft requirements was promulgated in 2018 but these were for discussion with aviation stakeholders and the wind industry and it cannot be assumed that these are going to be the final criteria. Even if the standards are defined, it may be that any single radar will not be capable of delivering the required coverage where, for example, a wind farm is located on a hill and aircraft may approach below the wind farm from any direction. It may then become necessary to install multiple radars in order to achieve the required coverage at low level. This in itself may lead to limitations due to mutual interference in what is already a crowded part of the electro-magnetic spectrum, (although the Terma radar does have some anti-interference capabilities) but the additional radars may affect other systems working in the same frequency band. There would also be additional planning issues to consider, such as the visual impact of additional aerals, and rotating arrays. Technical constraints also mean that it will be necessary to position the radars some distance outside the windfarm as shown in the example below in order to avoid turbines screening the radar and to provide the required height coverage.



Figure 10 Terma 5002 Radar at a Wind Farm in Germany

41. The one major advantage of PSR is that it will detect any aircraft, both those transponding and those that are not, known as non-co-operative targets. Depending upon how the regulatory process

moves forwards, this may have a major effect on which systems to use for ADLS. In response to a recent planning inquiry paper the CAA responded stating in a letter dated 21 April 2021: *For the UK, there are some challenges to be resolved. The cost/benefit of the use of primary surveillance radar for the active detection of aircraft, spectrum availability, incentive pricing cost and geographical separation required before frequencies can be re-used potentially makes this a less than optimal solution.*

42. The alternate system is one based upon a reliance on aircraft carried Electronic Conspicuity (EC) transponders. Currently light aircraft flying clear of regulated airspace in the UK below 10,000ft are not required to carry a transponder (one example being Secondary Surveillance Radar or SSR). Most aircraft do, but not all. The CAA has been encouraging fitment by all aircraft and hope to have a regulatory system in place within the next few years requiring all flying machines to be fitted. Unfortunately this is not as simple a process as one might imagine. This issue has been running for at least 20 years so far, however some limited progress is now being made. In the same response to a recent planning inquiry paper the CAA stated: *'At the same time, the lack of interoperability between the wide variety of electronic conspicuity devices currently available may require careful consideration of the specification of any passive system receivers and how they are deemed compliant to be deployed and operated.'* The letter goes on to state: *'We concur that not every situation may require ADLS to be fitted and operated; Article 222 or 223 requirements of the Air Navigation Order will remain, and the CAA may agree a specific solution under Section 7 of Article 222 and Section 11 of Article 223. However, ADLS could potentially provide an acceptable means of compliance that could provide greater certainty for developers when developing planning proposals on CAA acceptance and assist with discussions with communities during planning consultation.'* What this letter is saying is that ADLS using EC is technically feasible but that until the regulatory actions concerning the mandatory carriage of a compatible EC system have been completed and signed into law, and the coverage requirements agreed, nothing can be done unless a planning condition to require the retrospective installation of a system is considered appropriate. The length of time that this is likely to take is difficult to estimate, however, realistically it is likely to be within a two to five year timeframe as it is a small part of a much wider airspace modernisation programme currently under way. Additionally, the CAA also issued a Guidance Notice dated 26/10/21 entitled: *'Electronic continuity specifications: enabling interoperability between airspace users'*. This announced the establishment of a task force to jointly develop electronic conspicuity specifications to enable interoperability between airspace users. It goes on to state: *'The adoption of EC specifications will not be mandated UK wide. Users of other systems can continue to benefit from the functionality that those products offer'*. This does not mean that an EC triggered ADLS system will not be feasible, but the regulatory challenges mentioned above may take longer to resolve.

43. What is clear is that once the carriage of compatible transponders is mandated and all aircraft fitted with them, this is likely to be a realistic way of triggering an ADLS system. Such systems are passive at the wind farm and will not, therefore cause any interference. As shown in Figure 11 they require unobtrusive small aerials, approximately 1.2 metres long that are very reliable and relatively inexpensive to install and operate.

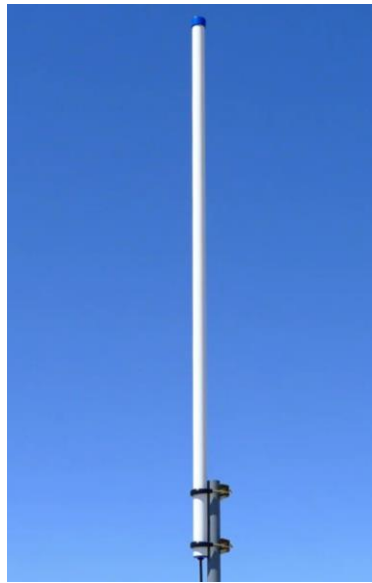


Figure 11 ADSB/SSR Passive Aerial

44. Bearing the above in mind, it might be considered prudent to ensure that lighting installed on the turbines is compatible with any future EC triggered ADLS system, so that when the regulatory process and aircraft equipage has been completed, it will be a relatively cheap and simple exercise to retro-fit such a system. Alternately, the ADSB/SSR aerials and system could be installed when the wind farm is constructed, ready for activation when required. It may therefore be suitable for use as the basis of a planning condition requiring the activation of the system **but only once the regulatory and equipage hurdles have been overcome.**

45. An ADLS system may not be suitable for every location, depending upon the nature of aviation operations at night in the area around the wind farm and the activation criteria that are finally mandated by the CAA. If located close to the approach for a major airport for example, the lights might be required to be turning on and off continuously, however, in a location like Mynydd Fforch Dwm, with limited night low level civilian traffic, the number of times the lights will activate is likely to be small. The EC activated ADLS system will be able to differentiate between civil traffic and SAR/HEMS/military traffic using Night Vision Devices (NVD) and not therefore activate when these types of aviation operations are taking place within the activation zone for the system. The infra-red lights that these types of operations rely on will always be on at night, but of course are invisible to the naked eye and will have no effect on the visual impact of the development.

Comment

46. In recent months various briefing documents have been in circulation suggesting that visible obstruction lights are not required in the current aviation environment. The CAA have briefed WPAC that they do not support this position and would consider prosecuting organisations that do not follow the existing guidance and regulations. However, change will come; this will be led by the CAA and be centred on the new draft CAP 764 (as adhered to in this report) and the future development of ADLS.

47. From the direct experience of WPAC staff who have over 40 years of day/night low flying over land and sea both with and without NVG/Ds, the inclusion of adequate visible red lighting is important to cater for both routine operations and the inevitable unplanned outcome. Pilots uncertain of their location together with emergency situations and system failures of critical night low flying equipment are circumstances that require a degree of visible obstruction lighting on large wind turbines.

48. In addition, future green energy aircraft (hydrogen/electric and battery powered) will fly considerably lower and slower than current aircraft and will be significantly limited in track variation by much shorter ranges. Good visible obstruction lighting will become more, not less important in this low direct flight environment.

49. Finally, an aircraft colliding with a wind turbine is thankfully an extremely rare event but one with enormous potential consequences. A standard risk assessment as part of an aviation safety case would conclude that even a very low probability of a significant dangerous event is still unacceptable and must be mitigated, in this case by the fitting of visible obstruction lights.

Conclusion

50. This report has assessed the requirements for both visible, CAA approved aviation lighting and MOD approved Infra-Red lighting for the Mynydd Fforch Dwm Wind Farm. The resulting layout is set out in Figures 4 and 6 and makes use of both CAA/ANO Red lights and MOD IR lights. The proposed layouts were sent to the CAA and MOD DIO for approval. The MOD will approve the IR lighting layout as there is no concession required and the CAA have responded approving the lighting concession as shown in Appendix C.

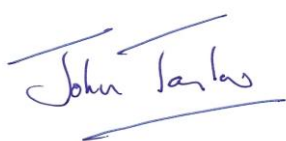
51. The report also provides the brilliance of lights that will be visible taking into account the elevation angle between the turbine hub obstruction light and the viewpoints and the distance between each turbine and each viewpoint. The report shows that for up to 88% of the time, the medium intensity lights will only be required to operate at 10% luminous intensity, which will significantly reduce obstruction light effects in the area. Further interpretation of these results can be undertaken by a Landscape and Visual Impact Assessment expert.

52. The report then identifies additional mitigation options that, *should the regulatory process allow*, enable the visible medium intensity turbine lights to be switched off for the vast majority of the time and activated only on those rare occasions in this location when an aircraft activates the system, enabling future lighting effects to be mitigated to the extent of becoming almost non-existent.

Authors

Cdr John Taylor RN (Ret) – after a career in the Royal Navy specialising in Air Traffic Control (ATC), Airspace Management and Air Defence which culminated in leading both the ATC and Fighter Control Specialisations, John worked for Lockheed Martin UK for three years as a Principal Consultant and Business Area Manager responsible for Air Traffic Management Consultancy, including the provision of advice to wind farm developers. In 2008 he founded WPAC Ltd and since then he and his team have provided aviation advice in relation to over 2000 wind farm and wind turbine sites, given evidence at a number of planning inquiries and enabled many sites to overcome aviation objections where it was feasible to do so. He and his team have also provided advice to a number of Local Planning Authorities, Renewable UK and the Aviation Fund Management Board, including organising workshops and the provision of guidance documents. John also advises planners and developers in relation to physical and technical safeguarding of non-wind farm developments in the vicinity of aviation facilities.

Sqn Ldr Mike Hale RAF (Rtd) has over 45 years, piloting, instructing and examining experience on numerous military fast jet aircraft through to a range of civilian and military general aviation training aircraft and gliders. He has held many posts including Flying Instructor, Training Officer, Flight Commander, Squadron Commander and Principal Tornado AD Force Examiner. He has amassed over 10,000 flying hours of experience when operating at many locations around the world. In parallel to his flying duties, Mike held the post of Officer Commanding the MOD Low Flying Operations Squadron (OC LFOS). In this post he was both Low Level Airspace Manager for the MOD & Wind-Farm Subject Matter Expert for the Defence Infrastructure Organization (DIO). During that period, he assessed over 14,000 wind-farm pre-applications and 2000 full applications against low flying, weapons range, specialist airspace, local community and aerodrome safeguarding criteria. Mike also instigated two Qinetiq ground based Infra Red obstruction lighting trials. These were followed by instigating and managing the MOD Infra Red/Low Intensity (Henlow) flight trials and the CAA/MOD/Trinity-House/RUK off-shore IR/Morse (North Hoyle) flight trials. In conjunction, Mike organised numerous and various supporting trials including night vision equipment compatibility and detailed lighting beam overspill analysis (where light is emitted outside the required specification envelope). In 2012, he was awarded an MBE for generating a proactive and mutually successful working relationship between the Wind Power Industry and the MOD Air Staff.



Cdr John Taylor RN (Ret)
Managing Director
Wind Power Aviation Consultants Ltd
www.wpac.co.uk



Sqn Ldr Mike Hale MBE MSc CFS RAF (Retd)
Aviation Consultant for WPAC Ltd



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Appendix A Lighting Results Tables

These results assume that Turbines 1,5 and 6 will be permanently limited to 200cd as per the report.

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	3.02	-1.9		45		4.9	
2	3.35	-1.4	691	69	61.6	6.2	
3	2.82	-3.1	212	21	26.8	2.7	
4	2.41	-3.0	217	22	37.5	3.7	
5	2.98	-2.8		24		2.7	
6	2.65	-2.6		27		3.9	

Viewpoint 1 St Illtyd's walk near Carn Caca

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	1.87	-5.0		11		3.0	
2	1.60	-5.2	75	8	29.3	2.9	
3	3.60	-3.4	199	20	15.4	1.5	
4	3.06	-3.5	194	19	20.8	2.1	
5	3.17	-3.8		18		1.8	
6	2.58	-4.0		17		2.6	

Viewpoint 2 East of Tonna

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	3.33	-1.3		76		6.8	X
2	3.60	-0.6	1443	144	111.5	11.1	X
3	2.60	-4.7	125	13	18.5	1.9	
4	2.99	-2.8	239	24	26.8	2.7	X
5	2.46	-4.8		12		2.0	
6	2.95	-2.7		26		3.0	X

Viewpoint 3 By-way near Cynonville

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	2.22	-4.8		12		2.4	
2	2.07	-4.6	132	13	30.6	3.1	
3	3.24	-4.2	158	16	15.1	1.5	
4	3.18	-3.8	181	18	17.9	1.8	
5	2.66	-5.0		11		1.5	
6	2.65	-4.4		15		2.1	

Viewpoint 4 Afan Bike Park



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Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	4.75	-1.8		48		2.1	
2	4.70	-1.6	576	58	26.0	2.6	
3	5.72	-2.0	413	41	12.6	1.3	
4	5.17	-1.9	448	45	16.8	1.7	
5	5.58	-2.0		41		1.3	
6	5.04	-1.9		45		1.8	

Viewpoint 5 Sarn Helen

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	6.03	-0.9		109		3.0	X
2	6.46	-0.5	1582	158	37.9	3.8	X
3	4.26	-3.1	212	21	11.7	1.2	
4	4.82	-2.3	333	33	14.3	1.4	X
5	4.65	-2.8		24		1.1	
6	5.24	-1.9		45		1.6	X

Viewpoint 6 Heol-Y-Fedw, Croeserw

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	2.47	-6.7		8		1.2	
2	2.06	-7.5	75	8	17.6	1.8	
3	4.09	-4.2	158	16	9.5	0.9	X
4	3.86	-3.6	190	19	12.7	1.3	X
5	3.47	-5.2		8		0.6	X
6	3.23	-4.9		11		1.1	X

Viewpoint 7 Tonmawr Road, Tonmawr

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	4.87	-3.7		19		0.8	
2	4.53	-3.8	181	18	8.8	0.9	
3	6.57	-3.2	208	21	4.8	0.5	
4	6.01	-3.3	203	20	5.6	0.6	
5	6.17	-3.4		20		0.5	
6	5.58	-3.4		20		0.6	

Viewpoint 8 Cilfrew



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1	4.03	-3.4		20		1.2	
2	3.58	-3.5	194	19	15.1	1.5	
3	5.69	-3.0	217	22	6.7	0.7	
4	5.46	-2.8	239	24	8.0	0.8	
5	5.07	-3.2		21		0.8	
6	4.83	-3.1		21		0.9	

Viewpoint 9 Bridleway near Cimla Equestrian Centre

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	7.70	-2.7		26		0.4	
2	7.20	-2.7	256	26	4.9	0.5	
3	9.65	-2.3	333	33	3.6	0.4	X
4	9.19	-2.3	333	33	3.9	0.4	X
5	9.10	-2.5		29		0.4	X
6	8.60	-2.5		29		0.4	M

Viewpoint 10 Heol Penlan, Neath Abbey

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	11.90	-2.0		41		0.3	
2	11.39	-2.0	413	41	3.2	0.3	
3	13.71	-1.9	448	45	2.4	0.2	
4	13.41	-1.9	448	45	2.5	0.2	
5	13.09	-2.0		41		0.2	
6	12.77	-1.9		45		0.3	

Viewpoint 11 Beach Path, Swansea University Bay Campus

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	12.69	-0.8		119		0.7	
2	12.33	-0.8	1192	119	7.8	0.8	
3	14.39	-1.0	982	98	4.7	0.5	
4	13.83	-0.9	1087	109	5.7	0.6	
5	14.01	-1.0		98		0.5	
6	13.42	-0.9		109		0.6	

Viewpoint 12 Cwn Clydach walk outside Pontardawe



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1	17.63	-0.4		172		0.6	
2	18.03	-0.4	1721	172	5.3	0.5	
3	16.48	-0.6	1443	144	5.3	0.5	
4	16.46	-0.5	1582	158	5.8	0.6	
5	17.00	-0.6		144		0.5	
6	17.00	-0.5		158		0.5	X

Viewpoint 13 National Park, above Pontneddfechan

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	16.80	-0.5		158		0.6	
2	16.82	-0.4	1721	172	6.1	0.6	
3	17.27	-0.7	1318	132	4.4	0.4	
4	16.81	-0.6	1443	144	5.1	0.5	
5	17.34	-0.6		144		0.5	
6	16.89	-0.6		144		0.5	

Viewpoint 14 National Park, above Ystalfera

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	21.06	-1.1		90		0.2	
2	20.57	-1.0	982	98	2.3	0.2	
3	22.80	-1.1	902	90	1.7	0.2	
4	22.55	-1.1	902	90	1.8	0.2	
5	22.18	-1.1		90		0.2	
6	21.91	-1.1		90		0.2	

Viewpoint 15 Mumbles Head (AONB: Gower)

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	1.56	-7.8		8		3.1	X
2	1.18	-10.0	75	8	53.5	5.4	M
3	3.23	-3.9	176	18	16.9	1.7	X
4	2.96	-3.7	185	19	21.1	2.1	X
5	2.61	-4.9		11		1.6	X
6	2.33	-5.0		11		1.9	X

Viewpoint 16 John's Terrace, Tonmawr



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1	5.21	-2.5		29		1.1	X
2	4.70	-2.7	256	26	11.6	1.2	X
3	7.12	-2.1	385	38	7.6	0.8	X
4	6.75	-1.9	448	45	9.8	1.0	X
5	6.51	-2.3		33		0.8	X
6	6.12	-2.2		36		1.0	X

Viewpoint 17 Cimla Common

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	6.28	-2.5		29		0.7	X
2	5.77	-2.7	256	26	7.7	0.8	X
3	8.23	-2.1	385	38	5.7	0.6	X
4	7.81	-2.0	413	41	6.8	0.7	X
5	7.65	-2.4		31		0.5	X
6	7.19	-2.2		36		0.7	X

Viewpoint 18 A474 flyover, Neath

Turbine	Distance (km)	Elevation Angle	Candela	Candela at 10%	Microlumens per square metre (lux ¹⁰⁻⁶)	Microlumens per square metre (lux ¹⁰⁻⁶) at 10%	Obscured
1	6.00	-1.5		63		1.8	X
2	6.33	-0.8	1192	119	29.7	3.0	X
3	4.64	-2.8	239	24	11.1	1.1	X
4	5.19	-2.1	385	38	14.3	1.4	X
5	4.82	-3.0		22		0.9	
6	5.40	-2.3		33		1.1	X

Viewpoint 19 Pleasant View, Caerau



Appendix B – Abbreviations and Definitions

ADSB.....	Automatic Dependent Surveillance Broadcast
AGL.....	Above Ground Level (Height)
ANO.....	Air Navigation Order
AMSL.....	Above Mean Sea Level (Elevation)
ASG.....	Aviation Steering Group
CAA.....	Civil Aviation Authority
CAP.....	Civil Aviation Publication (Referrers to Specific Documents)
cd.....	Candela, a measure of light intensity
DIO.....	Defence Infrastructure Organisation
HNTA.....	Helicopter Night Training Area
In Flight Visibility.....	The distance a pilot can see ahead to fly & navigate the aircraft
IR.....	Infra-Red
Kts.....	Knots: a measure of airspeed (10 kts = 12mph = 19 kph)
LED.....	Light Emitting Diode
MOD.....	Ministry of Defence
mW/sr.....	milliWatts per steradian: electromagnetic energy output related to solid angle
Nm.....	Nautical Mile
NVD	Night Vision Devices - Aircraft Mounted
NVG.....	Night Vision Goggles - Operator Worn
Radar Altimeter.....	An altimeter that uses radar to accurately measure height above ground
QFE	Setting on Altimeter that gives Height above Airfield
RoAR.....	Rules of the Air Regulations
Rule 5.....	The Low Flying Rule – part of RoAR
Rule 28.....	VFR Rules Outside Controlled Airspace – part of the RoAR
ReUK.....	Renewables UK – The UK Wind Industry Body
SAR Box.....	Night Training Area for Search and Rescue Helicopter Units
SSA.....	Sector or Safety Altitude
SSR.....	Secondary Surveillance Radar
UKAB.....	United Kingdom Air Prox Board – Investigates Aircraft Near Misses
VFR.....	Visual Flight Rules (Flight without ATC on a see-and-be-seen basis)
VMC.....	Visual Meteorological Conditions (Weather suitable for VFR flight)

Appendix C CAA Response (this is for the updated 6 turbine layout but with a single typing error in para 2 which refers to 7 turbines, the approved design is for the 6 turbine layout)

**Strategy and Policy Group
Windfarm Policy**



Mike Hale
Aviation Consultant
Wind Power Aviation Consultants Ltd.
38 Hadrian Way
Chilworth
Southampton
SO16 7HX

10 May 2023
Ref Windfarms/ Mynydd Fforch Dwn

Dear Mike,

Proposed Obstacle Lighting Scheme for Mynydd Fforch Dwn Wind Farm

Reference: Mynydd Fforch Dwn Wind Farm Revised Obstacle Lighting Plan Report e-mailed 5 May 2023

1. Thank you for the report at reference, discussing the proposed obstacle lighting plan for the Mynydd Fforch Dwn wind farm. We note that the developer for the wind farm has had to make a subsequent change to the design layout following planning discussions. As a result, one turbine has been removed from the layout that we provided a variation to in December 2022. Also, because of the design layout change, the numbering of the turbines has been revised and therefore we consider that a new variation is required for this development.
2. The proposed Mynydd Fforch Dwn wind farm consists of 7 turbines orientated east-west, sitting on two hills, Mynydd Fforch Dwm and Mynydd Blaenafon and straddling the Nant Blaenpelenna River. The turbines are proposed to have tip heights of between 180 and 220 metres above ground level (AGL), which brings them within scope of the Air Navigation Order (ANO) Article 222.
3. We have considered the report carefully and take note of the intent to address concerns relating to the night-time visual impact of such aviation lighting while ensuring that the lighting installed on the turbines meets air safety requirements.
4. We note the local terrain aspects and additional mitigation provided by the provision of infra-red lighting for those operators who carry Night Vision Device capability.

Civil Aviation Authority
1W Aviation House City Place Gatwick Airport South West Sussex RH6 0YR www.caa.co.uk
Telephone 0330 138 3166 andy.wells@caa.co.uk



5. As a result, the CAA agrees a variation to the lighting requirements specified in the ANO Article for the Mynydd Fforch Dwn wind farm, under provisions given in the Air Navigation Order (ANO) Article 222 section 6, as per the following:

- medium intensity steady red (2000 candela) lights on the nacelles of turbines T02, T03 and T04;
- a second 2000 candela light on the nacelles of the above turbines to act as alternates in the event of a failure of the main light;
- the lights on these turbines to be capable of being dimmed to 10% of peak intensity when the lowest visibility as measured at suitable points around the wind farm by visibility measuring devices exceeds 5km;
- low intensity steady red (200 candela) lights on the nacelles of turbines T01, T05, and T06 with an accompanying alternate on each in the event of a failure of the main light;
- infra-red lights to MoD specification installed on the nacelles of turbines T01, T02, T03, T04, T05 and T06.

The following conditions apply to this variation:

- i. The dimming of the peak intensity does not apply to the 200cd lights. For the avoidance of doubt, the peak intensity shall not reduce below 200cd.
- ii. The obstruction lights that are 200cd will have the same beam pattern as ANO 2000cd lights.
- iii. Dimming of intensity requirements do not apply to IR lighting.

6. Taking into account that the corners of the wind farm are lit by 2000 cd peak intensity red lights, the remaining turbines have 200 cd lights and all are fitted with IR lights, intermediate level 32 candela lights are not required to be fitted on the turbine towers.

7. If the proposed design of the wind farm changes (other than variations due to micro-siting etc.) this is likely to require a revision to this aviation obstacle lighting variation.

8. Please let me know if you have any queries on the contents of this variation.

Yours sincerely



Andy Wells
Manager Rulemaking and Safety Publications

Continued (2 of 2 pages)