Enoch Hill Windfarm

Radar Line of Sight Analysis

Date: 30 April 2020
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Revision: Issue 1
Osprey Ref: 71417 001

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Registered in England and Wales under No: 06034579

Document Details

Reference	Description
Document Title	Enoch Hill Windfarm
	Radar Line of Sight Analysis
Document Ref	71417 001
Issue	Issue 1
Date	30 April 2020
Client Name	RWE Renewables
Classification	Commercial in Confidence

Issue	Amendment	Date
Issue 1		30 April 2020

Approval Level	Authority	Name
Author	Osprey CSL	Stewart Heald
Reviewer	Osprey CSL	Nicole Saunders

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1 Introduction

This Section defines the requirements and scope for the analysis.

1.1 Background

E.ON Climate and Renewables (EC&R) submitted the Enoch Hill Windfarm for planning approval and gained consent for the development from the Scottish Government during 2019. The consented Enoch Hill Windfarm will consist of 16 turbines and will be built on land located five kilometres (km) southwest of New Cumnock, East Ayrshire. EC&R have merged with RWE Renewables (RWE) who is considering the progression of a planning variation to increase the blade tip height of the 16 Wind Turbine Generators (WTG) to a maximum blade tip height of 149.9 metres (m) above ground level (agl), the location of the wind turbines will not change.

Osprey has previously completed a radar Line of Sight (LoS) analysis to the WTG layout at the consented blade tip height of 130 metres (m) above ground level (agl). The conclusions of the radar line of sight analysis at that blade tip height indicated that 15 of the WTG will be theoretically detectable by the NATS Lowther Hill Primary Surveillance Radar (PSR) and all 16 by the Glasgow Prestwick Airport (GPA) PSR.

As the locations of the WTGs will not change, the increase in blade tip height is unlikely to change the previous radar LoS results however; Osprey will confirm the previous analysis in which the recently acquired GPA Terma PSR will be included in the analysis.

1.2 Notes on WTG Effects on Radar

Radar detectable WTG are a significant cause of radar false plots, or clutter, as the rotating blades can trigger the Doppler threshold (e.g., minimum shift in signal frequency) of the Radar Data Processor (RDP) and therefore may be interpreted as aircraft targets. Significant effects have been observed on radar sensitivity caused by the substantial RCS of the WTG structural components (blades, tower and nacelle) which can exceed that of a large aircraft; the effect 'blinds' the radar (or the operator) to wanted targets in the immediate vicinity of the WTG. False plots and reduced radar sensitivity may reduce the effectiveness of radar to an unacceptable level and compromise the provision of a safe radar service to participating aircraft and detection of aircraft targets.

In terms of WTGs, generally, the larger a WTG is, the larger its RCS will be, which will result in more energy being reflected and an increased chance of it creating unwanted returns (non-aircraft), known as 'clutter' to be produced on Radar Data Display Screens (RDDS). This issue is compounded by increasing numbers of WTGs that cause a cumulative effect of greater areas and densities of clutter. Generalised effects on radar systems are as follows:

- Twinkling appearance/blade flash effect;
- Masking of true aircraft targets by increased clutter on an RDDS;

- Increase in unwanted targets or false aircraft tracks;
- Receiver saturation;
- Receiver desensitisation causing loss of targets that are of a small RCS;
- Loss of targets due to Adaptive Moving Target Indication (AMTI) techniques;
- Shadowing behind the wind turbines caused by physical obstruction (blocking of radar transmitted signal);
- Degradation of tracking capabilities; and
- Degradation of target processing capability.

Traditional radar systems in operation currently cannot distinguish between returns from WTG (false returns, or 'clutter') and those from aircraft. Air Traffic control (ATC) are required to assume that actual aircraft targets could be lost over the location of a windfarm; furthermore, identification of aircraft under control could be lost or interrupted.

It is mainly for the above reasons that aviation radar system operators object to windfarm developments that are within LoS to their radar systems.

1.3 Identified Radar Systems

The following systems provide radar coverage of the airspace in the vicinity of the development:

- GPA S511 and Terma PSR systems;
- NATS Lowther Hill PSR;
- NATS Cumbernauld PSR; and
- Glasgow Airport PSR.

1.4 Document Structure

This report is structured as follows:

- Section 1, this section, introduces the requirement and the scope of the report; and
- Section 2 presents the conclusions from the radar LoS analysis from the identified radar system.

2 Radar LoS Conclusions

This section details the Osprey LoS analysis methodology and provides a summary of the results of the Radar LoS analysis for the potentially affected radar systems.

2.1 Caveat on Radar LOS Analysis

Osprey used the ATDI ICS LT (Version 4.3.3) tool to model the terrain elevation profile between the identified radar systems and the 16 WTGs at a blade tip height of 149.9 m agl. Otherwise known as a point-to-point LoS analysis, the result provides a graphical representation of the intervening terrain and the direct signal LoS (taking into account earth curvature and radar signal properties).

This is a limited and theoretical desk based study; in reality there are unpredictable levels of signal diffraction and attenuation within a given radar environment that can influence the probability of an operational wind farm being detected. Our analysis is designed to give an indication of the likelihood of the WTGs being detected by radar.

The qualitative definitions utilised in our LoS assessment are defined in Table 1.

Result	Definition
Yes	The WTG is highly likely to be detected by the radar: direct LoS exists between the radar and the WTG
Likely	The WTG is likely to be detected by the radar at least intermittently
Unlikely	The WTG is unlikely to be detected by the radar but cannot rule out occasional detection
No	The WTG is unlikely to be detected by the radar as significant intervening terrain exists

Table 1 - Qualitative Definitions of LoS Results

2.2 GPA PSR System Radar LoS Analysis

GPA is an international airport, which was purchased by the Scottish Government in November 2013 to protect jobs and to safeguard a strategic infrastructure asset. GPA has procured a Terma Scanter 4002 system[1] as a technical mitigation solution for the effects of multiple windfarms within its Area of Responsibility (AOR) for the

[1] Terma in conjunction with NATS have delivered a number of Scanter 4002 radar systems that are in operation at a number of UK airports including Edinburgh, Chester Hawarden, Liverpool John Lennon and Newcastle Airports, as both replacement systems and 'gap-filling' systems, successfully mitigating the effects of windfarms on ATC radar operations https://www.terma.com/press/news-2016/terma-provides-wind-turbine-mitigation-radar-for-nats/

provision of radar-based Air Traffic Services to aircraft. Mitigation of WTG effect to GPA air traffic systems by the Terma PSR is not automatically guaranteed. GPA should be consulted in order to establish if mitigation utilising the Terma PSR is feasible. Figure 1 provides an illustration of the radar LoS results between the blade tips of the individual WTG of the Enoch Hill Windfarm and the GPA Terma PSR which indicates that theoretically all of the WTG are highly likely to be theoretically detectable by the system. The LoS results for the GPA Watchman S511 PSR are identical.

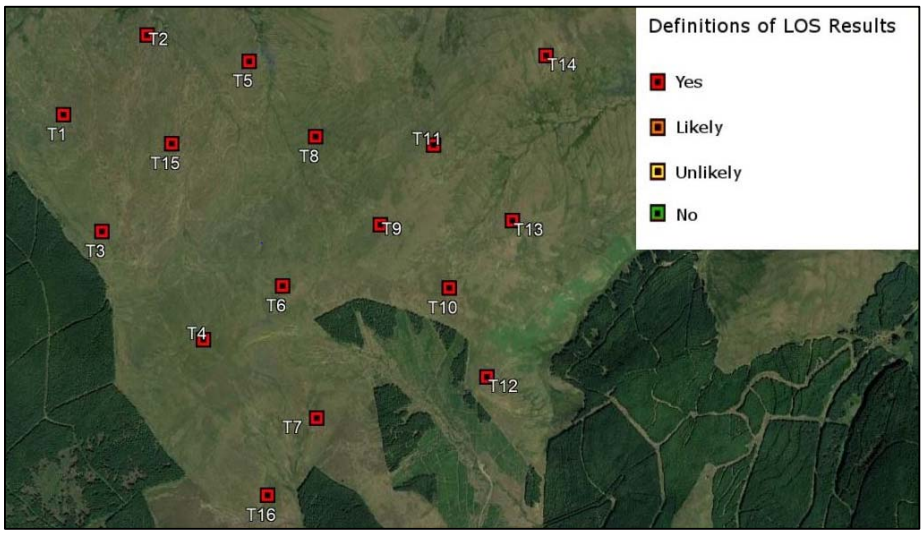

Figure 1 GPA Terma PSR LoS Results for 149.9 m agl WTG Blade Tip Height

2.3 NATS PSR System Radar LoS Analysis

NATS is split into two main service provision companies: NATS En-Route PLC (NERL) and NATS Services Ltd (NSL). NSL competes for contracts to provide ATC at airports in the UK and overseas, as well as providing related services including engineering, consultancy, information services and training.

NERL is responsible for the safe and expeditious movement in the en-route phase of flight for aircraft operating in UK airspace. To undertake this responsibility it has a comprehensive infrastructure of radars, communication systems and navigational aids throughout the UK, all of which could be compromised by the establishment of a wind farm. In this respect it is responsible for safeguarding this infrastructure to ensure its integrity to provide the required services to ATC. Figure 2 provides the theoretical results of the radar LoS analysis between the Lowther Hill PSR and the WTG blade tips of the proposed Development which indicates that theoretically all of the Enoch Hill Windfarm WTGs will be detectable by the Lowther PSR.

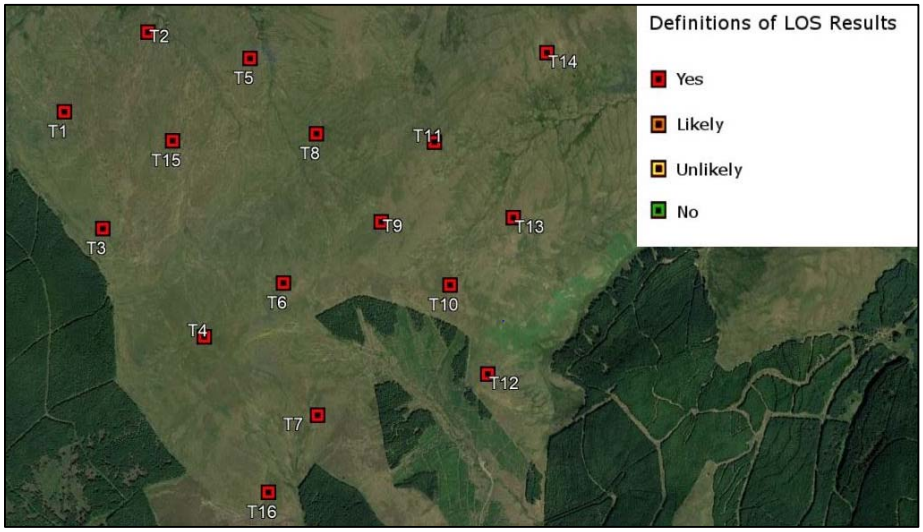

Figure 2 Lowther Hill PSR LoS Results for 149.9 m agl WTG Blade Tip Height

Figure 3 below provides the theoretical radar LOS results between the Cumbernauld PSR and the blade tip of the Enoch Hill WTGs which indicates that the results are mixed. Turbines 9 and 10 at a blade tip height of 149.9 m agl are likely to be detectable intermittently by the PSR; occasional detection may be apparent by a further six WTG.

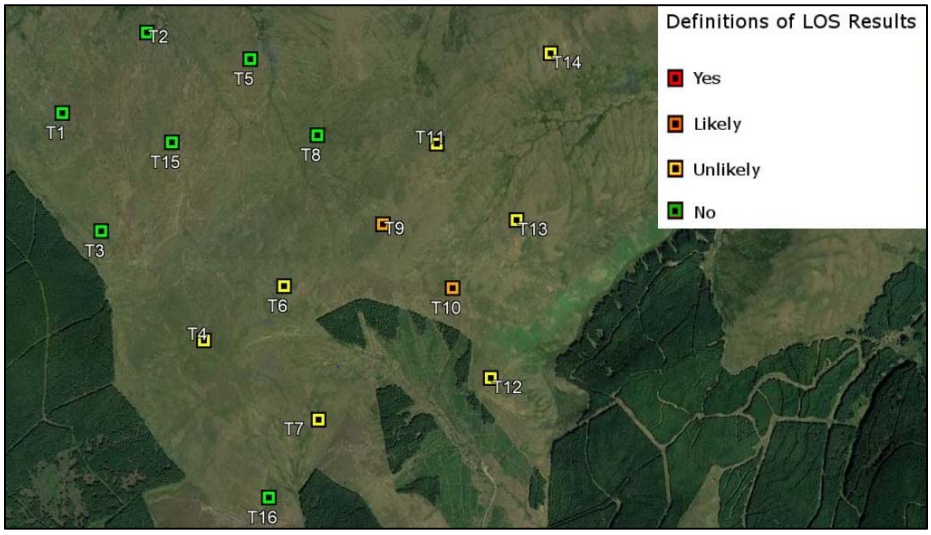

Figure 3 Cumbernauld PSR LoS Results for 149.9 m agl WTG Blade Tip Height

2.4 Glasgow Airport System Radar LoS Analysis

Confirmation that the Glasgow Airport PSR will not theoretically detect Enoch Hill WTGs at a blade tip height of 149.6 m agl is provided in Figure 4 below.

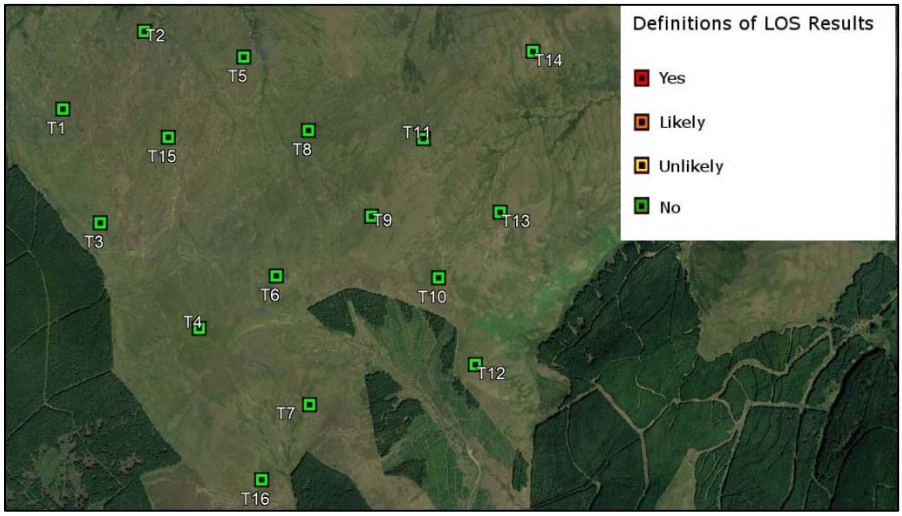

Figure 4 Glasgow Airport PSR LoS Results for 149.9 m agl WTG Blade Tip Height

2.5 Conclusions

The analysis has confirmed that the GPA S511 PSR will theoretically detect all of the WTG at the increased blade tip height; this result is mirrored by the theoretical detectability to the GPA Terma PSR. All of the Enoch Hill WTGs are theoretically detectable by the Lowther Hill PSR (an increase of one WTG from the previous analysis). Analysis cannot rule out theoretical intermittent detectability of two WTG by the Cumbernauld PSR.