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Clash Gour Wind Farm Stage 2 Engagement

Airspace Change Design Options ACP-2021-046

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Acronyms

Acronym	
ACAS	Airborne Collision Avoidance Systems
ACP	Airspace Change Proposal
ADS-B	Automatic Dependent Surveillance-Broadcast
ATC	Air Traffic Control
ATCRMS	Air Traffic Control Radar Mitigation Scheme
agl	above ground level
ATS	Air Traffic Service
CGH	Clash Gour Holdings
DP	Design Principles
EDFER	EDF Energy Renewables
EFIS	Electronic Flight Information Systems
GW	GigaWatt
IMC	Instrument Meteorological Conditions
m	metre
MAA	Military Aviation Authority
MOD	Ministry of Defence
MW	MegaWatt
NM	Nautical Mile
PSR	Primary Surveillance Radar
RA	Regulatory Article
RAF	Royal Air Force
RAG	Range Azimuth Gating
RCS	Radar Cross Section

RDDS	Radar Data Display Screen
RDP	Radar Data Processor
RMZ	Radio Mandatory Zone
SSR	Secondary Surveillance Radar
TMZ	Transponder Mandatory Zone
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

Terminology

Term	Meaning
Automatic Dependent Surveillance-Broadcast	An ADS-B system is a hardware equipment installed onboard aircraft. It transmits automatically the location (latitude, longitude) of the aircraft and its movement data (speed, heading, altitude) via a digital data link. These transmissions are received and can be used by other aircraft and Air Traffic Control (ATC) to display the aircraft's position.
Development Areas	The combination of the three distinct array areas of Clash Gour together with the array areas of the existing Berry Burn and consented Berry Burn 2 Wind Farms, which are located within the envelope of the Clash Gour Wind Farm.
Primary Surveillance Radar	A conventional radar sensor that illuminates a large portion of space with an electromagnetic wave and receives back the reflected waves from targets within that space. Primary radar detects all aircraft (and other objects, such as flocks of birds, weather phenomena, other environmental factors and wind turbines) without selection, regardless of whether or not they possess a transponder. It can also detect and report the position of anything that reflects its transmitted radio signals, including the rotating blades of the wind turbines. It indicates the position of targets but does not identify them. Because wind turbines blades are moving targets, it is hard for a radar to distinguish them from aircraft. Radar data processing connects returns from successive sweeps of the radar, and from this infers speed. Multiple wind turbines in a windfarm create multiple radar returns and these can appear as stationary or rapidly moving primary returns on the radar display.

Primary Radar RAG Blanking	Range-Azimuth Gate (RAG) radar blanking blocks any primary radar return within selected ranges and azimuth sectors. This can be mapped to suppress plots within wind turbine clutter regions. However, the primary blanking in any given area is complete, hence the primary return from any aircraft entering this area would also be suppressed. Thus the aircraft would not appear on the radar unless they were operating with a transponder, and hence detected by the Secondary Surveillance Radar (SSR).
Radar Mitigation Scheme	A scheme necessary and sufficient to prevent the operation of the Clash Gour wind turbines impacting adversely on the primary surveillance radar performance at RAF Lossiemouth and Inverness Airport. The scheme may be in combination, or individually and take the form of a hardware or software solution which will be implemented and maintained for the lifetime of the development or for such shorter period as may be agreed in consultation with the MOD and Inverness Airport as necessary to mitigate any such adverse impact.
SSR	Secondary Surveillance Radar works together with transponders which are installed on the aircraft. The ground based SSR radar interrogates the transponder which transmits a signal which is captured by the radar. The information transmitted by the transponder identifies the aircraft, along with details as to aircraft altitude (note that transponder equipage is mandatory for instrument flight, and flight above Flight Level (FL) 100 (approximately 10,000 feet above sea level) however, some aircraft may operate above FL100 subject to specific rules and areas of operation. As such all commercial aircraft and the vast majority of general aviation aircraft are transponder equipped).
TMZ	A Transponder Mandatory Zone is an area of defined dimensions wherein the carriage and operation of aircraft transponder equipment is mandatory. All flights operating in airspace designated by the competent authority as a TMZ shall carry and operate SSR transponders capable of operating on Modes S or, in exceptional circumstances, SSR Modes A and C. However, the advent and increasing affordability of technology such as Automatic Dependent Surveillance – Broadcast (ADS-B) means that the concept of a TMZ may now evolve to utilise alternate types of electronic conspicuity systems. A pilot wishing to operate in a TMZ without serviceable transponder equipment may be granted access subject to specific arrangements agreed with the TMZ Controlling Authority

1 Introduction

1.1 Project Overview

This document forms part of the document set required in accordance with the requirements of the CAP1616 Airspace Change process and aims to provide sufficient evidence to satisfy Stage 2 Develop and Assess Gateway, Step 2A Airspace Change Design Options.

Force9 Energy (Force9), jointly with EDF Energy Renewables Limited (EDFER) is developing the Clash Gour Wind Farm (Clash Gour) in the name of its wholly owned subsidiary Clash Gour Holdings (CGH). Clash Gour will be a substantial onshore windfarm which will be located in the Moray Council Area, approximately 13 Nautical Miles (NM) southwest of Royal Air Force (RAF) Lossiemouth and 15 NM southeast of Inverness Airport. Clash Gour will consist of 48 wind turbines with a maximum blade tip height of 180 metres (m) above ground level (agl). Figure 1 below provides the location of the three individual wind turbine array areas which will comprise Clash Gour.

Figure 1 Clash Gour Wind Farm Location

Clash Gour will have an installed capacity of up to circa 250 MegaWatt (MW) which will make it one of the largest onshore windfarms currently under consideration in

Scotland. Clash Gour is expected to produce between 570 GigaWatt (GW) hours and 710 GW hours of electricity annually which is sufficient to power up to 193,000 houses. Clash Gour is a strategically important project in the context of Scottish national targets (currently out for consultation) for renewable energy production (8GW-12GW on new onshore wind capacity by 2030).

1.2 Section 36 Electricity Act Application

As part of the development consent process for Clash Gour, CGH, through Force9, engaged with relevant aviation stakeholders to determine the impact of Clash Gour's operational wind turbines on aviation radar systems and operations. In particular and relevant to the Airspace Change Proposal (ACP), both the Ministry of Defence (MOD) and Inverness Airport have confirmed that, without mitigation, the development will have an operational effect due to an adverse impact on their ability to provide an Air Traffic Service (ATS) as a result of interference (radar clutter) caused by the detection of the operational wind turbines by the current Primary Surveillance Radar (PSR) systems in operation at RAF Lossiemouth and Inverness Airport.

The project was subject to a Public Inquiry (PI) during 2020. The Reporter appointed by the Scottish Government to hear evidence at the PI and report to Scottish Ministers has issued his report to the Scottish Government and a decision on the application is expected between May and July 2022. Aviation matters did not form a part of the evidence heard at the PI as agreement was reached between CGH and both Inverness Airport and the MOD on the wording of conditions which are expected to be attached to the grant of any consent. The conditions will require CGH to agree aviation mitigation plans with those parties, as set out below.

Condition Number	Condition	Reason
5	No wind turbine shall be erected unless and until an Air Traffic Control Radar Mitigation Scheme (ATCRMS) to address the impact of the wind turbines upon air safety has been submitted to and approved in writing by Scottish Ministers. The ATCRMS is a scheme designed to mitigate the impact of the development upon the operation of the Primary Surveillance Radar at RAF Lossiemouth ("the Radar") and the air traffic control operations of the Ministry of Defence which are reliant upon the Radar. The ATCRMS shall set out the appropriate measures to be implemented to mitigate the impact of the development on the Radar and shall be in place for the lifetime of the development provided the Radar remains in operation. The development shall be implemented strictly in accordance with the details set out in the approved ATCRMS.	In the interests of aviation safety.

Condition Number	Condition	Reason
6	No wind turbine erected as part of this development shall be permitted to rotate its rotor blades about its horizontal axis, other than for the purpose of testing radar mitigation for this development for specific periods as defined in the approved ATCRMS or otherwise arranged in accordance with provisions contained in the approved ATCRMS, until: a) those mitigation measures required to be implemented prior to any wind turbine being permitted to rotate its rotor blades about its horizontal axis as set out in the approved ATCRMS have been implemented; and b) any performance criteria specified in the approved ATCRMS and which the approved ATCRMS requires to have been satisfied prior to any wind turbine being permitted to rotate its rotor blades about its horizontal axis have been satisfied and Scottish Ministers have confirmed this in writing. Thereafter the development shall be operated strictly in accordance with the details set out in the approved ATCRMS for the lifetime of the development, provided the Radar remains in operation.	In the interests of aviation safety.
7	No wind turbine forming part of the Development shall operate, other than for testing and evaluation as agreed with the operator of Inverness Airport, unless and until a Radar Mitigation Scheme has been submitted to and approved in writing by the local planning authority, after consultation with the operator of Inverness Airport and the Civil Aviation Authority. No wind turbine(s) forming part of the Development shall be operational until and unless all measures required by the approved Radar Mitigation Scheme have been fully implemented. The Development shall thereafter be operated fully in accordance with the approved Radar Mitigation Scheme. In this condition "Radar Mitigation Scheme" means a scheme setting out measures to address and mitigate the impact of the wind turbines forming part of the development upon the operation and performance of the Primary Surveillance Radar at Inverness Airport. The scheme will include the	To secure mitigation of impacts and ensure the development does not affect the safe operation of Inverness Airport through interference with the Primary Surveillance Radar.

Condition Number	Condition	Reason
	appropriate measures to be implemented and that are to be in place for the operational life of the development provided the Radar remains in operation. It will also include provision for future and alternate agreement of the mitigation solution with the operator of Inverness Airport.	

Table 1 Consent Conditions Relevant to Aviation Radar

The ACP, entitled 'Clash Gour Wind Farm', has been initiated to create a path for CGH to satisfy the aviation related conditions expected to be attached to the grant of any consent for the wind farm. It will provide a mitigation solution to the operational effects on Inverness Airport and RAF Lossiemouth created by visibility of wind turbines on PSR. Under the ACP, CGH will then be able to operate the wind farm to test technical mitigation solutions to fully discharge the relevant conditions.

1.3 Wind Turbine Effects to Aviation Radar

Radar detectable wind turbines 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 Radar Cross Section (RCS) of the wind turbines structural components (blades, tower and nacelle) which can exceed that of a large aircraft; the effect 'blinds' the radar (or the operator) to required targets in the immediate vicinity of the wind turbine. False plots and reduced radar sensitivity may reduce the effectiveness of radar to an unacceptable level. This can therefore create an operational effect on air traffic control by compromising the provision of a safe radar service to participating aircraft and detection of aircraft targets.

Stationary objects do not cause an effect to radar systems as radar processing techniques remove stationary objects from the radar display; therefore, radar detectable wind turbines only create effect to radar once they are in operation.

Generally, the larger a wind turbine is, the larger its RCS will be to a radar. This results in more energy being reflected and an increased chance of it creating unwanted returns (clutter). This clutter will be processed by the radar and presented to the air traffic controller on their Radar Data Display Screens (RDDS). Additionally, the blades of wind turbines rotate which give an indication that the target is moving with respect to the radar and thus defeating doppler processing techniques. This issue can be further compounded by a large number of wind turbines located together which cause a cumulative effect over a greater volume with higher densities of clutter produced.

The generalised effects wind turbines have on radar systems are as follows:

- Twinkling appearance/blade flash effect which can distract a controller
- Masking of true aircraft targets by increased clutter on an RDDS.
- Increase in unwanted targets or false aircraft tracks.
- Receiver saturation.

- Target desensitisation causing loss of valid targets that are of a small RCS.
- Shadowing behind the wind turbines caused by physical obstruction (blocking of radar transmitted signal).
- Degradation of tracking capabilities including track seduction.
- Degradation of target processing capability and processing overload.

Radar detectability of wind turbines does not automatically provide justification for an objection from radar stakeholders. Other factors will determine the nature and severity of the operational impact on the receptor e.g.:

- The consideration of airspace structure and classification in the wind turbine vicinity.
- The operational significance of the airspace to the operator.
- The range of the development from the radar source.
- Aircraft traffic patterns and procedures.
- The type of radar service provided to air traffic using the airspace.

Wind turbine derived clutter appearing on radar displays can affect the safe provision of an ATS as it can mask aircraft from the air traffic controller and/or prevent the controller from accurately identifying aircraft under control. In some cases, radar reflections from the wind turbines can affect the performance of the radar system itself. In providing a safe ATS, an air traffic controller must maintain standard separation distances between aircraft that are under control and those radar returns that are unknown or not in receipt of a radar service. In many cases, the controller will need to provide a minimum of 5 NM radar separation between an aircraft receiving a radar derived ATS and any unwanted radar returns that have the potential to obscure unknown aircraft targets. The radar clutter presented on radar displays that would be associated with radar detectability of the development would require aircraft to be manoeuvred away from desired aircraft track to achieve the appropriate lateral separation criteria. Without specific wind turbine mitigation processing capabilities, radars cannot distinguish between returns from wind turbines (false returns, or 'clutter') and those from aircraft. Air traffic controllers 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 feasible that radar stakeholders may lodge objections to subsequent developments in areas where they had previously been able to accommodate proposed wind turbine developments based on the cumulative impact of a number of separate wind farms on the safety and efficiency of the aerodrome and the radar services provided. The MOD and Inverness Airport have both stated in response to the Section 36 application that mitigation is required to ensure the continued safe and efficient provision of radar based air traffic services in the presence of the Clash Gour Wind Farm.

2 Design Options

2.1 Overview

CGH have considered a variety of design options in order to provide sufficient mitigation on the operational effects which radar detectable wind turbines will have on RAF Lossiemouth and Inverness Airport. The options are expected to be capable of allowing operation of Clash Gour which in turn will allow testing of technical mitigation solutions at each of the impacted surveillance radar systems, where required. The following options have been developed in accordance with the Design Principles (DPs).

The following range of mitigation design options were considered:

- Do nothing.
- The ability to temporarily close down the operation of the WTGs.
- SSR Alone operations.
- The use of In-fill radar.
- Introduction of Controlled Airspace.
- Radio Mandatory Zone (RMZ).
- Range Azimuth Gating (RAG) blanking and Transponder Mandatory Zone (TMZ).

2.1.1 Option 0: Do Nothing

No mitigation against radar clutter. In the event that no mitigating actions are implemented for Clash Gour, the clutter created by the detectability of the operational wind turbines will affect the safe and effective provision of a radar based air traffic service by RAF Lossiemouth and Inverness Airport in the ways described at Section 1.3 and set out in consultees responses to the Section 36 application for the development.

Each of these individual effects reduces the overall effectiveness of the radar in detecting targets, which can result in the misidentification of aircraft, loss of track position, and loss of track identity as aircraft symbols and track history may be obscured. These in turn can affect the accuracy and timeliness of controller instructions and potentially cause serious safety and operational issues to ATC and the flying community operating within the area of wind turbine induced radar clutter.

If mitigation is not introduced, RAF Lossiemouth and Inverness Airport air traffic controllers would be required to limit or suspend the ATC radar services that it provides to aviation operating within the vicinity of the Development Areas. Furthermore, dependent on the radar service being provided, controllers would be required to vector all aircraft around the wind turbine induced radar clutter which would inevitably lead to greater track distances flown, an increase in both pilot and controller workloads, greater noise exposure to communities, greater fuel burn and an increase in NO^2 and CO_2 emissions through extended routing around the area of wind turbine clutter. The Do Nothing option is considered not to be a viable option due to the requirement to mitigate the impact created to the RAF Lossiemouth and

Inverness PSRs and as set out in consultation responses to the Section 36 application and defined in the conditions detailed at Table 1.

2.1.2 Option 1: Temporary Wind Turbine Suspension of Operation

Radar clutter would only be apparent when the Clash Gour wind turbines are operational. The technical and commercial complexities associated with this option are listed below:

- Frequency and duration of switch offs. Individual wind turbines are turned off for maintenance however, any increase in the activation and deactivation of the wind turbines would lead to excessive wear and tear;
- As any instruction to turn off the wind turbines is not likely to be immediate, there is uncertainty over the time it would take for the wind turbines to stop turning which may not suit the dynamic air traffic requirement; and
- RAF Lossiemouth or/and Inverness Airport would effectively require the rights to turn off the wind turbines at any point in time for any duration.

Consideration was given to providing the ability to close down the wind turbine via a telephone call to the CGH operations room. However, due to the unpredictable nature of operations within uncontrolled airspace, in which CGH is located, this option is unviable, as it would be unable to be sufficiently robust for the dynamic ATC operational environment. Control of the wind turbine would remain with the developer, and the time taken in initiating the request and the cessation of wind turbine rotation would introduce delay and increased workload at a time when speed is of the essence to ATC.

Electrical generators have a ramp down rate: this is the limit at which the machine can safely reduce its power output to zero, without causing significant aging and/or damage to the equipment. The electrical machines and mechanical equipment need to brake and reduce speed in a controlled manner and emergency stop procedures should only be implemented in emergency conditions. This option would not be acceptable to CGH; furthermore, in the fast moving, dynamic world of ATC operations, it is considered that Option 1 would be operationally unmanageable, and unacceptable to RAF Lossiemouth and Inverness Airport ATC.

2.1.3 Option 2: SSR Alone Operations

SSR is a co-operative surveillance technique that relies on the aircraft being equipped with a transponder. The target aircraft's transponder responds to interrogation by the ground station by transmitting a coded reply signal. The sole reliance and use of this surveillance technique, without appropriate airspace use rules in place, is not totally approved in the UK due to the complex nature of ATC environments. It should be noted that the circumstances when SSR may be used alone in the provision of ATS are limited. In the case of primary radar failure, Inverness Airport revert to a non-radar based procedural service for the separation of participating aircraft.

The Military Aviation Authority (MAA) provide Regulatory Articles (RA) to provide a framework of policy, rules, directives, standards, processes and the associated direction, advice and guidance, which governs military aviation activity and against which air safety is assessed. RA 3241 covers contingency arrangements for the continued provision of ATS utilising SSR alone. Military airfield ATC radar controllers may provide an ATS using SSR alone providing its use is defined in unit orders. However, military controllers are encouraged (in accordance with local orders) to

hand-over control of aircraft to adjacent units within overlapping radar coverage (subject to the adjacent unit's radar serviceability) at the earliest opportunity when other mitigation methods are not available. This is impracticable within the vicinity of the Development Areas as there is limited adjacent radar equipped ATC units providing uncluttered and overlapping radar cover in the region of Clash Gour.

Within SSR Alone operations and without radar blanking, the primary radar would be deselected to remove wind turbine induced clutter. Since it is not possible to deselect PSR for a specific area, this would mean that the entire area of operations for the air traffic controller would be without primary radar data displayed. This means that it will not only be impossible to detect any aircraft entering the airspace above the Development Area, but any aircraft operating within the coverage of the effected radar system without a transponder fitted and activated, leading to an unacceptable loss of situational awareness for the controller.

2.1.4 Option 3: In Fill Radar

The principle of radar infill is to find an existing radar or position a new radar where terrain screening prevents it from detecting the wind turbines while at the same time providing coverage of aircraft targets at low enough levels to be operationally satisfactory. Recently there has been development of a number of radar systems which have successfully mitigated the impact created by the detection of operational wind farms to ATC PSR systems. This option requires a suitable site for the infill radar to be positioned, provision of power, and telecommunications links which may not be available. A new radar will itself require planning consent which may not be granted. Furthermore, it is estimated to have an upfront cost of at least £10.5m not including any land lease or utilities which may prove commercially unacceptable. It is considered that this option is not yet viable but could potentially replace an ATCRMS in the future.

2.1.5 Option 4: Introduction of Class D or E Controlled Airspace

Clash Gour would sit within uncontrolled Class G airspace which is established above the development to FL195 (approximately 19,500 feet above sea level). The introduction of Class D airspace provides a known traffic environment which allows aircraft to operate under both under Visual Flight Rules (VFR) and Instrument Flight Rules (IFR). ATC will separate IFR aircraft from each other. Aircraft operating Visual Meteorological Conditions (VMC) can request a VFR transit. ATC will pass traffic information to VFR aircraft about IFR aircraft; separation between VFR and IFR traffic is based on "see and avoid".

Class E airspace enables flight under both IFR and VFR. IFR flights must obtain an ATC clearance before entering Class E airspace and comply with ATC instructions. VFR traffic does not require clearance to enter class E airspace but must comply with ATC instructions (if they are under a service). Class E does not currently extend to the surface in the UK. Option 4 does not include blanking of the RAF Lossiemouth and Inverness Airport PSR systems, wind turbine induced radar clutter will still be encountered from detectability of Clash Gour; therefore, Option 4 is not considered to be a viable solution to successfully mitigate the operational effects on RAF Lossiemouth and Inverness Airport caused by wind turbine induced clutter on the PSRs. Furthermore, establishing controlled airspace in the region of Clash Gour may adversely impact other airspace users which are incapable of flying in controlled airspace and would potentially restrict the free flow of aircraft.

2.1.6 Option 5: Class E+ airspace

Class E Controlled Airspace which also includes a TMZ has already been deployed in the UK (for example to replace Class F airways). There is therefore a precedent for this airspace solution. However, as previously stated, there is currently no provision to deploy Class E down to surface level in the UK. Under this airspace solution, the conspicuity element would be provided by the concept of compliance with a TMZ as described in the Terminology table. This option does not include radar blanking of the RAF Lossiemouth and Inverness Airport PSR systems and is therefore not considered to be a viable solution to successfully mitigate the operational impact created by the radar detectability of Clash Gour.

2.1.7 Option 6: Radio Mandatory Zone (RMZ)

A RMZ is an area of defined dimensions within which a pilot must be in two-way communication with the airspace owner, prior to entry. Pilots must also provide information pertinent to the flight, for example, route required and altitude/height. A RMZ created in the airspace above the Development Areas would provide a degree of situational awareness to the controller about the nature of the aviation within the airspace.

Although ATC would be able to provide some level of service to aviation operating within the RMZ, it would not prevent the generation and display of false tracks/clutter created from the radar detection of Clash Gour with the associated loss of situational awareness to air traffic controllers. An RMZ carries no requirement to operate a transponder in the blanked airspace and no requirement to identify aircraft operating in the RMZ. This mitigation does not go far enough to reduce the risk of collision, as ATC would potentially not detect all aircraft within the clutter and would not be able to provide any prescribed separation between aircraft. For these reasons it is considered that Option 6 is not a viable mitigation solution as it provides insufficient mitigation for the operational effects caused by wind turbine induced clutter on radar.

2.1.8 Option 7: Range Azimuth Gating and/or Transponder Mandatory Zone

Clash Gour consists of three distinct areas where wind turbines will be placed. These three areas surround the Berry Burn Wind Farm which consists of 29 wind turbines and has been operational since 2014. An application was submitted to extend the Berry Burn Wind Farm consisting of an additional nine wind turbines. This Extension, known as Berry Burn 2 was consented by Ministers of the Scottish Government in December 2021. Figure 2 below provides an illustration of the individual wind farm areas of Clash Gour and Berry Burn/Berry Burn 2.

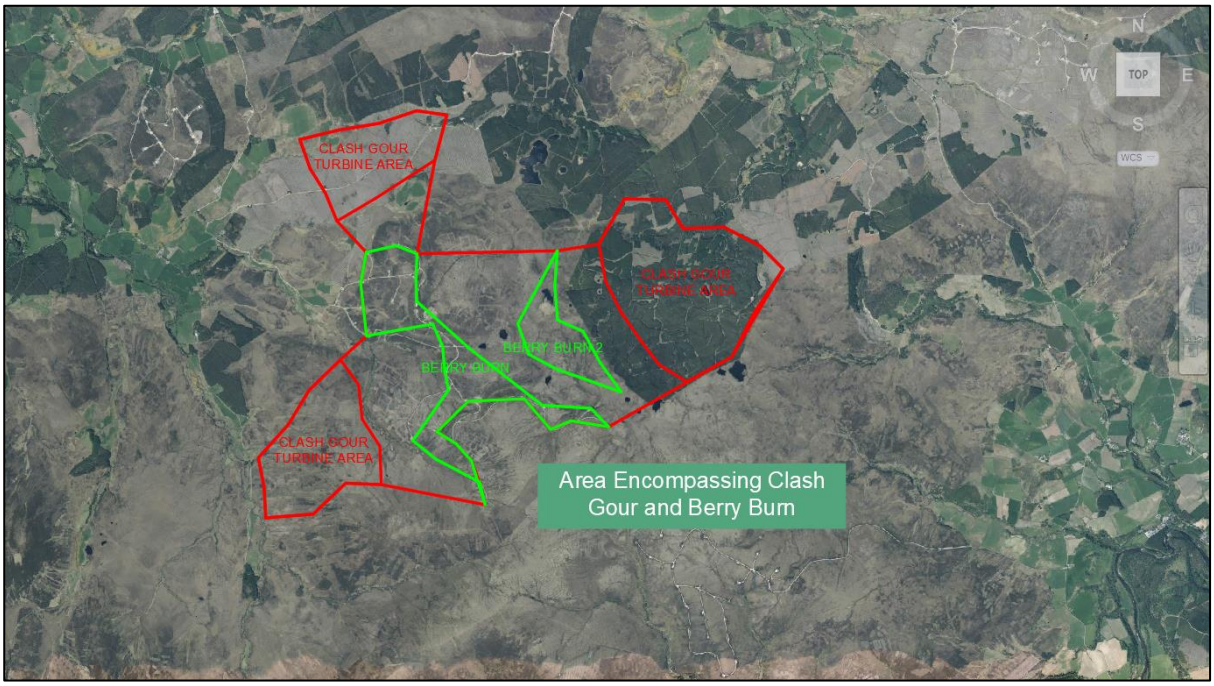

Figure 2 Outline areas of Clash Gour and Berry Burn/Berry Burn Extension

It would be difficult for a pilot to make a visual distinction between the Clash Gour and Berry Burn and Berry Burn 2 Wind Farm wind turbines. Therefore, from an airspace user's visual perspective and the physical locality of Berry Burn and Berry Burn 2 to Clash Gour, CGH consider that if mitigation involves a change to local airspace arrangements, then it is simpler to encompass all of the wind turbines of Clash Gour, Berry Burn and Berry Burn 2 within a single airspace boundary, rather than three individual TMZs surrounding the Clash Gour arrays areas. The benefit of a single airspace boundary rather than consideration of three individual TMZ areas over the three distinct areas of array development for Clash Gour is that a single array boundary would produce a regularly shaped TMZ which will make it easier to define from the air and would be simpler for air traffic controllers to display on their respective RDDS and monitor. The perception and benefit of a single airspace boundary encompassing Clash Gour and Berry Burn/Berry Burn 2 is considered in all the options for design and implementation of a TMZ which will measure Proposed TMZ, (excluding a 2NM buffer), 4.32NM west to east, and 3.24NM north to south and is therefore small in size.

Option 7 falls into six possibilities of implementation:

A. RAG blanking of the RAF Lossiemouth and Inverness Airport PSRs.
B. TMZ (without RAG blanking) over the windfarm array locations.
C. RAG blanking and TMZ over the proposed windfarm array locations.
D. RAG blanking and TMZ over the proposed windfarm array locations. TMZ extended to include a 2 NM buffer.
E. RAG blanking over the proposed windfarm array locations. Simplified polygon TMZ 'rubber banded[1]' around the proposed windfarm locations with no buffer.

[1] Rubber banded - Shortest perimeter fully enclosing the wind farm development. It is used to smooth an irregular perimeter.

F. RAG blanking over the proposed windfarm array locations. Simplified polygon TMZ 'rubber banded' around the proposed wind farm locations extended to include a 2 NM buffer.

The DPs used to evaluate these options are as described in detail in the Design Principles document (Stage 1 Gateway Assessment).

Option 7 (A): RAG Blanking.

Range Azimuth Gating involves blanking the clutter (created by the detection of the Clash Gour wind turbines on a PSR) from showing on radar displays. It blanks the area of the source of clutter on the RDDS and removes it from the controllers display. This means that, within the area of the RAG the PSR will not detect any primary radar contacts (from wind turbines, aircraft or other contacts).

Blanking of the RAF Lossiemouth and Inverness Airport PSR systems without an associated TMZ is not considered a viable option for mitigation. RAG blanking effectively creates a 'black hole' in the radar coverage overhead the windfarm location in which no primary radar returns would be created. This option is considered to be unsafe and hence is thought to be likely unacceptable to the air traffic controllers at the affected airfields.

Option 7 (B): TMZ over the proposed windfarm array locations.

The objective of establishing a TMZ, which will be the minimum TMZ cover required to restrict non-transponder equipped aircraft overflying the Development Area, is not to prevent aircraft from operating near the wind turbines, merely to require that they operate a transponder when entering the TMZ.

The airspace classification of a TMZ would remain unchanged. Hence, the ATS available within and around the TMZ would continue to be applied according to CAP 774 UK Flight Information Services[2] through the assured provision of SSR data to the controller.

Without the use of RAG blanking applied to the TMZ area, wind turbine induced primary radar clutter could negatively affect the degree, accuracy and timeliness of the instructions, advice and information a controller is able to provide to pilots within the TMZ, with consequent impacts on safety and expedition.

There could be an increase in controller workload and the clutter could also result in poor radar performance as a result of processing saturation and desensitisation or shadowing, resulting in loss of radar detection of aircraft within the vicinity of the TMZ. For these reasons, the TMZ only option is considered insufficient in providing the required mitigation and is not considered a viable option for mitigation.

Option 7 (C): RAG blanking and TMZ over the proposed windfarm array locations.

Figure 3 below provides a TMZ design which aligns the 3 arrays of Clash Gour. As a result of the nature of the development and the geography of the area, this also takes in the Berry Burn and Berry Burn 2 Wind Farm array areas. This option of implementation provides the minimum TMZ cover required to restrict non-

[2] CAP 774 details the suite of ATS which (excluding aerodrome services) are the only services provided in Class G airspace within the UK Flight Information Region. The document is equally applicable to all civilian and military pilots, air traffic controllers, and flight information service officers.

transponder aircraft[3] overflying the RAG blanked area of the radar systems; this is the same area that would be blanked on the radar systems.

This option produces an irregularly shaped TMZ which will make it overly complicated for pilots and air traffic controllers alike. This could lead to a potential Human Factors issues because the shape would be difficult to accurately define in the geography of the area when flying and may lead to inadvertent penetration of the TMZ. A non-transponder equipped aircraft (primary radar only returns) would disappear from the radar screen if it inadvertently crosses into the red area and enters the RAG blanked region. The establishment of a TMZ without an additional buffer zone around the TMZ would prevent the controller from maintaining primary radar track identity as the aircraft enters/leaves the TMZ as the buffer zone would not be subject to radar blanking.

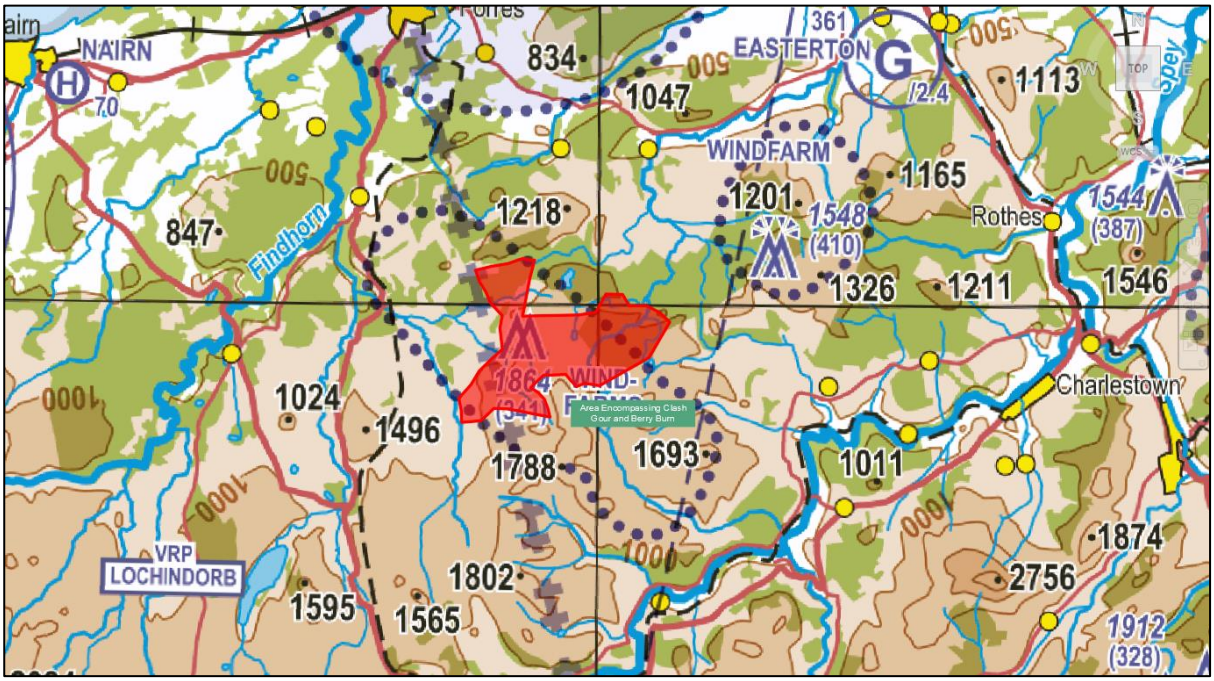

Figure 3 Basic TMZ (red shape) over Clash Gour and Berry Burn/Berry Burn 2

Option 7 (D): RAG blanking and TMZ over the proposed windfarm array locations. TMZ extended to include a 2 nautical mile (NM) Buffer.

Figure 4 below provides the TMZ design which aligns the 3 clusters of Clash Gour which as before takes in the Berry Burn/Berry Burn 2 Wind Farm array areas, all with an additional 2 NM buffer. Previously a 2 NM buffer has been utilised on other airspace change proposals and may be seen as 'best practice'. A 2 NM buffer has been selected as it is considered that a buffer of such dimensions would allow more time for the air traffic controller to maintain track identity and provide warning if an aircraft inadvertently enters the TMZ. Furthermore, a 2 NM buffer would allow the PSR sufficient processing time to re-establish a target/plot once an aircraft has exited the RAG (blanked) area.

[3] Provision will exist for conditional access by non-transponder equipped aircraft through prior arrangement with the appropriate ATS Unit.

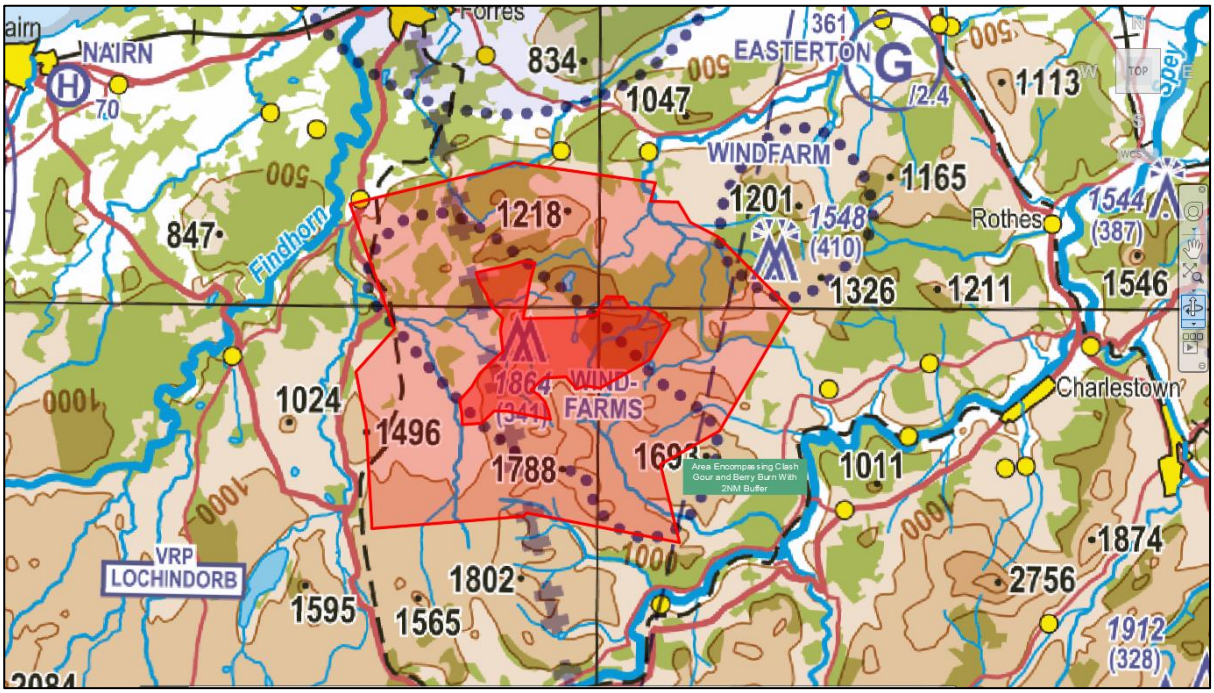

Figure 4 Basic TMZ (red shape) over Clash Gour and Berry Burn/Berry Burn 2 with two NM buffer

In order to assure safe and expeditious ATS provision, an additional lateral buffer for ATS purposes is considered appropriate, particularly to mitigate the potential navigation error that might occur whenever pilots of non-transponding aircraft fly close to the blanked area. The chance of non-transponding aircraft operating within the vicinity of the proposed TMZ cannot be ruled out, the addition of a 2 NM buffer means that controllers would have a greater chance of detecting a non-transponding aircraft tracking towards the lateral limits of the TMZ before it enters and hence would be able to provide pertinent information to aircraft operating within the airspace contained by the TMZ. Thus, it is concluded that an additional volume of airspace (the 2NM buffer, which would not be the subject of RAG blanking) should be added to the TMZ to accommodate the resolution of the radar, and to assure safe and expeditious ATS provision at all times.

Notwithstanding this, there is always potential for a non-transponder equipped aircraft to enter the TMZ inadvertently, thereby becoming invisible to the radar controller. This would pose a potential threat to other flights operating under the jurisdiction of an air traffic controller; a non-transponding aircraft entering the TMZ would simply disappear from the controller's display. Once a non-transponding aircraft has entered the TMZ, any opportunity to provide separation from other aircraft operating within it is lost. Like Option 7 (C) above this design option still produces an irregular shaped TMZ which would be difficult to define from the air and may lead to inadvertent penetration of the TMZ.

Option 7 (E): RAG blanking over the proposed windfarm array locations. Simplified polygon TMZ 'rubber banded' around the proposed windfarm locations with no buffer.

Figure 5 below provides an illustration of Option 7 (E), this design is a simplified polygon surrounding the locations of 3 arrays which comprise Clash Gour and as

before, take in Berry Burn/Berry Burn 2 Wind Farms, all with no buffer. This option is similar to those presented previously but provides a simplified boundary shape. Aircraft entering the TMZ will be required to be equipped with and operate SSR transponder equipment or to have established two-way radio communications with the TMZ Controlling Authority[4] before entry.

The TMZ proposed under this option purely covers for the geographical layout of the Development Areas and does not consider the establishment of a buffer zone. Establishing a TMZ without an additional buffer zone around the RAG would prevent the controller from maintaining primary radar track identity as the aircraft enters/leaves the TMZ however, the simplified design is advantageous for pilots to display on in-cockpit Electronic Flight Information Systems (EFIS) and air traffic controllers on radar displays. As such this is preferable for Human Factors reasons as the potential misinterpretation of the airspace comprising the TMZ and inadvertent penetration is reduced.

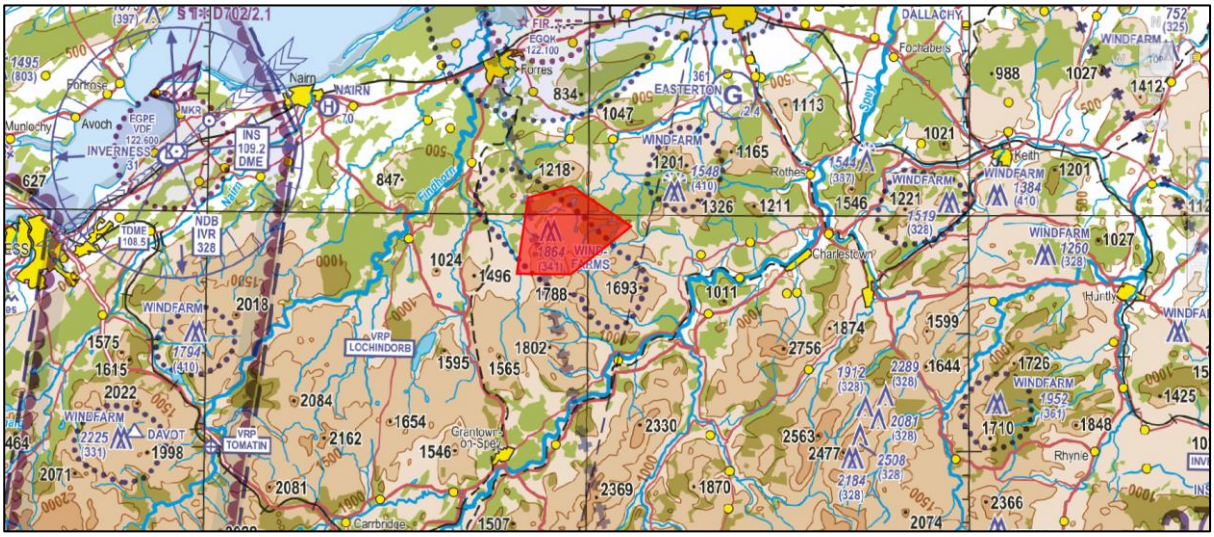

Figure 5 Simplified polygon TMZ (red shape) rubber banded around Clash Gour and Berry Burn/Berry Burn 2 with no buffer.

Option 7 (F): RAG blanking over the proposed windfarm array locations. Simplified polygon TMZ 'rubber banded' around the proposed wind farm locations extended to include a 2 NM buffer.

Figure 6 below provides an illustration of Option 7 (F). This option is an amalgamation of Options 7 (C) and 7 (E). It combines the advantages of the simplified TMZ shape with the benefit of the 2 NM buffer. The addition of a buffer allows the PSR to re-establish a target/plot once an aircraft has exited the RAG (blanked) area. This option has been successfully utilised as a radar mitigation scheme in previous wind farm developments requiring mitigation.

[4] Controlling Authority of the airspace change will be agreed further along in the ACP process.

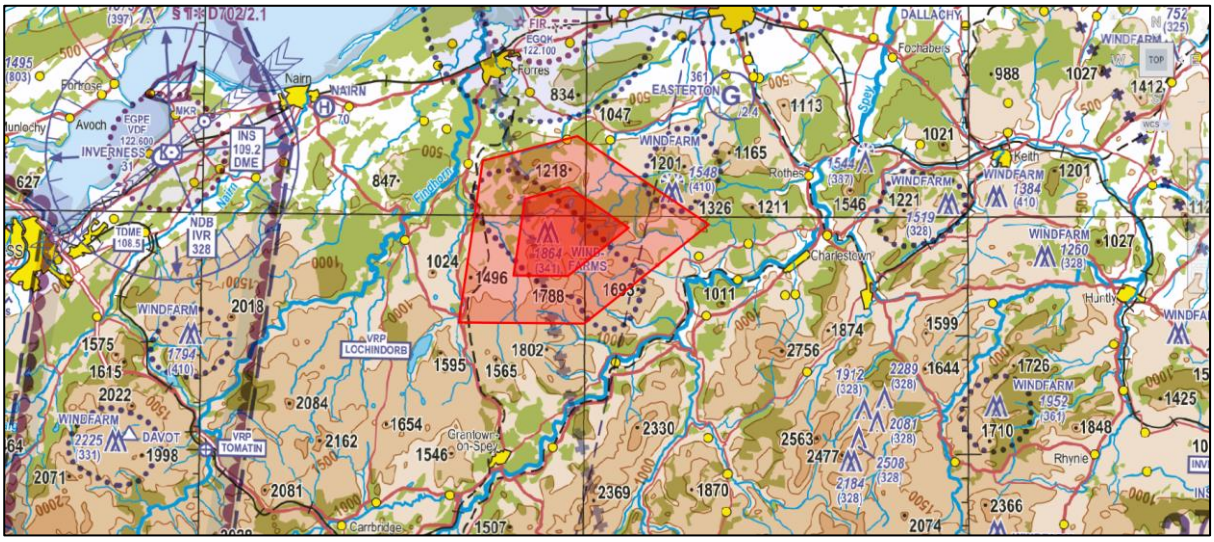

Figure 6 Simplified polygon TMZ (red shape) rubber banded around Clash Gour and Berry Burn/Berry Burn 2 with 2 NM buffer.

3 Request for Feedback

Osprey Consulting Services Ltd (Osprey) on behalf of Force9 and EDFER are progressing an Airspace Change Proposal to mitigate against radar interference to the RAF Lossiemouth and Inverness Airport PSR systems (anticipated as a result of radar detectability the operational wind turbines of the Clash Gour Wind Farm).

We are currently at Stage 2 of the CAP1616 Airspace Change process. This stage involves preparing and evaluating Design Options for this change. This stage of the process provides an opportunity to engage with you and request your feedback of the Design Options considered within this document.

This document provides our Step 2A - Design Options. At this stage of the CAP 1616 process we are required to provide evidence that design options have been developed and influenced by stakeholder feedback. As such, we would like to invite your feedback on the options contained in this document to be provided to [redacted] by Friday 29 April 2022.