PAGERPOWER

Case Study 04:

Pen Y Bryn Wind Turbine Development

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CONTENTS

1 INTRODUCTION

A small wind turbine was erected on private land adjacent to West Wales Airport where testing of military Unmanned Aerial Vehicles (UAVs) takes place. There is also a nearby military radar facility at Aberporth.

The owner of the wind turbine was of the view that planning permission had been granted for the wind turbine, whereas the local planning authority took the view that it had not.

The local planning authority issued an enforcement notice requiring that the wind turbine be dismantled because it did not have planning permission, and it would adversely affect operations at West Wales Airport.

Pager Power was appointed to advise the wind turbine on operator regarding UAV and radar interference issues at the subsequent Public Inquiry.

2 BACKGROUND

There were four areas of potential concern regarding the wind turbine. These were:

- Effects on the Aberporth Primary Surveillance Radar (PSR)
- Effects on the Aberporth Secondary Surveillance Radar (SSR)
- Physical collision risk to aircraft using West Wales Airport
- Electromagnetic Interference between the wind turbine and UAVs using Aberporth

The wind farm's owner appealed the enforcement notice issued by the local planning authority – resulting in a public inquiry held on 13 September 2011.

3 THE CHALLENGE

The appeal was quite unusual because the wind turbine was small and had already been built. The wind turbine was situated next to the runway at West Wales Airport, where UAVs are tested, and was also in range of the Ministry of Defence (MOD) radar at their Aberporth test facility run by QinetiQ.

Whilst there was plenty of evidence relating to the effects of wind turbines on radar and airports, generally there was little evidence relating specifically to the effects of wind turbines on UAV operations.

4 THE RESULT

The appeal against the enforcement notice was allowed. Excerpts from the decision notice[1] are reproduced below:

> *1. The appeal is allowed, the enforcement notice is quashed and planning permission is granted on the application deemed to have been made under section 177(5) of the 1990 Act as amended for the development already carried out, namely the erection of a wind turbine structure for the production of electricity on land forming part of Pen-y-Bryn, Blaenannerch, Cardigan SA43 2BN referred to in the notice.*
>
> *….*
>
> *3. The inquiry opened on 13 September 2011. Following discussions between the parties during the day, the inquiry was adjourned at the end of that day until 29 September 2011, to enable a section 106 obligation to be drawn up in accordance with heads of terms agreed at the inquiry, together with a side agreement between the appellants and West Wales Airport (WWA).*
>
> *4. The period for completion of the section 106 obligation and side agreement was subsequently extended and certified copies of an executed obligation by way of unilateral undertaking and an associated deed of grant of easement by agreement, both dated 21 November 2011, were eventually submitted on 5 December 2011. The unilateral undertaking relates to the provision of a control mechanism enabling the wind turbine to be switched off and restarted in accordance with terms set out in the deed of grant of easement. The deed of easement enables WWA to install, maintain and operate the control mechanism so that it can ensure that the turbine does not operate at times when this would be inimical to WWA's aviation operations. The section 106 unilateral undertaking is a material consideration to which I have had regard in reaching my decision.*
>
> *….*
>
> *9. The parties agree that the turbine's height and position does not infringe the obstacle clearance surface relating to WWA. The Council confirmed at the Inquiry opening that the sole basis of its concern in relation to the turbine related to the possible effects of its operation on radar/radio communications systems at WWA and radar systems forming part of the Ministry of Defence (MoD) facility at Aberporth.*
>
> *….*

[1] Appeal Ref: APP/D6820/C/11/2149763

15. The other aspect of the air safety issue relates to operations at the nearby Aberporth range, operated by Qinetiq under a long term partnering agreement with MoD. The MoD Aberporth facility includes a primary surveillance radar (PSR) installation located 2.7km from the turbine and a secondary surveillance radar (SSR) installation located 1.4km away. The Defence Infrastructure Organisation submitted a letter of objection on behalf of MoD dated 3 August 2011. The basis of the objection was stated as being that "the turbine is 1.39km from, in line of sight of, and will cause unacceptable interference to the range control radar at Aberporth". The letter of objection went on to identify the potential detrimental effects of wind turbines on radar performance as including the desensitisation of radar in the vicinity of the turbines and the creation of false aircraft returns.

16. These matters are dealt with in the evidence on behalf of the appellants provided by Mr Watson (Pager Power aviation studies). Mr Watson's evidence was the only expert evidence provided on this matter, and is not challenged by the Council. Mr Watson's evidence points out that the MoD objection letter is unclear because the stated distance clearly relates to the SSR, whereas the description of the anticipated effects relates to PSR. In the absence of meaningful clarification from MoD's technical advisors as to whether the concerns related solely to the turbine's effect on the Aberporth SSR referred to in the letter or to effects on the Aberporth PSR as well, and as to the detailed nature of any concern in relation to the PSR and SSR, Mr Watson has assessed the turbine's potential effects in relation to both the PSR and SSR installations.

17. In relation to the PSR, the turbine is well below line of sight, due to the intervening high ground. The indicative radar detectability calculation undertaken, based on an advanced methodology published in the first edition of Civil Aviation Publication 764, shows that the energy reflected back to the radar from the turbine will be a hundred times smaller than the minimum level the radar is able to detect, due to terrain shielding. As such, the turbine is highly unlikely to affect the PSR.

18. In relation to the SSR and the issues raised on behalf of MoD, the thrust of Mr Watson's expert evidence is that wind turbines do not cause desensitisation on SSR; they can only produce false targets via reflections of genuine targets; fundamentally the effects of wind turbines on SSR performance would not be expected to differ from those of static structures; there are many larger static structures than the turbine in the vicinity of the SSR including hangars, airport and commercial buildings and masts; neither the MoD nor Qinetiq has reported any effects of the existing wind turbine on the SSR; Mr Watson knows of no instance of such a small turbine ever having affected an SSR radar in any way whatsoever. The conclusion of Mr Watson's evidence is that it is highly unlikely that the wind turbine will ever have a significant effect on the SSR.

19. Shortly before the inquiry opened the Defence Infrastucture Organisation confirmed that, after consideration of further reports from its technical experts, the MoD had elected not to be represented at the Inquiry.

20. I find no reason to doubt the expert evidence submitted in relation to this matter, which points unequivocally to the turbine having no materially adverse effect on the operation of the radar installations at MoD Aberporth.

21. On the evidence before me I conclude that the potential for the turbine to have any detrimental effect on the operation of the radar installations at MoD Aberporth is negligible. Coupled with my conclusion that the existence of the section 106 obligation and associated side agreement addresses the operational issues raised in relation to WWA, I conclude overall on the main issue that the wind turbine has no material adverse implications for the nearby aviation operations at WWA and MoD Aberporth. As such, the development does not conflict with the provisions of UDP policy ENVP3.4, or with government policy guidance concerning wind turbines and aviation issues.

5 THE EVIDENCE

Michael Watson's proof of evidence is reproduced below:

Land at Pen – Y – Bryn, Cardigan, Ceredigion

Proof of Evidence

Eur Ing **Michael Watson** CEng MIET

Qualifications and Experience

1. My name is Mike Watson. I have an honours degree in Electronic, Computer and Communications Engineering and am a Chartered Engineer. I have worked as a commissioning engineer at Sizewell B nuclear power station and have worked as a software developer for Barclays Bank plc. I founded Pager Power Limited in 1997. Pager Power advises wind farm developers and undertakes studies for them. The company deals with aviation, radio communications and radar issues for wind farm developers and consultants. The company deals with onshore and offshore wind farms and occasionally with other building developments.

2. I am a member of the Renewable UK (formerly BWEA) aviation strategy group which meets regularly in London to discuss aviation and wind farm issues.

3. The International Energy Agency (IEA) runs Topical Expert Meetings on wind farms, radar and radio. I was technical chairperson of the last meeting in Amsterdam.

4. The NATO Research and Technology Organisation is considering the impact of wind turbines and radar. I attended the second meeting in Paris.

5. Eurocontrol are currently drafting guidelines on wind farms and radar. I have commented on these guidelines and participated in a workshop to finalise the guidelines.

6. I addressed the American Wind Energy Association conference in Dallas in May 2010 regarding my successful data fusion mitigation solution for the 140 turbine Whitelee wind farm in central Scotland.

7. In 2010, I addressed the British Wind Energy Association [now Renewable UK] conference in Liverpool regarding Ministry of Defence threat radar.

8. Pager Power helped Scottish Power and BAA overcome issues associated with the 62 turbine Black Law wind farm and its potential impact on the radar at Edinburgh Airport in 2003.

9. The company has acted for the majority of major UK wind farm developers on hundreds of wind farm proposals. The company has also worked on wind farm developments in Ireland, Belgium, Canada, Bulgaria, Seychelles, South Africa and Australia. We have a good relationship with wind developers and consultants in the USA, Netherlands, Sweden, Czech Republic and Romania.

10. I have a good relationship with the Civil Aviation Authority, the Ministry of Defence, National Air Traffic Services, BAA and many airport operators. I also have a good relationship with Eurocontrol and a number of overseas aviation and military bodies.

11. I used to hold a Private Pilots Licence and have flown subject to air traffic control in the vicinity of wind farms.

Scope

12. I have considered the impact of the turbine at Pen-Y-Bryn on the Qinetiq Range Radar at Aberporth, West Wales Airport and the operation of Unmanned Aerial Systems from West Wales Airport.

Wind Turbine

13. The wind turbine is located at Blaenannerch. It is a small 5 kilowatt Evance R9000 turbine which has UK MCS certification[2]. This turbine has 0.2% (or two one-thousandths) of the electrical output of a typical 2.5MW machine currently being installed in wind farms throughout the UK.

14. The diagram below indicates the relative size of the Pen-Y-Bryn turbine compared with a typical large turbine.

[2] Evance R9000 brochure

15.

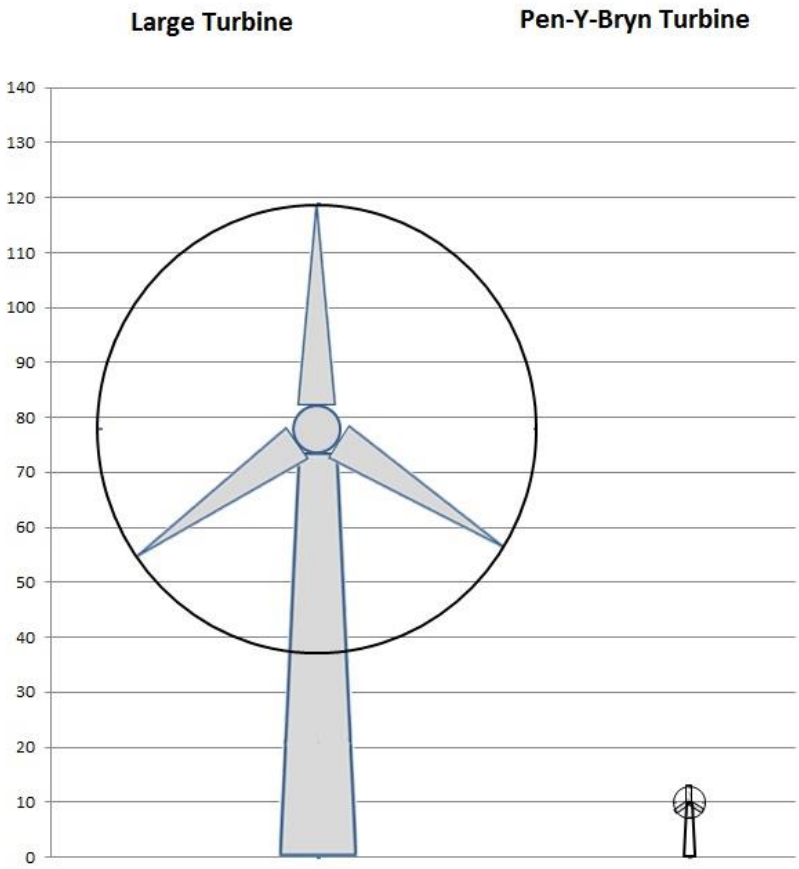

Figure 1 Comparison of turbine sizes

16. The Evance R9000 turbine conforms to the International Standard IEC[3] 61400-2 which runs to hundreds of pages having specific requirements for the turbine's electrical and protection systems.

17. The Ministry of Defence operates a similar Evance R9000 turbine at the Duke of York's Royal Military School in Dover[4]. This is understood to be the first wind turbine ever installed by the Ministry of Defence.

18. The Evance R9000 is classified as a small wind turbine. Renewable UK, who represent the UK wind industry, advise that Small wind turbines are unlikely to

[3] International Electrotechnical Commission

[4] http://dev1.acms.mod.uk/armysafety/features/windpower.htm

have any detrimental effects on aviation and associated radar or navigation systems.[5]

Published Guidance

19. The UK Civil Aviation Authority publishes a number of documents which are relevant to the situation in question. Civil Aviation Publication 764 is entitled CAA Policy and Guidance on Wind Turbines; Civil Aviation Publication 168 has guidance pertaining to the physical safeguarding of aerodromes and Civil Aviation Publication 722 is entitled Unmanned Aircraft System Operations in UK Airspace[6].

20. In 2002 the UK Government published "Wind Energy and Aviation Interests – Interim Guidelines"[7].

21. In July 2008 the US Department of Commerce published "Assessment of the Effects of Wind Turbines on Air Traffic Control Radars"[8].

22. There are many more documents available discussing the impact of wind turbines on radar and aviation.

Coexistence of Wind Turbines and Radar

23. Two turbines have recently been erected at East Midlands Airport. Qinetiq[9] undertook technical studies to allow these turbines to coexist with the Primary Surveillance Radar and other navigation equipment at the airport.

[5] http://www.bwea.com/small/faq.html#height

[6] The latest editions of all of these documents can be downloaded from www.caa.co.uk

[7] ETSU W/14/00626/REP

[8] NTIA Technical Report TR-08-454

[9] http://www.eastmidlandsairport.com/emaweb.nsf/AttachmentsByTitle/Wind+Turbine+Information.pdf/$FILE/Wind+Turbine+Information.pdf

Figure 2 Wind Turbines at East Midlands Airport, UK

Qinetiq Range Radar – Aberporth

24. The Ministry of Defence has advised that it objects to the wind turbine in a letter to Ceredigion County Council[10].

25. Qinetiq operates the Aberporth range under a long term partnering agreement with the Ministry of Defence[11].

26. The specific text relating to the objection is reproduced below:

Range control radar

The turbine is 1.39 km from, in line of sight of, and will cause unacceptable interference to the range control radar at Aberporth.

Wind turbines have been shown to have detrimental effects on the performance of Ministry of Defence radars. These effects include the desensitisation of radar in the vicinity of the turbines, and the creation of "false" aircraft returns which air traffic controllers must treat as real. The desensitisation of radar could result in aircraft not being detected by the radar and therefore not presented to air traffic

[10] Letter from Margot Williams to Rosemary Rhys dated 3 August 2011 with Ministry of Defence reference DE/C/SUT/43/10/1/13747

[11] www.ltpa.co.uk

controllers. Controllers use the radar to separate and sequence both military and civilian aircraft, and in busy uncontrolled airspace radar is the only sure way to do this safely. Maintaining situational awareness of all aircraft movements within the airspace is crucial to achieving a safe and efficient air traffic service, and the integrity of radar data is central to this process. The creation of "false" aircraft displayed on the radar leads to increased workload for both controllers and aircrews, and may have a significant operational impact. Furthermore, real aircraft returns can be obscured by the turbine's radar returns, making the tracking of conflicting unknown aircraft (the controllers' own traffic) much more difficult.

27. Pager Power has a schedule of Ministry of Defence radar sites, provided by the Ministry of Defence, that is used when assessing wind turbine[12] radar interference. This schedule shows two radar sites at Aberporth. There is a Secondary Surveillance Radar SSR to the south west of Parc-llyn next to the road and a Primary Surveillance Radar PSR at a separate location within the Qinetiq complex near the coast.

28. Map inspections, aerial photography and Pager Power's records all indicate that there are indeed two separate radar sites at Aberporth.

[12] Schedule of sites requiring wind farm protection 9 May 2008

29. The diagram below shows the turbine and two radar at Aberporth superimposed on a detailed Ordnance Survey map. It should be noted that the map is not at its original scale.

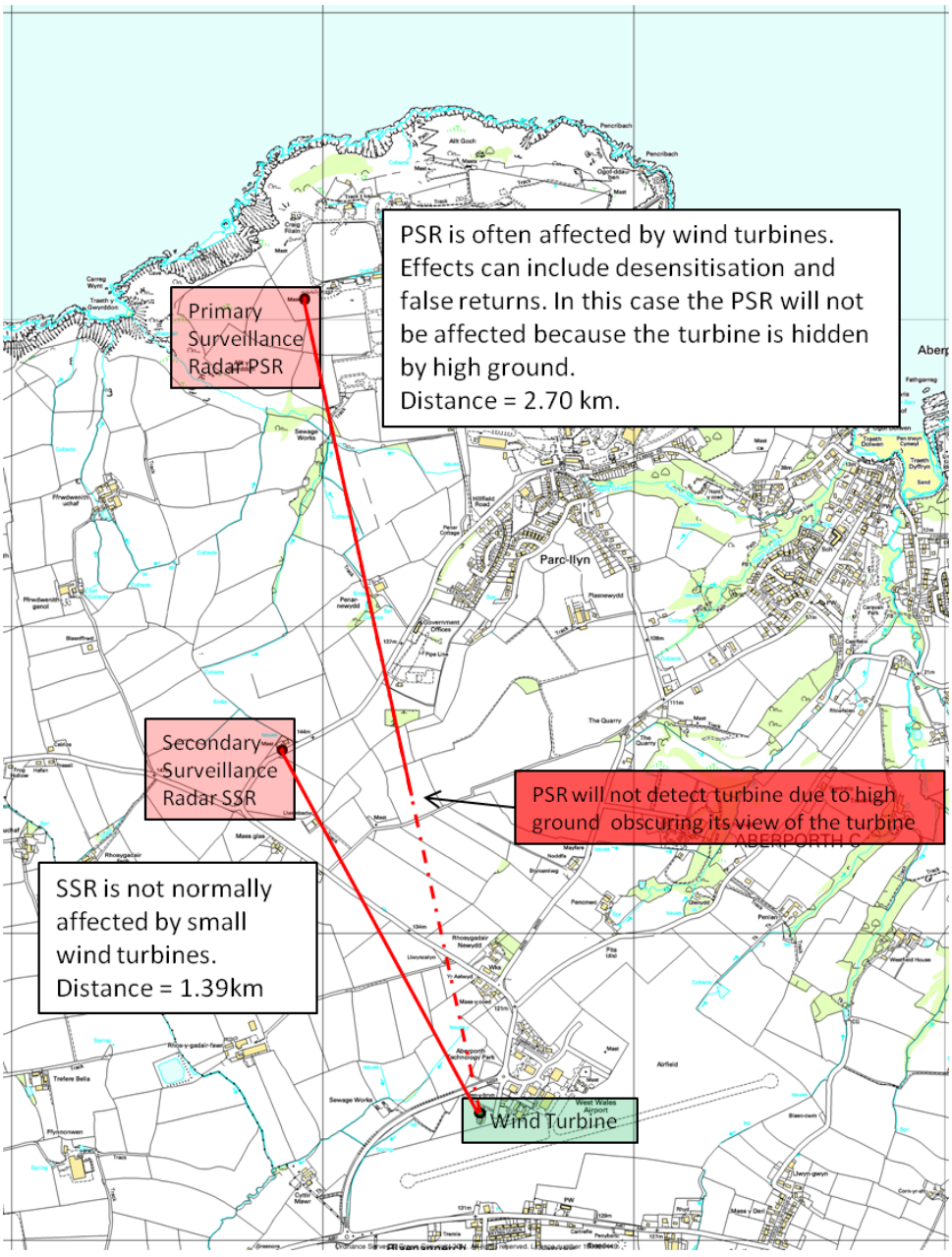

Figure 3 Qinetiq radar and wind turbine

30. It can be seen that the turbine lies approximately 1.4km from the Secondary Surveillance Radar (SSR) and approximately 2.7km from the Primary Surveillance Radar (PSR).

31. I consider the Ministry of Defence objection letter to be unclear because the stated distance clearly relates to the SSR whereas the description of the anticipated effects relates to the PSR.

32. Pager Power has sought clarification to determine whether the Ministry of Defence objection relates to the PSR or the SSR. Whilst the Ministry of Defence has responded to the clarification request[13] it is not clear whether the Ministry of Defence's objection relates to one radar or both.

33. Both radar have consequently been assessed.

Qinetiq Range Radar – Primary Surveillance Radar – PSR

34. Wind turbines can have a technical effect on PSR. These effects are summarised in the Ministry of Defence objection letter and are described in CAA Civil Aviation Publication 764 Policy and Guidelines on Wind Turbines[14] as well as in the UK Government's Interim Guidelines[15].

35. Wind turbines will not affect radar if they are not in line of sight of the radar. CAA Civil Aviation Publication 764 states[16]:

36. Prediction of the affect on a particular radar site by a proposed wind turbine development is a complex task as this depends on many factors including terrain, weather, maximum heights of the radar and the wind turbines, LOS, the operational range of affected radars, diffraction, antenna beam tilt, radio propagation characteristics, curvature of the earth etc. However, assessing whether the wind turbines are within the radar's LOS is a useful basic indication of whether the wind turbine could have potential impacts on the radar performance or not.

37. The Wind Energy and Aviation Interest Interim Guidelines state:

> ***3.5.2.2.2*** *Both the towers and the blades of wind turbines may be detected if they are in the line of sight of the radar.*

[13] Four emails between Michael Watson and Margot Williams - August 2011

[14] Chapter 2

[15] §3.5.22

[16] Appendix 2

38. Pager Power has been undertaking Radar Line of Sight calculations for the past nine years using in-house software. The Line of Sight chart between the Aberporth PSR and the turbine at Pen-Y-Bryn is shown below.

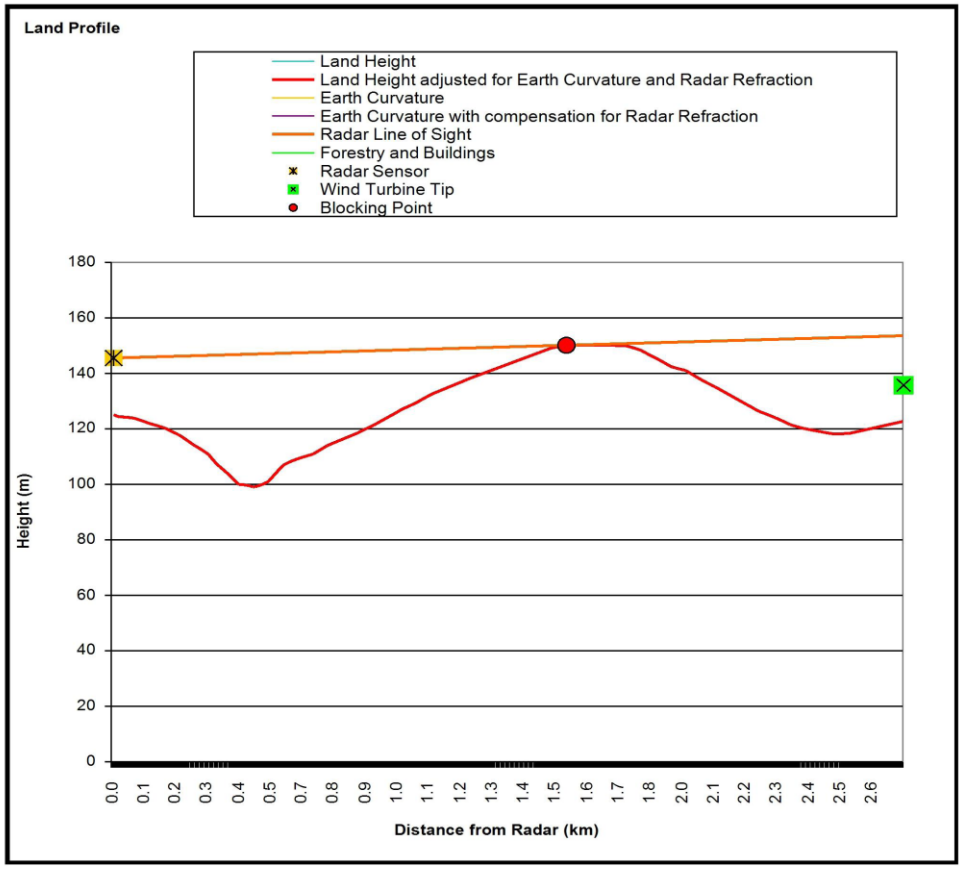

Figure 4 Radar Line of Sight Chart

39. This line of sight analysis accounts for terrain, earth curvature and standard radar refraction.

40. Analysis of the above shows that the turbine is well below the radar line of sight (17.8 metres) and therefore highly unlikely to affect the PSR.

41. An indicative radar detectability calculation has also been undertaken, based on an advanced methodology published in the first edition of Civil Aviation Publication 764. This shows that the energy reflected back to the radar from the turbine will be a hundred times smaller than[17] the minimum level the radar is able to detect – due to terrain shielding.

[17] Received power -143.33 dBm. Receiver threshold -123.00 dBm.

42. A number of reports, by Qinetiq and others, have been published showing that radar reflections from small wind turbines are much smaller than reflections from larger ones.

43. The wind turbine has been operational since 2010. Neither the Ministry of Defence or Qinetiq has provided any evidence that the wind turbine is affecting the radar.

44. It is highly unlikely that the wind turbine will ever have a significant effect on the PSR.

Qinetiq Range Radar – Secondary Surveillance Radar

45. There is a lot of documentation that refers to the potential effects of wind turbines on SSR[18]. The potential effects of larger turbines on SSR include:

    a) False targets caused by signal reflections

    b) Presenting an obstruction

    c) Bearing errors

46. The Ministry of Defence /Qinetiq objection refers to desensitisation and false returns. Wind Turbines do not cause desensitisation on SSR. They can only produce false targets in the presence of a genuine target (i.e. via reflections).

47. There is very little documentation that refers to the effects of small wind turbines on SSR. This is likely to be because small wind turbines generally do not affect SSR.

48. Section 5 of the US Department of Commerce report states:

    5 CONSIDERATION OF THE EFFECTS OF WIND TURBINES ON SECONDARY

    RADAR (ATCBI) PERFORMANCE

    As mentioned in Section 2, there are conflicting reports in the literature regarding the effects of wind turbines on SSR performance. Whereas it is stated in [6] that SSR performance does not appear to be affected, [7] states that impacts have been reported. It appears that although impairments of SSR performance can occur, they are much less likely than the impacts on primary surveillance radar, or PSR, performance.

    Impacts due to shadowing and signal corruption have not been reported. Possible impacts that need to be considered include: errors in bearing and target

[18] Interim Guidelines §3.5.2.4; CAA Civil Aviation Publication 764 Chapter 2 Section 3; US Department of Commerce Report Section 5

splits and jumps, collectively referred to here as ghost targets. Errors in bearing have been reported, but are generally less than 2 degrees. Ghost targets caused by multipath from the turbine on the SSR uplink are the most common impairment. This possibility can be assessed by using the methodology in Section 3.4 to calculate the strength of the "false interrogation" reflected from the turbine, and comparing this to the sensitivity of the transponder on the target. Report [7] also presents calculated SSR nobuild radii rule-of-thumb values. These values are based on the same methodology as described in Section 3.4 to calculate the strength of the "false interrogation" reflected from the turbine and targets. RCS and transmitter powers also play a role in calculating the no-build radii rule-of thumb values.

Fundamentally, the effects of wind turbine farms on SSR performance would not be expected to differ from those of static structures, given that SSRs do not employ any processing technique analogous to MTI; in other words, the movement of wind turbine blades should not affect SSR performance per se. The FAA can presumably treat wind turbine farms in the same manner as it treats static structures concerning SSR effects.

49. The final sentence quoted states that the FAA[19] can presumably treat wind turbines in the same way as static structures.

50. There are many static structures which are larger than the wind turbine in the vicinity of the radar including hangars, airport buildings, masts and other structures.

51. Neither the Ministry of Defence or Qinetiq has reported any effects of the existing wind turbine on the SSR.

52. Pager Power knows of no evidence of such a small turbine ever having affected an SSR radar in any way whatsoever.

53. It is likely that other buildings and structures will have a greater affect on the SSR than the wind turbine.

54. It is highly unlikely that the wind turbine will ever have a significant effect on the SSR.

West Wales Airport – Physical Safeguarding

55. Specific concerns have been raised by the airport's management regarding the turbine's impact on West Wales Airport[20].

[19] US Federal Aviation Authority

[20] Letter from Barrie Forster to Ms R Rhys dated 26 May 2011

56. I initially considered the impact of the turbine on the Airport's normal operations – without specifically considering Unmanned Aerial Systems[21] [UAS].

57. When wind turbines or other structures are erected near airfields it is necessary to determine whether they will not be obstacles and physically endanger aircraft. There is a prescriptive standard for doing this based on a system of imaginary surfaces described in CAA Civil Aviation Publication 168 Chapter 4.

58. The wind turbine lies beneath a surface known as the Transitional Surface which slopes upwards from the side of the runway with a gradient of 1:5.

59. I have calculated the vertical clearance between the Transitional Surface and the turbine tip with the following results:

    a) The turbine does not breach the Transitional Surface, or indeed any other physical safeguarding surface

    b) There is a vertical clearance of approximately 15 metres between the turbine tip and the Transitional Surface

    c) The turbine is not an obstacle, as defined in Civil Aviation Publication 168, and consequently does not present a physical obstruction risk to aircraft using the airport

60. The airport operators confirm that the turbine does not breach obstacle clearance surfaces stating the following in their letter to the council:

    a) Firstly that the height of the turbine(s) would not penetrate our safety or obstacle clearance surfaces – it would appear they do not.

61. The turbine does not and will not have any physical impact on operations at West Wales Airport.

[21] Also known as Unmanned Aerial Vehicles [UAV] or more simply drones

West Wales Airport – UAS Radar and Radio Systems

62. Unmanned Aerial Systems [UAS] have flown from and are likely to continue to fly from the airport in future.

63. There are few, if any, airports in the UK which have similar UAS operations.

64. The airport has raised concerns regarding the potential impact of the turbine on radar and radio systems sited on the airport having stated the following in their letter to the council:

    b) Secondly, and arguably we would seek from the applicant conclusive technical evidence that such rotating structures with large cross sectional areas would not adversely affect the performance of sensitive radar and/or radio navigational equipments sited on the Aerodrome, both now and in the future.

65. The airport has not identified any of the following:

    a) Specific radar or radio systems that may be affected now

    b) Specific radar or radio systems that may be affected in future

    c) Specific wind turbine interference mechanisms they are concerned about

    d) Specific technical impacts, or potential technical impacts, of wind turbine interference

    e) Specific operational impacts, or potential operational impacts, resulting from wind turbine interference

    f) How large it believes the “cross sectional area” of the wind turbine to be

    g) What impacts, if any, the turbine has on its current operation

    h) Whether there is radar or radio equipment at the airport now, and whether this is operating

66. Given this lack of information I can only undertake a generic assessment of the potential effects of the turbine on existing and future systems. Cooperative radar systems, such as SSR, are made up of two radio systems – one from ground to aircraft and one from aircraft to ground.

    The majority of, if not all, radio and radar systems are likely to involve one or both of the following:

    a) Radio data communication from a UAS to a radio installation at the airport

    b) Radio data communication from a radio installation at the airport to a UAS

67. There are three mechanisms by which wind turbines may potentially interfere with radio systems. These are:

    a) Radio emissions from the wind turbine electrical systems

    b) Radio reflections from the wind turbine tower and blades

    c) Shadowing by the wind turbine

68. Weak radio signals are emitted by most electrical systems across a very wide range of frequencies. This means that there are many emitters of weak radio signals around the airport including aircraft, road vehicles, building air conditioning units, standby generators and the airport's electrical distribution system.

69. The majority of new electrical equipment, including small wind turbines, is built to standards that ensure emissions are small enough to have no effect on radio and electrical systems. The wind turbine is manufactured to the International standard for small wind turbines IEC 61400-2.

70. There is nothing to suggest that emissions from the turbines will be greater than those from other electrical equipment in and around the airport.

71. The effect of any such emissions on the radio communications path between UAV and airport, in either direction, is likely to be much smaller than the effects of the UAV's on board electrical systems. This is because the UAV radio equipment is much closer to UAV electrical systems than the wind turbine.

72. It is extremely unlikely that signals emitted from the wind turbine will have any effect on radio communication between UAVs and the airport.

73. I shall now consider the reflection of radio signals from the wind turbine.

74. Normally a received radio signal is made up of two components. A direct component which goes straight from the transmitting aerial to the receiving aerial and a reflected component which is made up of signals that arrive indirectly after being reflected.

75. Typical reflectors in an airport environment include terrain, aircraft, hangars, buildings, masts and vehicles. The size of the reflected signal is dependent on the size of the reflector, the shape of the reflector and the reflector's distance from transmitter and receiver.

76. Large wind turbines are significant reflectors and can interfere with television reception and primary surveillance radar because of their size and the fact that the blades are moving.

77. This small wind turbine is insignificant in size when compared with large commercial wind turbines and when compared with buildings, hangars and aircraft that use the airport.

78. Any object, however small, will have a minute technical effect on radio signals. The size of this effect is unlikely to be significant in this case, because of the wind turbine's small size. Reflections from buildings, hangars and aircraft are likely to be much more significant.

79. Reflections from the wind turbine are unlikely to have significant technical effects on UAS radio systems.

80. The final potential effect considered is signal blocking or shadowing.

81. Shadowing effects occur when terrain, vegetation or a structure is physically in between the transmitting and receiving aerial. The signal loss arising from a structure is measured in decibels (dB).

82. This wind turbine could only cause shadowing in the fairly unlikely scenario where:

    a) Aircraft are flying very low and

    b) The airport aerial is close to the ground

83. Shadowing losses in this scenario, for this turbine, are likely to be in the order of 1 to 2 dB which is fairly insignificant.

84. Raising the height of airport aerials to 10 metres or more could alleviate shadowing concerns as the wind turbine would not be able to obstruct the radio path between airport and UAS.

85. Shadowing effects associated with the turbine are likely to be smaller than those associated with terrain, hangars and other structures.

86. It is unlikely that there will be any significant shadowing effects. It is likely that any effects could be mitigated by raising airport antennae.

87. Whilst specific radio and radar systems have not been identified or considered, a generic assessment of these systems shows that they are unlikely to be affected by the wind turbine. I have seen nothing that leads me to believe that the wind turbine is affecting any radar or radio systems currently.

88. The wind turbine is unlikely to affect current or future radio and radar systems used by UASs at West Wales Airport.

UAS Radio System Performance

89. I have briefly considered the generic radio sub-system for communicating data between the aircraft and the ground as part of the overall Unmanned Aerial System.

90. I should make the point that I am not currently a system designer but I have designed and commissioned a radio based safety alerting system for the reactor building at Sizewell B Power Station.

91. The UAS designer must consider the reliability of this radio sub-system, as well as all other sub-systems, to ensure the overall reliability of the UAS. This is particularly important for any radio system as radio system performance is affected by many factors including weather, terrain, buildings and structures, antennae system design, antenna positioning on the ground and on the aircraft and many other system and location specific factors.

92. There are various steps the system designer can take to improve the overall reliability of the UAS. These include:

    a) Selecting a reliable radio system which has good overall performance and built-in error correction

    b) Have back-up or duplicate systems that take over if a radio system fails

    c) Have a fail safe mode if radio systems fail (e.g. if radio signal disappears climb to 3000 feet and circle over the sea)

93. The UAS system commissioning engineer should ensure that the radio system is performing satisfactorily before it is used in any critical role. The commissioning engineer could do this by:

    a) Factory testing the radio systems

    b) Testing the radio system using road vehicles with test transmitters/receivers driven in the vicinity of the airport

    c) Testing the radio system from manned aircraft fitted with test radio equipment

94. The airport is licensed by the Civil Aviation Authority which places an obligation on the airport to have a Safety Management System [SMS] to ensure UAS operations are safe. The CAA may audit Aerodrome and UAS operating procedures at the airport[22].

95. If the unlikely event that the wind turbine were to adversely affect a future radio system it is likely that any such effects would be detected and rectified during the normal commissioning process of the future radio system.

96. It is therefore highly unlikely that the wind turbine will have any significant adverse effects on current or future UAS radio systems.

Summary

97. The wind turbine is unlikely to affect the Ministry of Defence /Qinetiq Primary Surveillance Radar because there is a hill between the radar and turbine.

[22] CAA Civil Aviation Publication 722 Section 3 Chapter 10

98. The wind turbine is unlikely to affect the Ministry of Defence /Qinetiq Secondary Surveillance Radar because the turbine is too small to affect it and there is no record of any current effects.

99. The wind turbine is not a physical obstacle because it does not breach the Transitional Surface used to safeguard the airport.

100. Specific UAS radio systems have not been considered, but generic radio systems have been considered.

101. Current UAS radio systems are unlikely to be affected because the turbine is small and there is no record of any current effects.

102. Future UAS radio systems are unlikely to be affected because the turbine is small and any radio system should be properly commissioned before use.