PAGERPOWER
Urban & Renewables

Telecommunications White Paper – Wind and Building Developments

First Edition

September 2023

PLANNING SOLUTIONS FOR:

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ADMINISTRATION PAGE

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FOREWORD

Onshore wind is undergoing a resurgence in the UK and will continue to be a significant contributor to the renewable energy mix. Internationally, onshore wind will play a major role in countries with the aim of reducing their reliance on fossil fuels, especially where there is not a vastness of shoreline available, which makes offshore wind more attractive. In any case, onshore wind will continue to be popular due to its proven deployment at a relatively low cost compared to its offshore counterpart. However, onshore wind developments are now more commonly facing telecommunications issues due to the reduced availability of appropriate development locations, and prime locations being seen to coincide with telecommunications infrastructure on elevated terrain. Not only this, but wind turbines are getting taller, with larger towers and rotor blades to ensure that sites that were previously less favourable become so. This equates to the likelihood of interaction between wireless infrastructure and wind turbines increasing.

It is not just wind turbines that can affect telecommunications infrastructure. Indeed, any tall object has the capability to do so, with the most common other than wind turbines being tall building developments. Therefore, whilst telecommunications issues due to wind turbines are the most common, this White Paper also considers the potential impact of building developments, or any static object placed in the vicinity of this infrastructure.

There is no known guide on best practices for the entire approach to assessing the impact of wind turbines or building developments upon wireless telecommunications infrastructure. Pager Power has been at the forefront of this planning issue since the mid-2000s, with over 500 assessments completed at the time of publication of this first edition. This experience has therefore led Pager Power to produce this White Paper, which draws on this experience to assist developers and stakeholders in formulating a definitive approach to managing telecommunication issues.

It is Pager Power's position that no wind or building development should be prevented where a telecommunications issue is identified, except in the scenario where the cost to mitigate the impact outweighs the benefits of developing the project in question[1]. There is always a technical solution however, in many cases, a way forward is prevented by mitigation costs or a developer's/stakeholder's ability to find an appropriate solution which is suitable to both.

This guidance document therefore presents the methodology recommended by Pager Power through assessment and project experience to ensure a solution is achieved as simply as possible. This paper should be used for reference and ideally, the methodology should be agreed with the relevant stakeholders where an assessment is required. There may be cases where the assessment scenario does not match the guidance criteria. In this situation, a pragmatic approach is recommended.

[1] This can sometimes mean aspects of a development are reduced i.e. a reduction in wind turbine numbers

White Paper Basis

Prepared for:

Developers, planners and stakeholders.

Aim:

To provide guidance for assessing the impact of wind turbines and building developments on wireless telecommunication infrastructure.

Receptors:

Point-to-point wireless links and telecommunications masts they are sited upon.

EXECUTIVE SUMMARY

Overview and Purpose

The purpose of this guidance document is to provide developers, planners and stakeholders with a best practice assessment process for managing point-to-point wireless telecommunications issues associated with wind and static structures, such as building developments.

Formal guidance around this topic remains scarce, with most requests for this assessment, be it from planners or stakeholders, falling short of providing a specific assessment methodology. Likewise, national and international guidance is scarce in terms of a specific process that is accessible to developers, planners and stakeholders alike. The aim of this paper is therefore to produce a standardised assessment process for all, from the early stages of a project through to mitigation, alongside presenting the most typical mitigation options.

This paper is based on knowledge initially gained through Pager Power's telecommunications assessment and project experience within the UK market and from over 500 assessments completed to date, both in the UK and internationally, for wind and building developments. Specifically, this paper draws from:

- Reviews of existing guidance and studies within the wider telecommunications topic;
- Telecommunications assessment and project experience and industry knowledge;
- Best practice recommendations.

Whilst aimed primarily at wind and building developers, this guidance is applicable for any object deemed an obstruction to telecommunications systems.

Key Receptors

The key receptors considered within this paper include telecommunications mast structures, point-to-point microwave and Ultra High Frequency (UHF) telemetry links. This infrastructure is typically used to form the backbone of a mobile phone communications network, send television signals from main transmitters to relay transmitters or send information between utility infrastructure, to name a few examples.

Consultation Process

Consultation with the most prominent telecommunications stakeholders is recommended at the earliest opportunity in the project timeline. This is typically following the completion of a wind turbine layout or initial building designs; however, consultation may begin as early as a site boundary is defined. These details should then be sent to the stakeholders to ensure the most up-to-date telecommunications infrastructure is provided and assessed.

Assessment Methodology

The assessment methodology is dependent on the telecommunications infrastructure type, the link frequency, its elevation and whether the obstruction is static or mobile – see Sections 3 and 5 for details.

Guidance Summary

The advice given in this paper should be followed to ensure the comprehensive assessment of point-to-point telecommunications systems. This paper provides guidance which is applicable to point-to-point wireless telecommunications systems located anywhere in the world.

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PAGER POWER COMPANY PROFILE

Company Background

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 58 countries within Europe, Africa, America, Asia and Australia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems.

Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

Pager Power's Experience

Pager Power has undertaken over 500 telecommunications assessments for wind and building developments in the United Kingdom and internationally.

GLOSSARY OF TERMS

Term	Definition
Diffraction (effects)	Diffraction is the physical phenomenon of electromagnetic waves 'bending' around obstructions. Diffraction effects are typically caused by obstruction of the wave, which results in a loss of power and quality.
Fresnel Zone	A Fresnel Zone takes the form of an ellipsoid surrounding a link path and represents the area in which any part of an object should not be sited in order to avoid diffraction losses. The n-th Fresnel is the locus of all points for which, if the radio signal travelled in a straight line from the transmitter to the point and then to the receiver, the additional path length compared to the straight transmitter-receiver path equals $n\lambda/2$, where λ = wavelength.
Nearfield effects	Interference effects that inherently occur due to an object being too close to a transmitting communications link end (typically within approximately 500m).
Node	A transmitting or receiving connection point on a point-to-point link pathway.
Microwave link	A communications link transmitting an electromagnetic signal typically in the frequency range from 1 GHz up to 40 GHz.
Point-to-point link	Point-to-point links are wireless radio pathways between two transmitting and receiving communications apparatus. These typically operate in the UHF or microwave frequency range of the electromagnetic spectrum.
Reflection effects	Reflection effects occur when an object reflects the incoming radio signal onto a receiving aerial. This can cause multipath interference unless the level of the reflected signal is negligible compared to the direct signal (in terms of timing and power received). The combination of direct and reflected signals and the time differences between their modulation may cause performance degradation.
Ultra High Frequency (UHF) link	A communications link transmitting an electromagnetic signal typically in the frequency range from 460 MHz up to 1 GHz.

Table 1 *Glossary of terms*

1 INTRODUCTION

1.1 Overview

1.1.1 In recent years, Pager Power has begun to see developers mobilise around new onshore wind development projects in the UK. In addition to this, building developers are beginning to propose taller buildings, mostly in city centres. This has led to an increase in the number and complexity of telecommunications impact assessments required to support these projects. Internationally, the same issues arise because point-to-point telecommunications equipment is mostly universal, and therefore the principles provided in this White Paper are technically applicable anywhere in the world.

1.1.2 Telecommunication impacts for developers of wind turbines and static structures, such as buildings, have always been a consideration. This is sometimes as a planning requirement or as best practice. However, due to larger and taller developments being proposed in increasingly constrained locations, telecommunications impacts are now becoming more prominent. It is Pager Power's position that no wind or building development should be prevented where a telecommunications issue is identified, except in the scenario where the cost to mitigate the impact outweighs the benefits of developing the project in question[2]. There is always a technical solution however, in many cases, a way forward is prevented by mitigation costs or a developer's/stakeholder's ability to find an appropriate solution which is suitable to both.

1.1.3 This White Paper has therefore been produced to ensure that best practice is followed by providing details of the key issues, the consultation and assessment process, and the most common mitigation options. The focus of this White Paper is on point-to-point telecommunications and the associated mast infrastructure.

1.1.4 It is derived from established propagation models, parameters and first principles. It is commensurate with a range of credible guidance sources in literature and from other bodies, including link operators, whilst it is acknowledged that the basis for set distance-based buffers used by many stakeholders is not scientifically derived.

1.1.5 In over 15 years of supporting developers in the management of telecommunication constraints, Pager Power has no experience of a development that satisfied the criteria as recommended within this paper and went on to cause significant interference to a link.

[2] This can sometimes mean aspects of a development are reduced i.e. a reduction in wind turbine numbers

2 TELECOMMUNICATIONS INFRASTRUCTURE

2.1 Overview

2.1.1 It is important to understand the types of telecommunications infrastructure that can be affected by wind and building developments as well as the mechanisms by which they can be affected. This section presents an overview of different types of infrastructure and the interference mechanisms accompanied by photographs of real-world examples of the telecommunications equipment in question.

2.2 Types of Telecommunications Infrastructure

2.2.1 The following subsections set out the details of the components that make up the most common point-to-point telecommunication infrastructure encountered by wind and building developers.

Point-to-Point Telecommunications Links

2.2.2 Point-to-point links are wireless radio pathways between transmitting and receiving communications apparatus. These typically operate in Ultra High Frequency (UHF) or microwave frequency range of the electromagnetic spectrum. Microwave links require radio line of sight to operate effectively, whereas UHF links can operate outside of this requirement due to the refractive properties of the lower-frequency radio signal transmitted.

2.2.3 These networks typically make up the backbone of a country's communications network for systems such as terrestrial television services, mobile phone and utility monitoring, to name a few. Whilst physical networks remain common, such as fibre optic or copper line connections, it is the versatility, robustness and cost of a wireless network that makes wireless telecommunication so popular. This is especially true in rural locations where running fibre cable is very costly compared to wireless point-to-point links.

Telecommunications Masts and Compound

2.2.4 Figure 1 on the following page presents a fairly significant mast site at Winter Hill in Lancashire, UK, however most sites are not as substantial as this. In the photograph, microwave dishes, Ultra-High Frequency (UHF) dishes, and receiving vertical antennas can be observed. At a typical mast site, the following are present:

- The mast itself;
- Telecommunications dishes and transmitters;
- A small utility building and/or a box containing the power supply (and possibly a backup power supply) and connection to the main network via a wire;
- A security fence.

2.2.5 Often signs will be present stating who operates a site, however this does not mean that they are the sole user of the mast, with many operators/stakeholders sharing mast infrastructure. In addition, there may be additional wireless links traversing a development site in question that are utilising masts which are not visible from the site itself. It is therefore essential to always consult with the most prominent telecommunications stakeholders regardless of any known and visible infrastructure at a site.

Figure 1 *The Winter Hill mast and compound in Lancashire, England*

Microwave Dish

2.2.6 Figure 2 below shows two fairly standard parabolic microwave dishes mounted to a chimney. It is common that the dishes are white in colour. These dishes are directional meaning they are orientated in the direction of the corresponding link end. Microwave links require radio line of sight to operate; therefore, depending on the dish height, it may be possible (on a clear day) to observe the corresponding link end, maybe with the assistance of binoculars. This does however depend on the length of the link path as ocular line of sight does not necessarily coincide with radio line of sight due to refraction.

Figure 2 *Two microwave dishes*

Ultra-High Frequency Transmitter

2.2.7 Figure 3 on the following page shows an omni-directional UHF transmitter, often used for transmitting terrestrial digital television services. Whilst this transmitter is not directional, the receiving aerials (shown in the following section) are. This means they need to be oriented towards the transmitter with the correct polarisation for optimum signal strength and quality. There are also directional UHF dishes which look similar to the microwave dishes presented in Figure 1, and again, it is common that they are white in colour. Due to their lower frequency, UHF signals do not necessarily need a direct radio line of sight to operate appropriately.

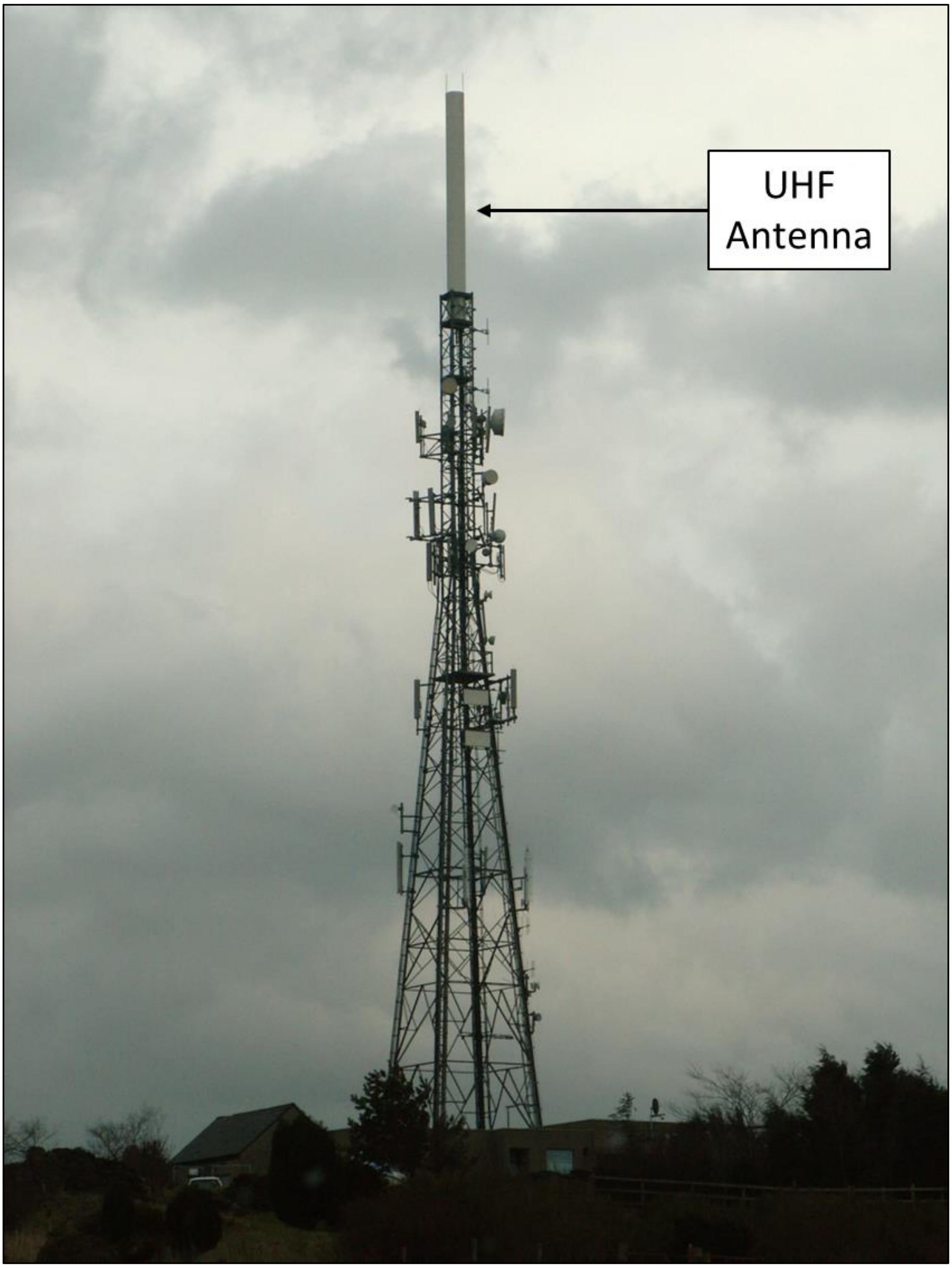

Figure 3 *UHF transmitting mast*

Ultra-High Frequency Receiving Antenna

2.2.8 UHF communications are most commonly used for television broadcast services but other frequent users of this infrastructure include utility companies, who commonly use UHF equipment to co-ordinate and monitor their infrastructure, such as electrical substations and reservoirs. On this basis, the type of aerial used by many households for receiving television transmissions is similar to those used by utility companies within their infrastructure.

2.2.9 Figure 4 below shows a receiving UHF antenna (or aerial). This is not a transmitter and the aerial is only capable of receiving a signal. The orientation of the elements dictates whether it is set to receive a horizontally or vertically polarised signal – see Figure 5 on the following page[3]. The separation of the elements also relates to the wavelength of the signal received.

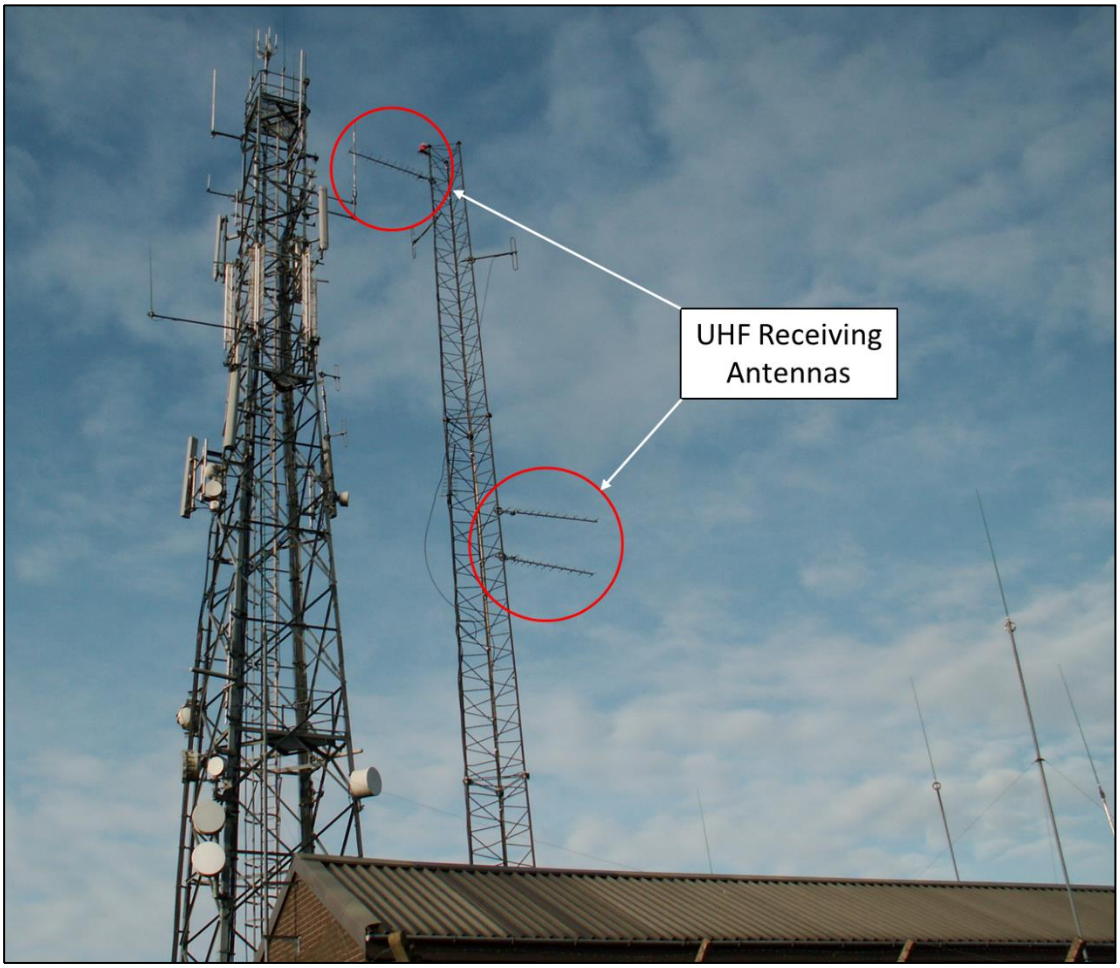

Figure 4 *UHF receiving antenna*

[3] Source BBC, what type of aeril do I need? Last accessed 26/09/2023.

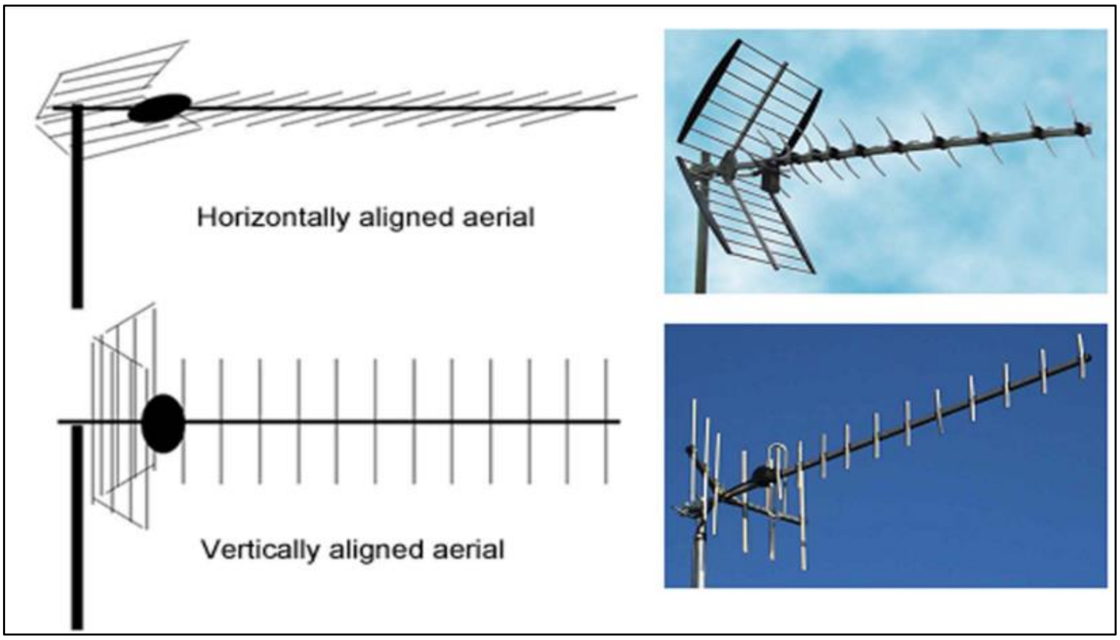

Figure 5 *UHF receiving antenna*

3 INTERFERENCE MECHANISMS

3.1 Overview

3.1.1 The Ofcom paper entitled 'Fixed-link wind-turbine exclusion zone method'[4] identifies three mechanisms in which wind turbines and static structures such as buildings may cause signal degradation. These include:

- Nearfield effects;
- Diffraction effects;
- Reflection effects.

3.1.2 Each of these is discussed in more detail in the following subsections.

3.2 Nearfield Effects

3.2.1 The basic theory for propagation of radio waves from point-to-point infrastructure works well for the most common scenarios where the object (wind turbine or other static structure) is a long way from the transmitting and receiving antennas (link ends) relative to antenna size, and wavelength of the signal. Close to the link ends, this theory is less accurate and the number of variables that can significantly affect transmission/ reception increases; therefore, the nearfield may be more sensitive to interference from these objects.

3.2.2 The Ofcom paper notes that for simplicity, these effects are assumed in all directions from an antenna, as "*it is believed that this will not result in impracticable restrictions*", suggesting that in practice, the affected area will be small. In reality, nearfield effects are much more likely if an object is positioned in the general direction of a link path i.e. if a wind turbine is located behind a link-end relative to a transmitter, nearfield effects are much less likely.

3.2.3 The Ofcom paper has the following equation where the antenna has no recognisable physical aperture (e.g. for a satellite television receiver, the aperture size might be the diameter of the dish) to calculate near field distance, D_{nf}:

- $D_{nf} = N_{nf} \lambda g / \pi^2$

3.2.4 A worked example is given below where:

- N_{nf} is the degree of conservatism, recommended to take the value 3 (very conservative);
- λ is the wavelength in metres (as an example, in the 460MHz – 460,000,000 Hz – frequency band, the wavelength is approximately 0.65m). This is a typical frequency for an Ultra High Frequency (UHF) link;

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[4] DF Bacon on behalf of Ofcom. Fixed-link wind-turbine exclusion zone method, version 1.1, 28 Oct 2002.

- g is the boresight gain (= $10^{0.1G}$, where G is the boresight gain in dBi – a measure of the 'directionality' of the antenna – in decibels, dBi), and assuming a conservative value of G for the antenna of 32dBi (as used in the Ofcom paper worked example), gives a value of g of 1,585;
- π has an approximate value 3.141.

3.2.5 This gives the result:

- D_{nf} = (3 x 0.65 x 1,585) ÷ 3.141^2 = 313m.

3.2.6 This is the distance beyond which wind turbines and other static structures should be located. In the absence of any data, Pager Power recommends a 250m exclusion zone is initially suggested for microwave links and a 500m exclusion zone is initially suggested for UHF links. The reason for the different stand-off distances cited is because UHF links are more susceptible to reflection issues therefore an initial higher stand-off distance is recommended.

3.2.7 As frequency decreases, boresight gain will tend to decrease as well, hence the value used is very conservative (it should be noted that a drop in boresight gain of 10dBi will reduce the value of D_{nf} by a factor of 10, so it reduces significantly with any reductions in gain).

3.3 Diffraction Effects

3.3.1 Diffraction is the physical phenomenon of electromagnetic waves 'bending' around obstructions. It is one of the mechanisms that allow sound to be heard around corners. It is possible for wave-transmitted energy that would miss a receiver to be diffracted by an obstruction towards the receiver, causing constructive or destructive interference. On this basis, siting of a link end close to obstructions can weaken the signal reaching the dish.

3.3.2 A Fresnel Zone takes the form of an ellipsoid surrounding a link path and represents the area in which obstructions should not be sited in order to avoid diffraction losses. The width of the zone at any point along the link path is determined by the Fresnel Zone number, the frequency of the link and the distance from each link end. The width of the zone is maximal at the midpoint of the link path.

3.3.3 The definition of a Fresnel Zone is described in the Ofcom paper as:

"The n-th Fresnel is the locus of all points for which, if the radio signal travelled in a straight line from the transmitter to the point and then to the receiver, the additional path length compared to the straight transmitter-receiver path equals nλ/2, where λ = wavelength."

3.3.4 Therefore the 1st Fresnel Zone is the locus of points that will cause a signal to travel ½ a wavelength further than the direct path, and the 2nd Fresnel Zone will cause a signal to travel one wavelength further. Fresnel zones are ellipses with the transmitter and receiver at the focus points of the ellipse (which will normally be very close to the ends of the ellipse).

3.3.5 The Ofcom paper recommends that for wind turbines, the 2nd Fresnel Zone is used as an exclusion zone for diffraction effects (the paper notes that this is considered conservative) where the link is microwave (1Ghz and above). The Ofcom paper has the following equation to calculate the 2nd Fresnel Zone, R_{F2}, where d1 and d2 are the distances from each link end where the assessed wind turbine becomes tangential to the link path.

- $R_{F2} = \sqrt{((2 \lambda d_1 d_2) / (d_1 + d_2))}$

3.3.6 The value for R_{F2} will be a maximum where $d_1 = d_2$, i.e., in the middle of the link. As an example, this maximum value will now be calculated given set parameters.

3.3.7 The link path length is 20km, or 20,000m long: in the middle of the link path a wind turbine is to be sited, therefore $d_1 = d_2$ (10,000m); because this is a microwave link, $\lambda = 0.3$m (equivalent to a link frequency of 1GHz):

- $R_{F2} = \sqrt{((2 \times 0.3 \times 10{,}000 \times 10{,}000) \div (10{,}000 + 10{,}000))} = 54.8$m

3.3.8 This represents the largest value for the 2nd Fresnel Zone for this example link. This is the distance from the straight line between the link end and receiver (link end to link end) at the mid-point of the link.

3.3.9 For UHF links and any static structure, 60% of the first Fresnel zone radius is commonly used. From the first section, the wavelength at 460MHz is 0.65m. A worked example for a UHF link is shown below:

- 60% of $R_{F1} = (\sqrt{((0.65 \times 10{,}000 \times 10{,}000) \div (10{,}000 + 10{,}000))}) \times 0.6 = 34.2$m

3.3.10 This represents the largest value for 60% of the first Fresnel Zone for this example link. This is the distance from the straight line between the link end and receiver (link end to link end) at the mid-point of the link.

3.3.11 An additional buffer distance e.g. 25m, may be added to account for micro-siting or co-ordinate inaccuracies.

3.4 Reflection Effects

3.4.1 Whilst link paths are typically designed so that the two link ends point directly towards each other, the actual signal that is propagated from the transmitter to the receiver travels outwards and disperses. This means the signal can be received in areas outside of the link boresight (the direct path) however these will be weaker than if the signal was received directly.

3.4.2 When a radio wave illuminates a wind turbine or static structure, a proportion is reflected in multiple directions. If this reflected signal can be received at the opposite link end, there is a chance that significant effects could occur due to multiple receipts of the same signal (also known as multipath effect). Unless the level of the reflected signal is negligible compared to the direct signal (in terms of timing and power received), the combination of direct and reflected signals and the time differences between their modulation may cause performance degradation. This is a particular concern for UHF links where the receiving antenna is not in direct line of sight but the obstruction does have line of sight to both link ends. Therefore, in instances where there is no line of sight between link ends, reflection effects are more likely.

3.4.3 Microwave links are much less susceptible to reflection effects due to the higher frequency being more directional, which means direct line of sight is required. Essentially, the lower the signal frequency, the higher the chance of reflection effects occurring.

3.4.4 Modelling reflection effects is a more complex calculation when compared to those for diffraction effects, which requires knowledge of the required signal (or 'carrier') to interference ratio (CIR), terrain data and signal propagation.

3.4.5 There is little in the way of consensus around a minimum CIR to be maintained by a link, or the extent to which moving elements (such as wind turbine blades) compound the potential impacts when compared to static structures. To this end, the recommended methodology is slightly less prescriptive than for the simpler diffraction exclusion zones due to the simple fact that there are many more variables that influence the outcome.

3.4.6 A minimum CIR value for UHF links put forth by the Joint Radio Company (JRC)[5] in the UK is 38 decibels[6]. It is understood that specific cases have been evaluated by the JRC with an even higher threshold than this. Values put forth by one of the main railway operators in South Africa for their UHF voice communication infrastructure was 15 dB. Other operators of bespoke equipment for UHF communications have used reference values as low as 10 dB.

3.4.7 In general terms, a threshold of 38 dB is considered appropriate but conservative in the absence of specific parameters about the network architecture, link function and baseline performance. The particulars of the calculation methodology will vary based on the obstruction type and antenna characteristics. In general terms, this should take into consideration:

- Link frequency;
- Free space path loss;
- Antenna directionality (at both transmitter and receiver);
- Radar Cross Section of the obstruction;
- Diffraction losses on direct link path and reflected link path;
- Cumulative effects if multiple reflectors are present.

3.4.8 In some specific cases, it may be appropriate to consider a greater or fewer number of parameters.

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[5] A UK-based telecommunications stakeholder who typically safeguards utility infrastructure.
[6] The Joint Radio Company Ltd. Calculation of Wind Turbine Clearance Zones, used by JRC for 460 MHz Telemetry Links, when turbine sizes and locations are accurately known. Issue 3.0.2. January 2007

3.4.9 In general, the smaller the radar cross section (RCS) of a wind turbine, the less significant the impact, however onshore[7] wind turbines are now consistently getting larger. Whilst the Ofcom paper correctly notes that RCS can be larger than the silhouette of the object as viewed from the direction of illumination, it also states the following:

- "*In the absence of more reliable information it is provisionally proposed that the optical silhouette of the complete blade set of a wind turbine, as viewed parallel to the axis of blade rotation, is used as the RCS.*"

3.4.10 This means the visible area of the rotor blades with the disc facing the observer. This area generally reduces with the square of the turbine rotor diameter (i.e. halving the radius represents a quartering of the area – that is a 75% reduction).

3.4.11 Although the Ofcom paper example indicates effects up to 500m along the link path, they do not extend more than 15m to either side of the link path. Stakeholders are however, beginning to look more cautiously upon reflection effects, especially within initial high-level assessments.

3.4.12 The methodology used by Pager Power draws from the JRC methodology. It is a complex calculation, which based on the variety of factors listed here, is not provided in detail.

[7] Predominantly telecommunications systems are affected by onshore wind turbines however, on occasion, offshore wind turbines may cause an impact, for example, if the wind turbines are located in the sea between two land masses.

4 CONSULTATION PROCESS

4.1 Overview

4.1.1 From identifying telecommunications links to moving forward into mitigation, the consultation process is fundamental to a wind or building development project. This section sets out the recommended process for consultation.

4.2 Consultation Requirement

4.2.1 It is considered best practice to consult and undertake a Telecommunications Impact Assessment as part of a planning application for wind or building developments as early as possible, regardless of whether a planning authority requests it. It is rare that a planning authority would possess a database of the most relevant telecommunications stakeholders as part of the statutory consultation process. Therefore, it is recommended that the developer proactively assumes this responsibility to undertake consultation, and this is often conducted by a suitably qualified expert who will consult and undertake the appropriate analysis. Publicly accessible databases (such as Ofcom from the UK) etc., may not provide the most up-to-date infrastructure details, therefore consultation is key to appropriately understanding the possible site constraints.

4.3 Consultation Process

4.3.1 Consultees typically include those who safeguard mobile phone, utility and emergency services infrastructure. Sometimes local or site-specific stakeholders will also need to be included, such as those who provide local wireless broadband networks or specific police services, however it may not be possible to capture all possible consultees. Therefore, it is standard practice to consult with the most prominent stakeholders, with others hopefully being identified throughout the planning process.

4.3.2 Consultation is typically undertaken in writing with the stakeholders. Requests are made for the most up-to-date telecommunications infrastructure that exists in proximity of the development site so that the assessment of a specific development design can be made, or so that a constraints map can be produced. The following should be requested:

- Link end co-ordinates;
- Link end heights;
- Link frequency.

4.3.3 Some stakeholders will provide the telecommunications infrastructure data, including some initial safeguarding advice and criteria, however others will request that they undertake their own assessment for a fee. Some stakeholders will also seek to keep their infrastructure details confidential whilst providing planning advice. It is encouraged that stakeholders provide the information listed above to ensure a more efficient and transparent consultation and assessment process.

4.4 Consultation Timescales

4.4.1 The consultation process can take anywhere between days to several months, with different stakeholders having different response times. It is recommended that consultation be undertaken as early as possible in the project timeline so that constraints can be identified. This can then feed into the site design and constraints mapping, as there are likely to be a number of additional constraints that a site faces e.g. flood risk areas or setback distances from roads. It is rare that a telecommunications issue presents a showstopper, however mitigation being required through re-routing links or repositioning of the turbine is not uncommon. In the worst cases for a wind development, a turbine may need to be removed from a scheme, and in fewer instances again, this could render a development economically unviable. For building development, it is rare that design alterations are required, however mitigation would need to be implemented. See Section 6 for further details.

4.4.2 If a stakeholder response is not received, and suitable chasing and availability to provide such data have been made, then it is reasonable to assume that the stakeholder has no concerns. In this instance, evidence of the consultation process should be provided to the planning authority. This approach does leave the risk of an objection at a later stage of the application once the planning application is submitted, but it does provide evidence that best-practice has been followed throughout the pre-application process.

4.5 Consultation Output

4.5.1 Once a stakeholder has responded, detailed analysis should be undertaken considering the relevant diffraction and reflection criteria. The associated diffraction exclusion zones should then be assessed against a specific wind turbine layout or building design, or plotted as a constraints plan. For reflection effects, the assessment criteria is more dynamic and therefore it may not be possible to produce a constraints plot. It remains important to know which turbines are producing the most significant reflection effect so that suitable advice can be provided.

5 ASSESSMENT PROCESS

5.1 Overview

5.1.1 Firstly, consultation with the link operators should be completed as per Section 4 to ensure the most up-to-date telecommunications link data is assessed.

5.1.2 Once link data has been received, the point-to-point link exclusion zones can be plotted as a constraints map against the site boundary if no turbine layout or building footprint is available, or assessed against a specific wind turbine layout or building design.

5.1.3 Analysis can be completed in 2-Dimensions or 3-Dimensions (where ground heights, mast heights and turbine dimensions are considered). Ideally, a wind turbine or building development should be located outside of the relevant exclusion zone for each communications link, but sometimes this is not possible due to other constraints.

5.2 Fresnel Zones

5.2.1 Different obstructions require varying considerations of the Fresnel zone. This depends on the frequency of the point-to-point telecommunications links, as well as whether the obstruction is static or mobile.

5.3 Assessment Criteria

5.3.1 Figure 6 below should be used to determine which Fresnel zone should be considered when undertaking the exclusion zone analysis for different project and telecommunication link types.

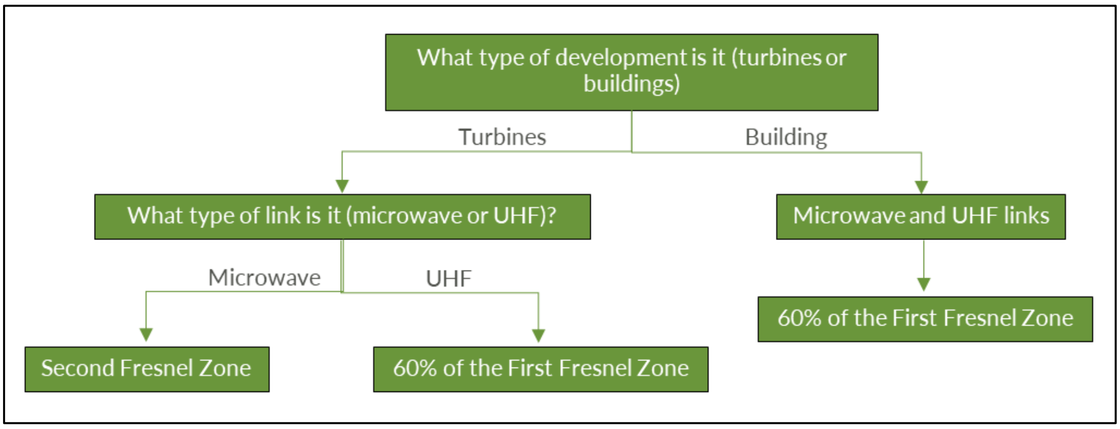

Figure 6 *The assessment parameters for telecommunications infrastructure*

5.4 Diffraction – Microwave and UHF Links

5.4.1 There are various approaches to safeguarding microwave links from diffraction effects against obstructions. The most common approaches are:

1. Implementation of a fixed stand-off distance around the link boresight;
2. Safeguarding the relevant Fresnel Zone.

5.4.2 The first approach is used by many stakeholders who request a set buffer distance. Set stand-off distances are often conservative and produce a large exclusion zone distance. The second approach is to assess an obstruction on a case-by-case basis to calculate the most accurate exclusion zone based on the link frequency and relevant Fresnel zone, as set out in section 3.3.

5.5 Reflections – UHF Links

5.5.1 Reflection effects occur when the transmitted signal from one link end is reflected by an object towards the other link end which causes interference to the signal. In order to establish whether an object will cause reflection effects, it is necessary to calculate the Carrier to Interference Ratio (CIR), also known as the Wanted to Unwanted Ratio, as set out in Section 3.4. This quantifies the strength of the direct (wanted) signal between the link ends relative to the interfering (unwanted) reflection from the obstruction.

5.5.2 Pager Power's approach for assessment is most influenced by the JRC methodology. Because the calculation is sensitive to the intervening terrain between the turbine and each link end, it must be undertaken for individual locations. This is why there is no fixed exclusion zone for reflection issues.

5.6 Assessment Process Step-by-Step

5.6.1 The following steps present the recommended approach for assessing a development against point-to-point telecommunications infrastructure:

1. Identify whether an assessment of a specific wind turbine layout, building footprint and/or site boundary is to be considered;
2. Consult with the most prominent communications stakeholders to gather the most up-to-date telecommunications infrastructure details;
3. Undertake an initial impact assessment of the communications links and masts identified to identify safeguarded zones;
4. Plots these with respect to the wind turbine layout, building footprint or as a constraints map on a site boundary;
5. Identify where any impacts are anticipated. If there are no impacts predicted, confirm with stakeholders and finalise the assessment;
6. If impacts are predicted, consider re-location of the object outside of the safeguarded zone. If this is not possible, move forward with mitigation discussions.

5.6.2 If mitigation is required, then the steps presented in the following section should be followed.

6 MITIGATION OPTIONS

6.1 Overview

6.1.1 Where an infringement of a safeguarded zone around a link path or mast has been identified, mitigation should be pursued at the earliest possibility in the planning process to avoid any unnecessary objections or delays. The following sections present the recommended assessment process through to mitigation, as well as the most common mitigation solutions.

6.1.2 Technical mitigation is almost always possible for communications links however the solution and the fee for mitigation varies on a case-by-case basis. The solution and fee will also be dependent on the number and type of communication links affected.

6.2 Mitigation Process Step-by-Step

6.2.1 The following steps present the recommended approach to identifying and implementing mitigation should re-location of the obstruction not be possible:

1. Consult with the stakeholder regarding the request to explore mitigation options;
2. Identify the most suitable mitigation option, and agree this with the stakeholder;
3. Conduct analysis to determine the technical viability of the preferred mitigation option;
4. If the preferred option is technically and financially viable, proceed to draw up planning conditions and/or contract agreements with the planning authority and the stakeholder;
5. If the preferred mitigation option isn't viable, revert to step 2.

6.2.2 It is likely that any impact requiring mitigation can be managed through a planning condition. This will ensure there is no obligation to pay for mitigation prior to receiving planning permission.

6.3 Telecommunications Masts

6.3.1 For wind turbines, a stand-off distance of 250m for masts with microwave telecommunications links present and 500m for UHF masts with UHF links present in the absence of further detailed modelling. This means that initial plans should allow for no wind turbines to be located within the given radius of the mast.

6.3.2 In built-up areas where telecommunications masts are situated on rooftops, this distance typically does not apply.

6.3.3 It is possible that this stand-off distance could be reduced when further analysis and consultation with the stakeholder is undertaken.

6.4 Microwave Link Mitigation

6.4.1 The four most recommended and cost-effective mitigation options for microwave links that are affected by wind turbines or building developments are:

- Micrositing / layout optimisation;
- Re-networking of the link via existing telecommunications sites;
- Use of a leased line or fibre optic connection;
- Changing the link elevation;
- Construction of a new telecommunications site for the purpose of re-networking the link.

6.4.2 One further option that can be considered for microwave links, but is less likely to be viable, is the use of alternative technology, such as a satellite link. Pager Power has not yet seen a solution such as this be implemented for mitigation purposes.

6.4.3 The recommended solutions are discussed in turn below.

Micrositing / Layout Optimisation

6.4.4 This is potentially the simplest solution, depending on the available site area. This solution involves simply removing the obstruction from the safeguarded zone associated with the telecommunications link. For wind turbines specifically, restriction on micrositing may be required to ensure a turbine does not encroach on the link when it is constructed on site – this can normally be managed through a planning condition.

6.4.5 There must be careful consideration for other link path exclusion zones and masts to ensure the relocated obstruction does not enter into the exclusion zone of adjacent telecommunications infrastructure.

6.4.6 This solution is typically not viable for building developments due to the precision with which they are constructed.

Re-networking Solution

6.4.7 In some cases, it is possible to re-network a microwave link via an existing telecommunications site that lies on a bearing away from the obstruction in question.

6.4.8 This involves adding an extra node on the link path, so that instead of the signal being sent from End A to End B, it is sent from End A to a re-networking site, and from the re-networking site to End B.

6.4.9 Implementation of such a solution requires identification of a suitable re-networking site, and assessment of the intervening terrain to ensure the appropriate Fresnel zone would not be infringed by terrain for the re-networked link. It also needs to be ensured that radio line of sight exists between the identified mast and the existing link end locations.

6.4.10 The costs and timescales associated with such a solution are variable, however it is likely to be more cost-effective and have a shorter timescale than the construction of a new telecommunications site.

Use of a Leased Line

6.4.11 In some cases, it is possible to replace the wireless link with a leased line between the link ends, thereby avoiding potential interference due to an obstruction. It is common for the solution to utilise a copper wire or fibre optic cable.

6.4.12 The feasibility of such a solution is dependent on the accessibility of each link end with regard to the installation of a leased line. It may not be that the whole link path needs to be replaced, but only a small section to a nearby mast or junction box.

6.4.13 The costs associated with the implementation of a leased line may be expensive and are dependent on the length of the line, the specific route, access to the link path and the cost of burying the cable.

Changing Link Elevation

6.4.14 It may be possible to raise or lower the receivers/transmitters of both the microwave link ends to increase the separation between the wind turbine and the relevant Fresnel zone.

Construction of a new telecommunications site for the purpose of re-networking the link

6.4.15 In circumstances where none of the above mitigation options are viable, or when the cost of mitigating multiple links simultaneously begins to increase, then a more economical option may be to build a new telecommunications mast to house one or more communications links.

6.4.16 Similarly to re-networking, the mast has to be suitably sited so that the telecommunications links can operate effectively, whilst also removing diffraction effects from any obstruction.

6.4.17 This is likely to be the most expensive single solution however it may still be less than mitigating numerous links simultaneously. It is possible that the new telecommunications mast would involve a separate planning application.

6.4.18 Any new mast would likely also require all of the additional infrastructure, as stated within Section 2.2.4.

6.5 UHF Telemetry Links

6.5.1 The six most recommended and cost-effective mitigation options for UHF telemetry links that are affected by wind turbines or building developments are:

- Micrositing / layout optimisation;
- Re-networking of the link via existing telecommunications sites;
- Use of a leased line or fibre optic connection;
- Increasing link elevation;
- Replacement of the UHF telemetry link with a microwave link;
- Construction of a new telecommunications site for the purpose of re-networking the link.

6.5.2 One final option that can be considered for UHF links, but is less likely to be viable, is the use of alternative technology, such as a satellite link. Pager Power has not yet seen a solution such as this be implemented for mitigation purposes.

6.5.3 The recommended solutions are discussed in turn in the following sub-sections.

Micrositing / Layout Optimisation

6.5.4 Relocating obstructions outside of a link path exclusion zone may be sufficient to overcome a stakeholder's concerns for diffraction effects, however it must be ensured that the relocated object does not encroach on the link when it is constructed on site – this can normally be managed through a planning condition.

6.5.5 Reflection effects may require further consideration, meaning that re-locating the obstruction outside of the appropriate Fresnel zone may not be sufficient. Therefore consideration of reflection effects may still be required.

6.5.6 There must also be careful consideration for other link path exclusion zones and masts to ensure the re-located obstruction does not enter into the exclusion zone of adjacent telecommunications infrastructure.

6.5.7 This solution is typically not viable for building developments due to the preciseness in which they are constructed.

Re-Networking Solution

6.5.8 Similar to the microwave link mitigation option, it is possible to re-network a UHF link via an existing telecommunications site that lies on a bearing away from the obstruction in question.

6.5.9 Implementation of such a solution requires identification of a suitable re-networking site, and assessment of the intervening terrain to ensure the appropriate Fresnel zone would not be infringed by terrain by a significant margin for the re-networked link. Reflection issues also need to be considered but radio line of sight is less stringent.

6.5.10 The costs and timescales associated with such a solution are variable, however it is likely to be more cost-effective and have a shorter timescale than the construction of a new telecommunications site.

Use of a Leased Line

6.5.11 This solution is the same as that for a microwave link.

Increasing Link Elevation

6.5.12 It may be possible to raise the receivers/transmitters of both the UHF link ends to decrease the diffraction losses due to the terrain, ideally bringing the total diffraction losses to a more operationally accommodatable level.

Replacement of the UHF Link with a Microwave Link

6.5.13 In cases where reflection issues are the only concern, replacement of the UHF telemetry link with a microwave link may be a suitable solution. This is because microwave links are not prone to reflection issues in the same way that UHF telemetry links are.

6.5.14 However, microwave links do require radio line of sight to operate, which UHF telemetry links do not. Therefore, a detailed assessment of the technical feasibility of such a solution would be required. This would include an assessment of the radio line of sight between the link ends and to establish whether the intervening terrain (or any other obstacle) would obstruct the appropriate Fresnel zone of a microwave link.

Construction of a new telecommunications site for the purpose of re-networking the link

6.5.15 This solution is the same as that for a microwave link however, in addition to removing diffraction effects from any obstruction, the mast siting also has to consider reflection effects.

6.6 Mitigation Conclusions

6.6.1 It is Pager Power's position that no wind or building development should be prevented where a telecommunications issue is identified, except in the scenario where the cost to mitigate the impact outweighs the benefits of developing the project in question[8]. There is always a technical solution, as outlined in the previous section, but, in many cases a way forward is prevented by mitigation costs or a developer's/stakeholder's ability to find an appropriate solution which is suitable to both.

[8] This can sometimes mean aspects of a development are reduced i.e. a reduction in wind turbine numbers

7 CONCLUSIONS

7.1 White Paper Purpose

7.1.1 Formal guidance around the topic of wind and building development with respect to telecommunication issues remains scarce, with most requests for this assessment, be it from planners or stakeholders, falling short of providing a specific assessment methodology. Likewise, national and international guidance is scarce in terms of a specific process that is accessible to developers, planners and stakeholders alike. The aim of this paper is therefore to produce a standardised assessment process for all, from the early stages of the project, through to mitigation.

7.1.2 This paper is based on knowledge initially gained through Pager Power's experience within the UK market however the methodologies are deemed applicable and have been used for worldwide wind and building developments. Specifically, this basis draws from:

- Reviews of existing guidance and studies within telecommunications;
- Telecommunications assessment experience and industry knowledge;
- Best practice recommendations.

7.1.3 Whilst aimed primarily at wind and solar developers, this guidance is applicable for any object deemed an obstruction to telecommunications systems.

7.2 Key Receptors

7.2.1 The key receptors considered telecommunications mast structures, point-to-point microwave and Ultra High Frequency (UHF) telemetry links.

7.3 Consultation Process

7.3.1 Consultation with the most prominent telecommunications stakeholders is recommended at the earliest opportunity in the project timeline. This is typically following the completion of a wind turbine layout or initial building designs. Alternatively a site boundary can be considered. These details should then be sent to the stakeholders to ensure the most up-to-date telecommunications infrastructure is assessed.

7.4 Assessment Methodology

7.4.1 The assessment methodology is dependent on the telecommunications infrastructure type, the link frequency and whether the obstruction is static or mobile. In general, the following steps present the recommended approach for assessing a development against point-to-point telecommunications infrastructure:

1. Identify whether an assessment of a specific wind turbine layout, building footprint or site boundary is to be considered;

2. Consult with the most prominent communications stakeholders to gather the most up-to-date telecommunications infrastructure details;
3. Undertake an initial impact assessment of the communications links and masts identified to identify safeguarded zones;
4. Plots these with respect to the wind turbine layout, building footprint or as a constraints map on a site boundary;
5. Identify where any impacts are anticipated. If there are no impacts predicted, confirm with stakeholders and finalise the assessment;
6. If impacts are predicted, consider re-location of the object outside of the safeguarded zone. If this is not possible, move forward with mitigation discussions.
7. Consult with the stakeholder regarding the request to explore mitigation options;
8. Identify the most suitable mitigation option, and agree this with the stakeholder;
9. Conduct analysis to determine the technical viability of the preferred mitigation option;
10. If the preferred option is technically and financially viable, proceed to draw up planning conditions and/or contract agreements with the planning authority and the stakeholder;
11. If the preferred mitigation option isn't viable, revert to step 8.

7.4.2 It is likely that any impact requiring mitigation can be managed through a planning condition. This will ensure there is no obligation to pay for mitigation prior to receiving planning permission.

7.5 Guidance Conclusions

7.5.1 The advice given in this paper should be followed to ensure the comprehensive assessment of point-to-point telecommunications systems. This guidance is applicable to telecommunications systems anywhere in the world.

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