Central Bedfordshire Council
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Wind Turbines near Public Rights of Way

Technical Appendix

Not Protected

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1. Types of user

1.1. Public rights of way generally have five legitimate types of users. These are:

- Walkers
- Horse riders[1]
- Cyclists
- Vehicular users (mechanically-propelled and horse-drawn)
- Occupational users

1.2. The above users can also be grouped into those users that:

- Habituate the vicinity of the wind turbines (occupational users)
- Are not significantly impacted by the presence of wind turbines (walkers, cyclists, motorists)
- Have the potential to either endanger themselves or others (horse riders and carriage drivers)

1.3. Every individual using a public right of way near a wind turbine or wind farm will have their own perceptions and responses to visual and audible stimuli.

- Walkers are likely to be able to take stock of the turbine and its environment as they slowly approach. They can stop and appraise any risk they perceive and act accordingly
- Cyclists are likely to approach a wind turbine at a faster rate and to switch their concentration between it and the ground immediately in front of them. They can, however, stop to appraise any risk - although they might not be aware of a hazard as quickly as a walker owing to their need to concentrate on the ground they are cycling over
- Horse riders are likely to have an elevated and thus advanced view of the wind turbine and, whilst possibly not being able to give it the same attention as a walker, are likely to be able to look at it more than a cyclist could. However, the main risk to the equestrian comes not from any inherent risk from the turbine, but from the (un)predictable response of the horse - whether mounted or hitched. Behavioural responses of horses are likely to be within the spectrum of tolerance to audible and visual stimuli, through skittishness, to refusal to proceed. In extreme cases, a horse could be startled enough to either shy, rear, or bolt, posing a real risk to the safety of the rider/driver and other users of the path as well as the horse's own wellbeing
- Car drivers and motorcyclists on byways are, to some degree, akin to cyclists in that their approach is faster than walkers and their need to

[1] Includes the very minor use of byways by horse and cart.

concentrate on wheel placement and route finding. Vehicle users can, to some degree stop at will to evaluate any hazards and may feel less vulnerable to any perceived hazards due to being enclosed or wearing protective equipment

- Occupational users are likely to be turbine engineers, farmers, or local residents using access/maintenance tracks. As such the users are likely to be de-sensitised to any audible or visual stimuli and may not perceive any potential risk. Conversely any change in the normal operation of the wind turbine may be more easily perceived compared to a stranger to the site.

1.4. Overall, it is only horse riders and carriage drivers that are likely to be adversely affected by any visual or audible stimuli due to the unpredictable nature of their horse. Equestrian use of rights of way includes bridleways, restricted byways, and BOATs.

2. Wind turbine effects

2.1. Wind turbines can affect public rights of way in a number of ways. Generally these effects can be categorised as one of the following:

- Inherent hazards which raise safety issues
- Visual effects
- Audible noise issues
- Physical presence
- Secondary infrastructure issues which affect the surface of the land

Inherent hazards

2.2. Hazards specific to wind turbines include the collapse of the structure, the disintegration of blades and the shearing/sloughing of ice from blades and nacelle.

2.3. In extremely high winds there is a very small chance that a wind turbine could topple over. When extreme winds are predicted wind turbines are programmed to shut down by retarding the rotor and feathering the blades in to a low-drag configuration. In the event of a turbine being blown down this would affect the land immediately down wind of the turbine. PPS 2 suggests that the topple safety distance for such an event should be equivalent to the tip height + 10%[2].

2.4. In some situations, high winds can lead to the turbine brake becoming inoperable - leading to a runaway acceleration in rotation speed. As rotor speed increases so does centripetal force on the blades. If the outwards force exceeds the material strength of the blade's structure or housing, the blade can spontaneously disintegrate. In such an event material (blade debris) is sent out initially perpendicular to the wind direction at high speeds and may travel up to 350 metres before hitting the ground[3]. Debris range is a function of tip speed rather than turbine height and so larger turbines may not

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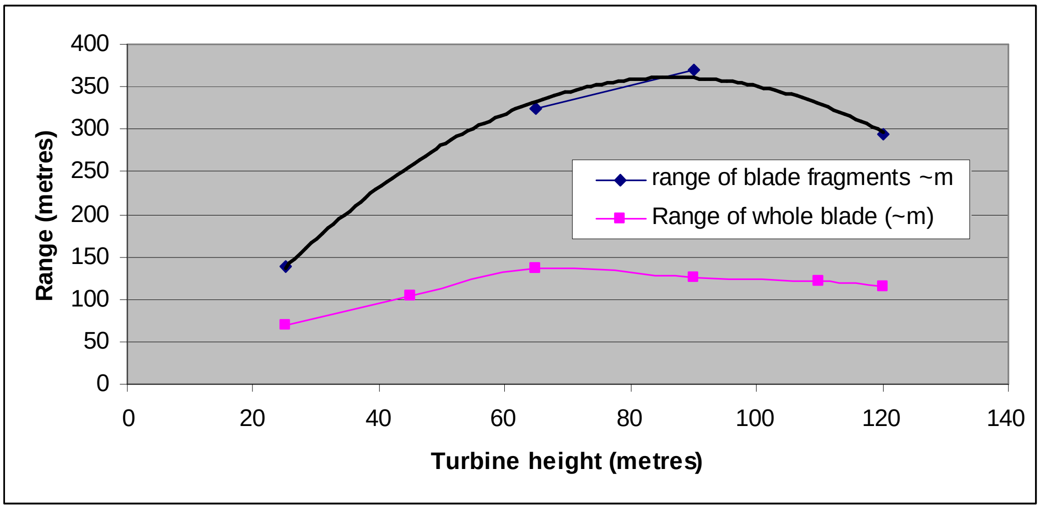
[2] The tip height is the nacelle (hub) height plus the blade length.

[3] **Permitting Setbacks for Wind Turbines and the Blade Throw Hazard**, California Wind Energy Collaborative, 2005.

necessarily pose a greater hazard. The main tower may remain intact or may topple over within the parameters outlined in 2.3 above.



Range of blade throw in relation to tower height[4]

2.5. During winter periods, ice can build up on the leading edge and sheltered surfaces of the blades and nacelle. Turbine manufacturers install controls to shut down a turbine when instability due to icing is detected. However, shearing of ice off moving blades does occur, as does the sloughing of ice from stationary blades and the nacelle. In very cold climates blades may be electrically heated; however, this engineering solution is unlikely to be used in Central Bedfordshire.

2.6. Research[5] has shown that ice can generally be thrown up to 200 metres from the turbine, and in exceptional conditions to 350 metres. Observations indicate that large ice fragments break up almost immediately into smaller particles, with masses of 250 - 1000 g travelling the furthest. Particle trajectories are effectively outwards and downwind of the rotor disk at the time of detaching.

2.7. Ice can still form on stationary blades and nacelles. In such situations, observations showed that larger ice fragments tended to be blown further than the smaller fragments. Risk from sloughed ice can be considered to again be below, or slightly downwind from the rotor disc.

2.8. It should be noted that severe icing conditions in Central Bedfordshire are uncommon. Research[6] suggests that ice throw resulting in an accident on a nearby highway would occur once in 300 - 3000 years - which would far exceed the hazards inherent in generally using a public right of way.

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[4] After **Permitting Setbacks for Wind Turbines and the Blade Throw Hazard** California Wind Energy Collaborative, 2005.

[5] **Risk analysis of ice throw from wind turbines**, Henry Seifert *et al*. Paper presented at BOREAS 6, 9 to 11 April 2003, Pyhä, Finland and **A model of ice throw trajectories from wind turbines** Sumita Biswas, Peter Taylor, and Jim Salmon, Wind Energy (2011). DOI: 10.1002/we.519.

[6] **Risk analysis of ice throw from wind turbines**, Henry Seifert *et al*. Paper presented at BOREAS 6, 9 to 11 April 2003, Pyhä, Finland

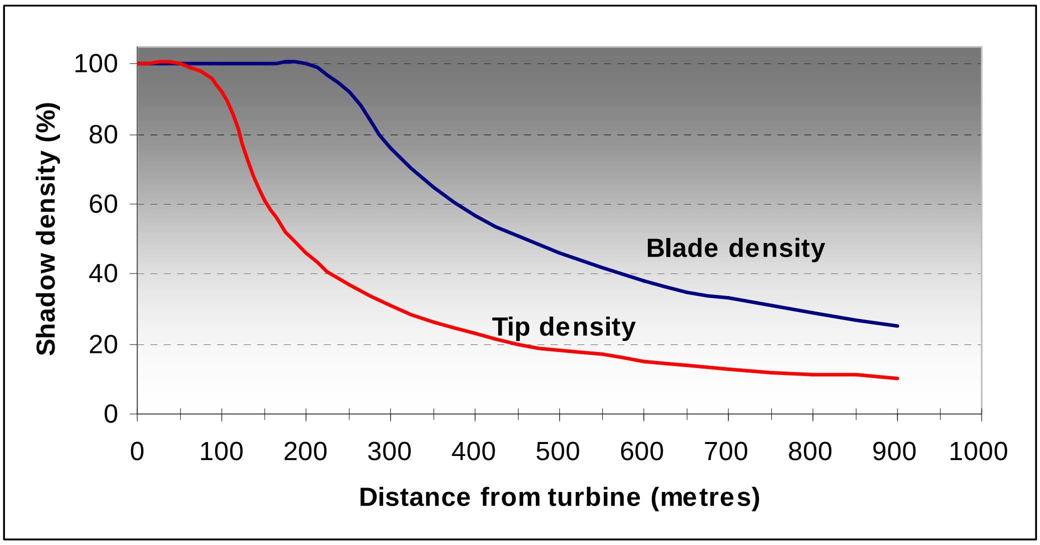
Visual effects

2.9. The rotation of wind turbine blades causes two distinct phenomena: "*shadow flicker*" and moving blade shadows.

2.10. Shadow flicker relates to the blade shadow passing over an aperture, such as a window, causing a periodic occulting effect. As this affects people within buildings it is not considered particularly relevant to users of public rights of way.

2.11. Moving blade shadow effects relate to the moving shadows that the turbine blades make on the ground. The reach of the shadow depends on the angle of the sun and therefore the time of day and year. The effect of blade shadows on a particular right of way can be modelled. This effect is reduced or enhanced by the wind direction causing the rotor disc to be in-line with, or at 90˚ to the sun respectively, with changes in topography, and where shadows are cast onto the faces of buildings or hedges.

2.12. The density of the turbine and blades' shadows are proportionate to the sun's intensity, the height of the turbine, and the sun's angle which governs the distance from the turbine that the shadow extends.



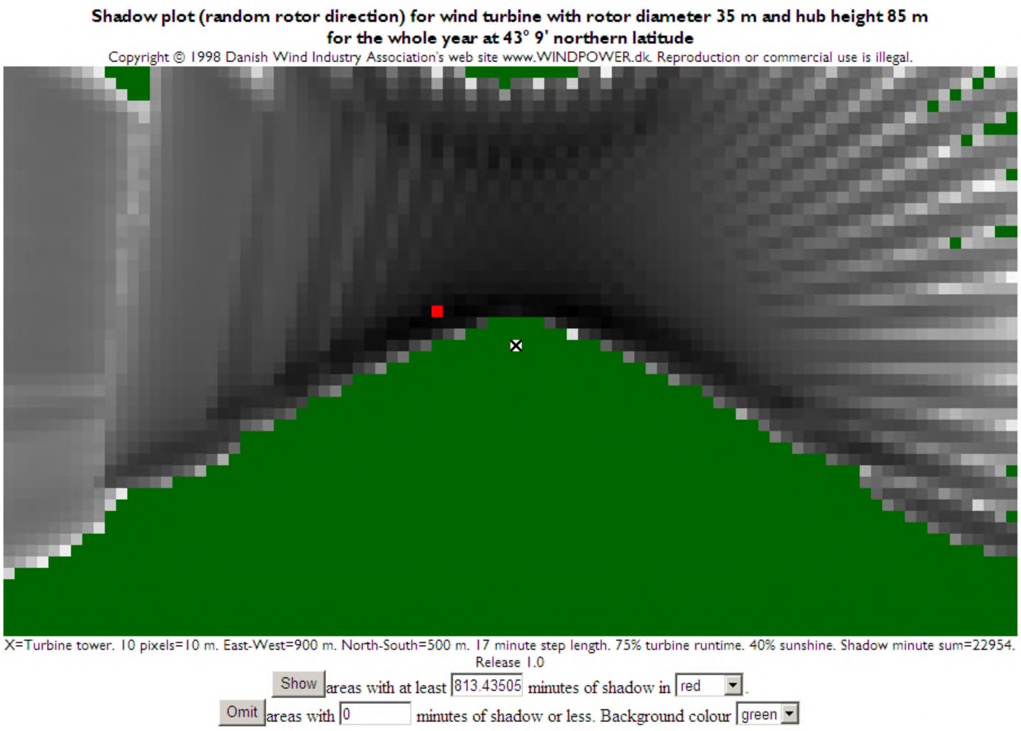
Density of blade and tip shadow for an 80 metre high turbine tower with a 90 metre diameter rotor[7].

2.13. The effect of moving blade shadows is to produce a rapidly moving band of shadow over the land. This rapidly moving shadow can be disconcerting and is identified by the British Horse Society in consultation responses[8] as the primary source of concern when riding close to turbines.

2.14. The effects of shadow density on equestrian behaviour are not modelled. For the purpose of this document a 33% diminution in shadow density of a turbine blade has been assumed to be acceptable. For a 125 metre tip height, this equates to a distance of approximately 340 metres - equivalent to 2.75 turbine

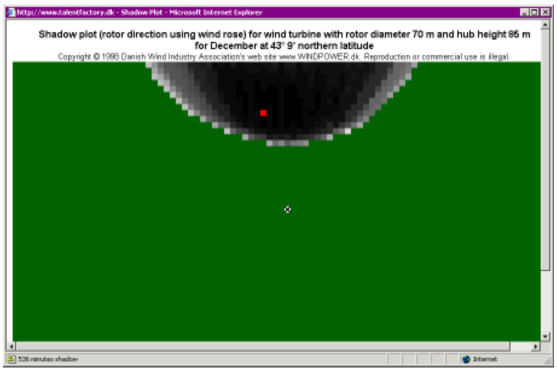
[7] Source: RWE NPower expert report for the Nun Wood wind farm in Northamptonshire.
[8] British Horse Society response to Poddington Airfield Wind Farm dated 30th October 2008.

heights, which is just below the 3 turbine height separation distance suggested by the British Horse Society[9] ..

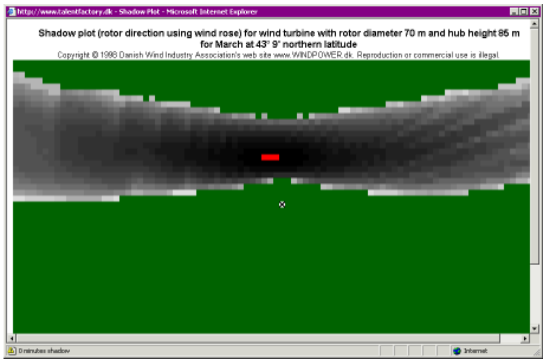


Land affected by shadow from a 120 metre tip height wind turbine located in central Bedfordshire[10] - whole year.

2.15. The above plot shows the area affected by blade shadows over the course of an entire year. When broken down into seasonal extremes, as in the images below, dramatic differences in the areas of land affected by shadows are identified. The areas affected by shadows at times that are unlikely to see equestrian use can be identified as lying to the south-west of the turbine at distances greater than 2.50 turbine heights.

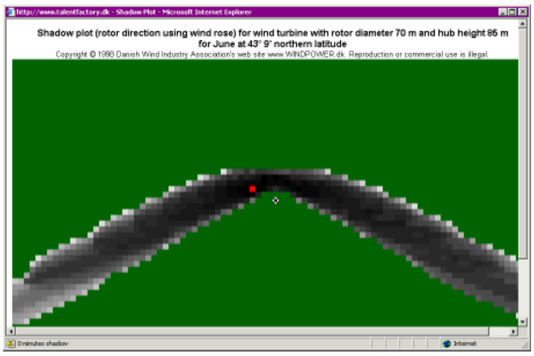


Shadow area - December

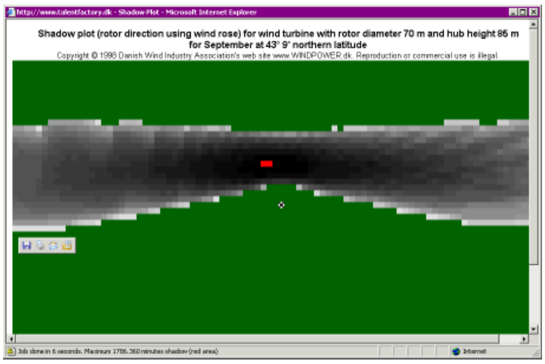


Shadow area - March

[9] The British Horse Society Wind Farms Advisory Statement April 2010.
[10] Data used with the kind permission of the Danish Wind Industry Association – http://wiki.windpower.org.



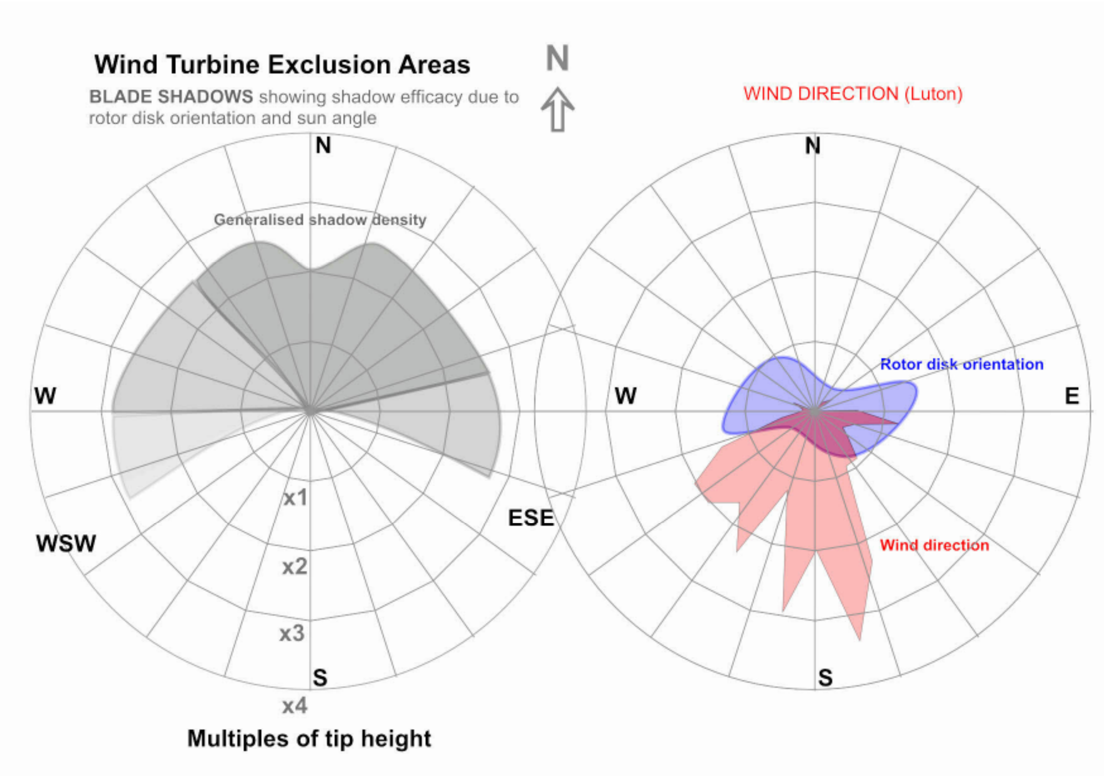
Shadow area - June



Shadow area - September

Land affected by shadow from a 125 metre tip height wind turbine located in Central Bedfordshire[11].

2.16. Visual effects will be most prominent for early morning and evening users of distal routes and for nearby users around midday with south-easterly and south-westerly winds, and southerly winds respectively during periods of little cloud cover. As can be seen from the above shadow plots, rights of way situated in a 100˚ arc to the south of a wind turbine are unaffected. Areas affected by shadows have the densest levels of interference within approximately 2.5 turbine heights of the mast.



Calculated shadow zones based on the predominant wind directions and sun angles.

[11] Data used with the kind permission of the Danish Wind Industry Association – http://wiki.windpower.org.

2.17. General wind directions for southern Bedfordshire, as indicated by the wind rose diagram above, are from the south-south-east to south-west quadrant - thus giving a rotor orientation of roughly east-west through to north-west-south-east. This will produce shadows from the rotor disk with differing aspect ratios dependent on the time of day.

Audible stimuli

2.18. Wind turbines consist of moving aerofoils. As these turn they create a blade swoosh as each blade passes closer to the listener. Typically the frequency of blade swoosh is about 1 per 1.0 - 2.5 seconds. The sound generated is lower range amplitude modulated white noise with some degree of infrasound (<500 Hz) which is inaudible to humans. The noise created is up to about 65 dB for low range (1000 - 5000 Hz) with a lower level for infrasound (~45 dB for <25 Hz)[12]. Manufacturers in accordance with PPS 22 aim to keep turbine noise with +5 dB of the ambient area and generally less than 45 - 55 dB. Any noise generated is likely to be carried downwind and affect this area more than the upwind side.

2.19. Additionally, noise can be occasionally generated by the downwards blade passing the tower. This “blade thump” is caused by the blade compressing air against the turbine tower.

2.20. The other main source of noise from wind turbines is the high pitched whine from the turbine which is situated high up in the nacelle. The low level of this noise is unlikely to be of an intrusive nature. Next-generation wind turbines use a direct-drive technology to connect the blades to the generator - rather than relying on gears to increase rotational speed in the generator - and thus emit lower frequency noise at a lower sound level.

2.21. A third source of noise comes from the nacelle motor used to control the orientation of the nacelle and rotors. This is mid-range mechanical noise. As the wind shifts this motor operates intermittently for periods of perhaps 30 seconds to a couple of minutes to keep the rotor-disc facing the wind.

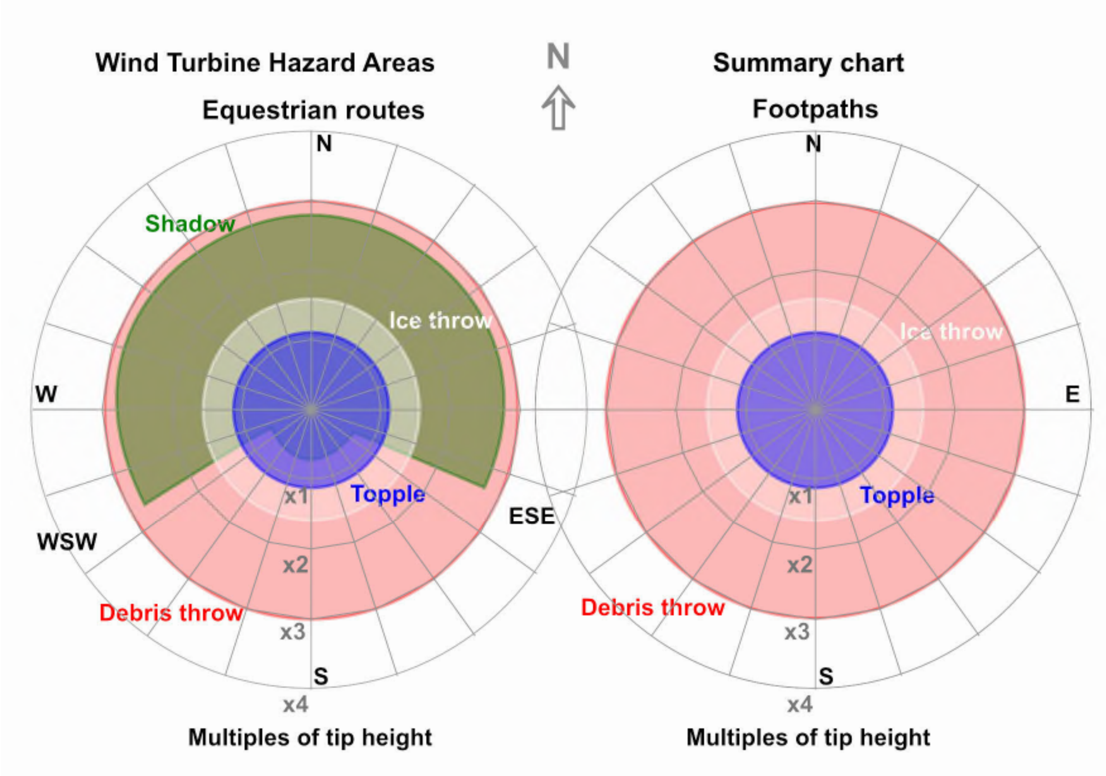
2.22. The Department of Trade & Industry publication “*Assessment and Rating of Noise from Windfarms*”[13] suggests that combined noise from collective wind turbines should not exceed 5 dB above background levels for day and night.

2.23. Blade swoosh, turbine noise, or the nacelle motor is unlikely to prove a great impediment to users of a nearby right of way.

General summary of hazards

2.24. The following chart provides a summary of the hazards discussed above normalised against tip heights. The largest hazard areas arguably have the smallest risks: disintegration of blades and ice throw. For these hazards, the distance is inversely proportional to the risk and so these have been discounted to some extent for the purposes of establishing the exclusion zones detailed in Section 6.6 of the WPGN.

[12] Web source: www.canwea.ca.
[13] “*Assessment and Rating of Noise from Windfarms - ETSU-R-97*” for the DTI. Web source: http://www.berr.gov.uk/files/file20433.pdf



Generalised chart indicating likely range of most hazards normalised to ratios of turbine tip height.

Physical presence

2.25. Wind turbines are very tall and are likely to be the most dominant features on any horizon. Even when passing at the PPS 22 suggested desirable distance of 200 metres the blade tip will be visible at an inclination of ~40˚ with the rotor disc spanning some 50 - 70 metres. At closer distances, the sheer size of a turbine would dominate the immediate vicinity and can be imposing. However, the sheer size means that users of a right of way have plenty of advanced warning of the turbine’s presence.

2.26. The British Horse Society has raised concerns that the moving blades will cause distress to horses. This could be especially relevant where glimpsed after passing obscuring buildings, woodland, or hedges or when the blades begin to turn from a stationary configuration. However, the turbine will be some way off and should be identified by the horse as non-threatening. However, some horses are known to have irrational fears of imposing features and may refuse to go near the turbine. In such cases the rider will be aware of their mount’s behaviour.

Secondary features

2.27. Wind farms incorporate an anemometer control tower. This tends to be a ladder construction (similar to a pylon) rather than a solid tower construction. Neither this, nor its foundation should have a detrimental effect on a public right of way.

2.28. When wind turbines are constructed they require extensive ground works to construct a 10 - 15 metre diameter concrete foundation. Areas of hard-standing are also required for the assembly crane and for the blade assembly area. These need to be situated on cleared level ground and should avoid existing public rights of way.

2.29. Wind turbines require well thought out access tracks owing to the size of the turbine blades which have to be transported in by long-loader and the weight of the assembly crane. Lanes may need to be widened and corners cut back for the long loads. This can affect rights of way furniture and signage and, where rights of way utilise farm tracks, it can lead to surfacing issues. However, construction and restoration are temporary phases and negotiations can result in improved rights of way facilities.

3. Relevance of route importance

3.1. The impact of a wind turbine on a right of way can also depend on the historical or national importance and level of use of the route in question. Generally routes can be classified as one of the following:

- Low use minor route with no historical relevance
- Medium usage connecting route without historical relevance
- High usage local routes (e.g. village cut-throughs)
- Variable usage connecting route with historical/cultural relevance
- High usage regional or national route with historical/cultural relevance.

3.2. Where a route is used infrequently and is insignificant in either a local or regional context, consideration should be given to the impact of the wind turbine on the relatively few users of the route and consequently, a lower minimum separation distance could be acceptable.

3.3. Where a route is nationally, or regionally important and/or is used extensively consideration should be given to retaining the rural nature of the route by requesting that a greater minimum separation distance be specified between turbine and right of way.

3.4. As there appears to be little guidance available on the proximity of wind turbines to public rights of way of differing importance it will be for the Case Officer to evaluate this on a case-by-case basis. This WPGN recommends, however, that for high use or nationally or regionally important routes the exclusion zones be extended by approximately one turbine height beyond the minimum requirement stated at Section 6.6 of the WPGN.

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