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CONSULTANTS IN ENGINEERING,
ENVIRONMENTAL SCIENCE
& PLANNING

APPENDIX 7

Aviation Impact Assessment Report

PAGERPOWER
Urban & Renewables

Risk Assessment (Aviation)

Brookfield Renewable Ireland Limited

Coom Green Energy Park

August, 2020





PLANNING SOLUTIONS FOR:

- Solar
- Telecoms
- Railways
- Defence
- Buildings
- Wind
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- Radar
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ADMINISTRATION PAGE

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Issue	Date	Detail of Changes
1	20 September, 2018	Initial issue
2	21 September, 2018	Minor amendments
3	16 December, 2019	Wind Farm Layout change
4	19 December, 2019	Additional Met Mast Added
5	August, 2020	Updated with revised coordinates

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EXECUTIVE SUMMARY

Background

The developer provided an indicative layout of 22 wind turbines for this assessment. Each turbine will have a maximum height of 169 metres above ground level with tip altitudes rising to nearly 1800 feet above mean sea level. The proposal lies north of the city of Cork and its centre is 27.4 kilometres (14.8 nautical miles) from Cork Airport.

Aviation Impacts

Wind turbines can impact aviation including aeronautical radio and radar systems. This report identifies aviation infrastructure that could be affected by the turbines and also provides an indication of the level of corresponding risk to the wind farm project.

Identified Receptors

The nearest significant airport is Cork to the south whilst there is a minor airfield 18km to the east called Fermoy (Knock).

The nearest aeronautical radar station is at Tullig More about 3 kilometres south west of Cork Airport. Tullig More is understood to consist of both Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR) operated by the Irish Aviation Authority (IAA). The nearest En-Route radar station is at Woodcock Hill, County Clare, about 70 kilometres north of the proposed development.

The nearest aeronautical radio navigation beacons are at Cork Airport and include a category II Instrument Landing System (ILS) for Runway 16. Test flights are regularly flown to confirm navigation beacons are working correctly.

IAA Consultation

The Irish Aviation Authority (IAA) has been consulted regarding the proposed development and has raised concerns that the proposed turbines could impede some ILS test flights.

Initial Risk Assessment

Physical Obstruction Risks

It is unlikely that there will be any significant physical obstruction risk to aircraft using Cork Airport and there will be no significant risk to aircraft using Fermoy (Knock) airfield.

Radar and Navigation Beacons

There will be no significant impact on the Tullig More Secondary Surveillance Radar (SSR). However there is likely to be a technical impact on the Tullig More Primary Surveillance Radar (PSR) which may well be operationally acceptable because:

- Any effects will be limited to the wind farm area which is just 0.04% of the radar's coverage area;
- Commercial aircraft flying in this area will be flying in Controlled Airspace where any wind farm effects on PSR may be disregarded;

and

- Air traffic controllers see flights from SSR radar which will not be affected by the proposal.

There will be no significant impact on the IAA Woodcock Hill radar station and there will be no significant impacts on aeronautical navigation beacons at Cork Airport.

ILS Test Flights

There is unlikely to be any significant impact on ILS test flights and in the event that test flights were impacted it is likely that these impacts could be mitigated. Overall impacts on ILS test flights are unlikely to be significant because:

- ILS coverage is already limited below 3000 feet meaning that requirements for test flights below this altitude will be limited;
- The exact paths of test flights are not defined with international (ICAO) flying regulations and can be amended to suit any limitations arising from terrain or structures;

and

- The majority of testing occurs within 5 degrees of the flight path and the proposed development lies beyond 5 degrees.

Wind Turbine Lighting

It is likely that there will be a requirement for the wind turbine nacelles to be fitted with red aeronautical ground lights which should be illuminated at night.

Recommendation

It is recommended that engagement and consultation with the Irish Aviation Authority (IAA) continues. Further analysis of ILS check flights could be undertaken.

Other Assessments

There are three assessments that have been undertaken – two as a result of consultation with the Irish Aviation Authority.

These reports are:

- Aviation Risk Assessment
- ILS Calibration Flight Impact Assessment
- Radar Vectoring Area Assessment

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company specializes in assessing the impact of wind turbines on aviation and radar - having undertaken projects in 48 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.

1 INTRODUCTION

The developer provided a layout of 22 wind turbines for this assessment. Each turbine will have a maximum height of 169 metres above ground level with tip altitudes rising to nearly 1800 feet above mean sea level. The proposal lies north of the city of Cork and its centre is 27.4 kilometres (14.8 nautical miles) from Cork Airport.

Wind turbines can impact aviation including aeronautical radio and radar systems. This report identifies aviation infrastructure that could be affected by the turbines and also provides an indication of the level of corresponding risk to the wind farm project.

1.1 Units of Measurement and Coordinate Systems

Units of measurement and coordinate systems normally used by the aviation and wind farm development industries differ. These differences are set out in the table below:

Parameter	Aviation	Onshore wind – Ireland	Conversion
Distance	Nautical Mile (nm)	Kilometre (km)	1nm = 1.852km
Height	Feet (ft)	Metres (m)	1ft = 0.3048m
Location	WGS84 Lat/Long	ITM Eastings and Northings	Specialist tool required

Table 1 Units of measurement and coordinate systems

2 WIND FARM INFORMATION

The Nagle Mountain wind farm consists of 22 wind turbines having a tip height of 169 metres above ground level. This layout is shown on the aerial photograph[1] below:

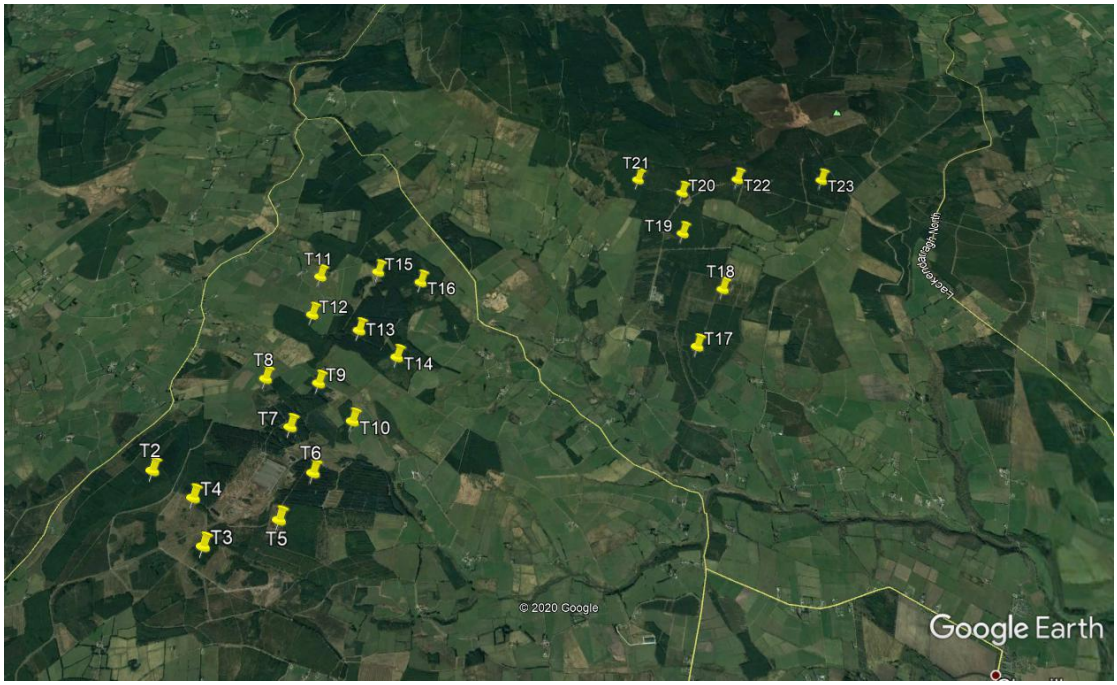

Figure 1 Wind Turbine Layout

There are two groups of wind turbines with turbine T22 being the most elevated towards the north-east corner. Elevation, heights and altitudes are shown in the table below:

Quantity	Metres (m)	Feet (ft)
Ground Elevation (approximate)	377	1,237
Turbine Tip Height above ground level	169	554
Turbine Tip Altitude (approximate)	546	1,791

Table 2 Turbine 22 height and altitude data

[1] Copyright © 2020 Google

2.1 Wind Turbine Coordinates

ID	X (ITM)	Y (ITM)
T2	562583	590234
T3	563227	589449
T4	563039	589951
T5	563936	589713
T6	564212	590214
T7	563907	590734
T8	563567	591306
T9	564146	591247
T10	564550	590806
T11	564002	592625
T12	563969	592119
T13	564515	591909
T14	564961	591567
T15	564661	592686
T16	565156	592556
T17	568267	591705
T18	568612	592430
T19	568206	593139
T20	568229	593738
T21	567708	593928

ID	X (ITM)	Y (ITM)
T22	568905	593906
T23	569943	593950

Table 3 Wind Turbine Coordinates

2.2 Permanent Meteorological Masts

A permanent meteorological mast (PMM1) is planned at ITM coordinates 562291 590024. The mast will have a maximum height of 100 metres on ground that has an elevation of approximately 289 metres making the maximum mast altitude approximately 389 metres which is 1,276 feet. This is approximately 500 feet lower than the tip of turbine T22.

A further permanent mast (PMM2) is planned at ITM coordinates 567498 594127. This 100 metre mast will have a maximum altitude of approximately 456 metres which is 1,496 feet. This is 295 feet lower than the tip of turbine T22.

The chart below shows the proposed turbine and permanent meteorological mast locations.

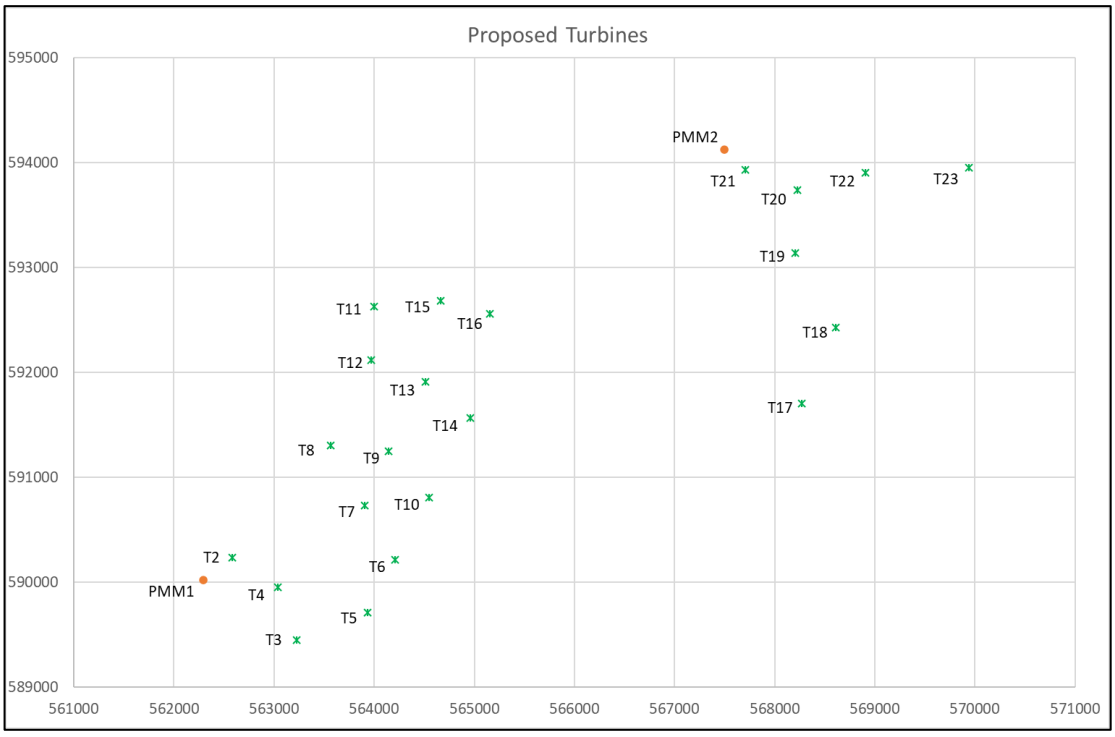

Figure 2 Chart showing Proposed Turbine and Meteorological Mast Locations

3 CORK AIRPORT

Cork Airport is located approximately 7km south of Cork. It is operated by Dublin Airport Authority plc. The airport handles around 1.6 million passengers a year. The diagram below[2] shows the airport's runways.

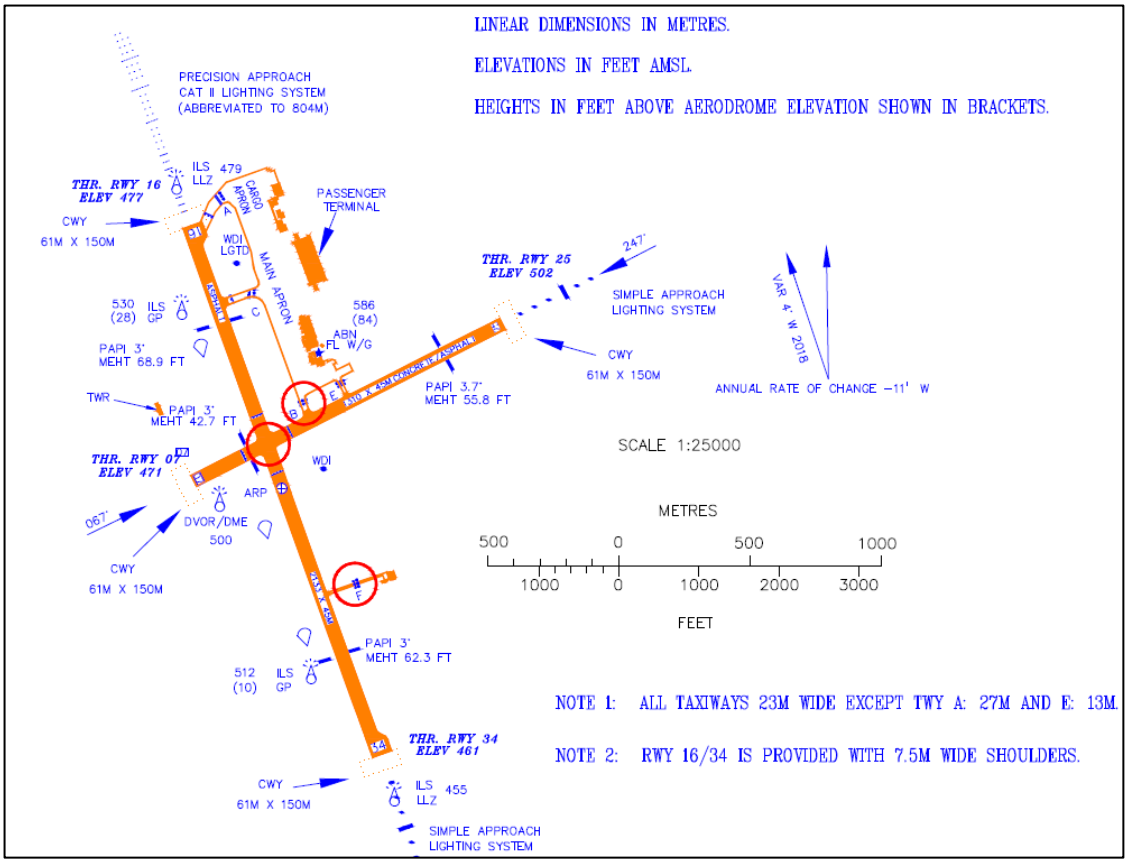

Figure 3 Cork Runways

The airport has two substantial paved runways which are 2133m and 1310m long. The airport has a variety of navigation equipment including visual markings and approach aids, radio navigation beacons, instrument landing system and radar.

[2] Sourced from the IAA Aeronautical Information Publication (AIP)

3.1 Cork Radar – Tullig More

Cork Airport has a radar to the south west of the airport at Tullig More. The radar is operated by the Irish Aviation Authority and is operated by air traffic controllers working in Dublin, but providing a service to aircraft arriving and departing Cork Airport.

Parameter	Value
Structure	Radome on Building
Location Description	Tullig More Hill
Coordinates (Latitude/Longitude)	51 49 17N 8 31 20W
Coordinates (ING)	164047E 63287N
Terrain Elevation	160 metres
Antenna Height agl	7.5 metres
Antenna Height amsl	167.5 metres

Table 4 Cork Radar Parameters (indicative)

3.2 Instrument Landing Systems

Cork Airport has Instrument Landing Systems (ILS) installed for aircraft approaching either end of the airport's longer runway (Runway 16/34). The proposed wind development lies within the radio beam of the Runway 16 Localizer (LLZ). Coverage of the Runway 16 Localizer is limited - the Airport's Aeronautical Information Publication (AIP) states:

> *Coverage is restricted to 35° either side of course line. Signals received outside the coverage sector including back beam radiation should be ignored. Use at 3000 feet AMSL restricted to 18NM, due low signal coverage. LLZ Flags may be observed below 3000ft AMSL outside 10NM range from threshold.*

4 OTHER AVIATION AND RADAR RECEPTORS

4.1 Fermoy (Knock) Airfield

Fermoy (Knock) is a privately owned unlicensed landing strip which lies approximately 18 kilometres east of the proposed development. The runway is 300 metres long and the coordinates are 52°07'N 08°13'W. The runway is grass and is orientated east/west with runway numbers 10/28.

4.2 Woodcock Hill Radar, County Clare

This is a national En-Route radar operated by the Irish Aviation Authority (IAA) as part of the national radar network. This is a Secondary Surveillance Radar (SSR) having coordinates 52°43'N 8°42'W.

5 IAA CONSULTATION

The wind farm developer consulted the Irish Aviation Authority (IAA) regarding the proposed wind development in July and August 2018. The following IAA comments have been made:

- Instrument Flight Procedures (IFPs) are unlikely to be affected.
- There are concerns relating to the potential impact on aircraft flying VFR (in accordance with Visual Flight Rules) beneath controlled airspace.
- There are potential concerns relating to Instrument Landing System (ILS) test flights.

6 ASSESSMENT

6.1 Physical Obstruction Risks

6.1.1 Cork Airport – Physical Safeguarding

The proposed development is 27 kilometres from Cork Airport and beyond its physical safeguarding Obstacle Limitation Surfaces (OLS) which extend 15 kilometres from the airport. The development does not therefore present a physical safeguarding risk.

6.1.2 Cork Airport – Instrument Flight Procedures (IFPs)

The Irish Aviation Authority (IAA) appears to have indicated that the proposed development will not affect IFPs. At this range from the airport IFPs have a minimum altitude of 3000 feet which is more than 1200 feet vertically clear of the highest turbine tip which has an altitude of approximately 1,791 feet.

6.1.3 Fermoy Knock Airfield

Minor airfields such as Fermoy are typically assessed when proposed wind farms lie within 5 kilometres. At a range of 18 kilometres the proposed wind farm will have no impact.

6.1.4 VFR Flights beneath Controlled Airspace

The southern part of the proposed wind farm lies entirely within Controlled Airspace. The northern part of the wind farm lies in Uncontrolled Airspace – with Controlled Airspace above it. The base of this Controlled Airspace has an altitude of 2,500 feet which is more than 700 feet above the tip of the highest turbine which has an estimated maximum tip height of 1,791 feet.

The wind turbines may cause a minor restriction to VFR flights flying around the Cork Airport Control Zone in certain conditions however no significant overall impact is predicted because the airspace is Controlled to the south and is less restricted to the north.

6.2 Tullig More Secondary Surveillance Radar (SSR)

Under Eurocontrol guidelines SSR are safeguarded against wind turbines to a range of 16 kilometres. The distance from the centre of the wind farm to the radar is 30 kilometres which is significantly more than this 16km safeguarding distance. Because of this no impacts are likely and no further assessment is recommended.

6.3 Tullig More Primary Surveillance Radar (PSR)

The majority of the wind turbines will be at least partially visible to the PSR. This means that the turbines will generate false returns on air traffic control displays in the vicinity of the wind farm. Whilst the wind farm is likely to cause a local technical effect the resulting operational effect may well be acceptable.

The schematic diagram below shows how data from multiple radar is combined before it is displayed to air traffic controllers directing aircraft to and from Cork Airport.

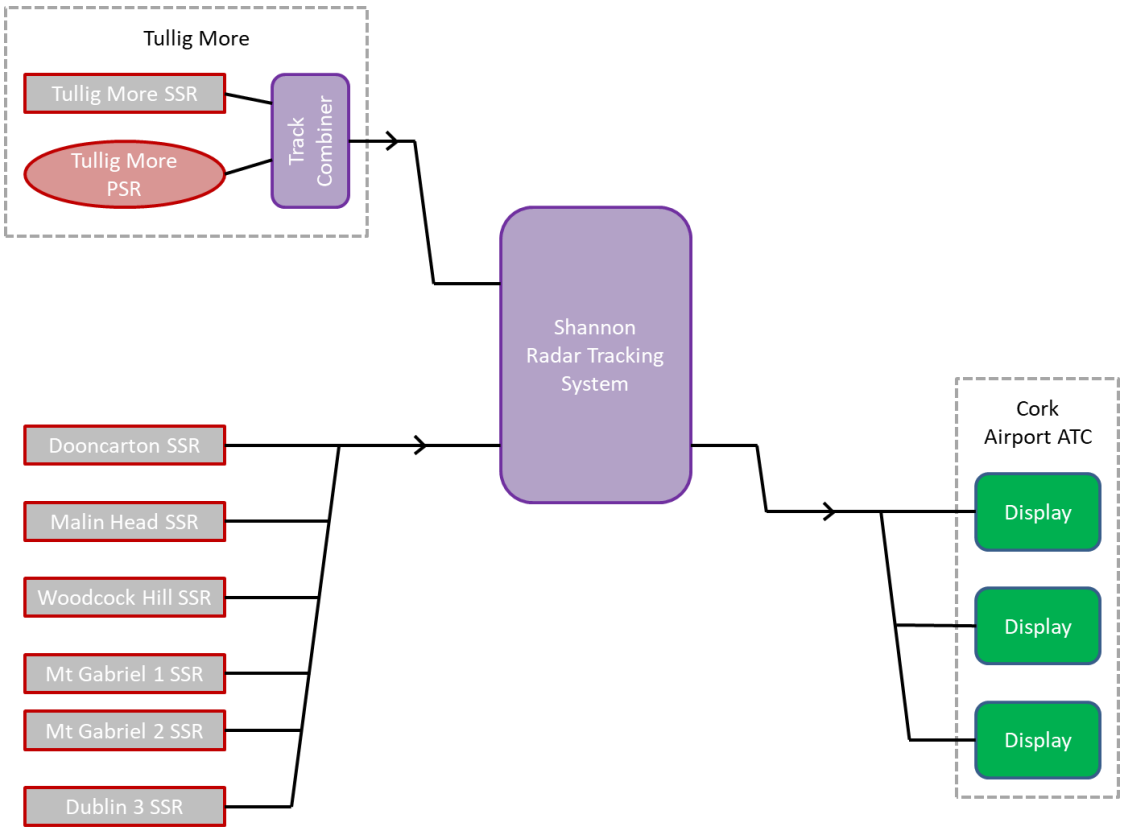

Figure 4 Schematic diagram showing Cork Airport radar data flow

This data combination process means that the wind farm's effects may be operationally acceptable because:

- Any effects will be limited to the wind farm area which is just 0.04% of the radar's coverage area[3];
- Commercial aircraft flying in this area will be flying in Controlled Airspace where any wind farm effects on PSR may be disregarded;

  and

- Air traffic controllers see flights from SSR radar which will not be affected by the proposal.

6.4 IAA Woodcock Hill Radar Station (SSR)

Under Eurocontrol guidelines SSR are safeguarded against wind turbines to a range of 16 kilometres. The distance from the centre of the wind farm to the radar is 70 kilometres which is significantly more than this 16km safeguarding distance. Because of this no significant impacts are predicted.

6.5 Cork Airport Radio Navigation Beacons including ILS

Safeguarding requirements for radio navigation beacons are defined by the International Civil Aviation Organisation (ICAO) in publication EUR DOC 015 *European Guidance Material on Managing Building Restricted Areas*.

All proposed wind turbines lie beyond the safeguarding distances specified for the radio navigation beacons at Cork Airport. Because of this no significant impacts are predicted.

6.6 ILS Test Flights

The International Civil Aviation Organisation (ICAO) publishes its *Manual on Testing of Radio Navigation Aids* which defines how flight tests for ILS localizers should be undertaken. ILS coverage requirements are defined in ICAO *Annex 10 to the Convention on International Civil Aviation – Aeronautical Telecommunications – Volume 1 – Radio Navigation Aids*.

A review of the above documents, the Cork Airport AIP, the IAA's comments and the relative geometry of the proposed wind farm led to the assessment below:

There is unlikely to be any significant impact on ILS test flights and in the event that test flights were impacted it is likely that these impacts could be mitigated.

[3] Calculated using a radar range of 60 nautical miles

Overall impacts on ILS test flights are unlikely to be significant because:

- ILS coverage is already limited below 3000 feet meaning that requirements for test flights below this altitude will be limited;
- The exact paths of test flights are not defined with international (ICAO) flying regulations and can be amended to suit any limitations arising from terrain or structures;

and

- The majority of testing occurs within 5 degrees of the flight path and the proposed development lies beyond 5 degrees.

6.7 Obstruction Lighting

All structures that are higher than 150 metres above ground level require aeronautical lighting in accordance with national and international legislation. It is therefore highly likely that the turbines' nacelles will have to be fitted with red aeronautical ground lighting.

7 CONCLUSIONS

7.1 Identified Receptors

The nearest significant airport is Cork to the south whilst there is a minor airfield 18km to the east called Fermoy (Knock).

The nearest aeronautical radar station is at Tullig More about 3 kilometres south west of Cork Airport. Tullig More is understood to consist of both Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR) operated by the IAA. The nearest En-Route radar station is at Woodcock Hill, County Clare, about 70 kilometres north of the proposed development.

The nearest aeronautical radio navigation beacons are at Cork Airport and include a category II Instrument Landing System (ILS) for Runway 16. Test flights are regularly flown to confirm navigation beacons are working correctly.

7.2 IAA Consultation

The Irish Aviation Authority (IAA) has been consulted regarding the proposed development and has raised concerns that the proposed turbines could impede some ILS test flights.

7.3 Initial Risk Assessment

7.3.1 Physical Obstruction Risks

Initial findings are that there will be no significant physical obstruction risk to aircraft using Cork Airport and there will be no significant risk to aircraft using Fermoy (Knock) airfield.

7.3.2 Radar and Navigation Beacons

There will be no significant impact on the Tullig More Secondary Surveillance Radar (SSR). However there is likely to be a technical impact on the Tullig More Primary Surveillance Radar (PSR) which may well be operationally acceptable because:

- Any effects will be limited to the wind farm area which is just 0.04% of the radar's coverage area;
- Commercial aircraft flying in this area will be flying in Controlled Airspace where any wind farm effects on PSR may be disregarded;

and

- Air traffic controllers see flights from SSR radar which will not be affected by the proposal.

There will be no significant impact on the IAA Woodcock Hill radar station and there will be no significant impacts on aeronautical navigation beacons at Cork Airport.

7.3.3 ILS Test Flights

There is unlikely to be any significant impact on ILS test flights and in the event that test flights were impacted it is likely that these impacts could be mitigated. Overall impacts on ILS test flights are unlikely to be significant because:

- ILS coverage is already limited below 3000 feet meaning that requirements for test flights below this altitude will be limited;
- The exact paths of test flights are not defined with international (ICAO) flying regulations and can be amended to suit any limitations arising from terrain or structures;

  and

- The majority of testing occurs within 5 degrees of the flight path and the proposed development lies beyond 5 degrees.

7.4 Wind Turbine Lighting

It is likely that there will be a requirement for the wind turbine nacelles to be fitted with red aeronautical ground lights which should be illuminated at night.

7.5 Recommendation

It is recommended that engagement and consultation with the IAA continues. Further analysis of ILS check flights could be undertaken.

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PAGERPOWER
Urban & Renewables

ILS Calibration Flight Impact Assessment

Brookfield Renewable Ireland Limited

Coom Green Energy Park

August, 2020

ADMINISTRATION PAGE

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Issue	Date	Detail of Changes
1	23 April, 2019	Initial issue
2	23 May, 2019	Minor amendments
3	19 December, 2019	Revised turbine layout
3.1	27 December, 2019	Reference to 22 turbine layout added
4	August, 2020	Updated with revised turbine layout

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1 KEY FINDINGS

1.1 Background

Brookfield Renewable Energy is developing a proposed wind farm named Coom Green Energy Park which lies north of Cork and approximately 27 kilometres from Cork Airport in southern Ireland. The wind development is also referred to as Nagle Mountain.

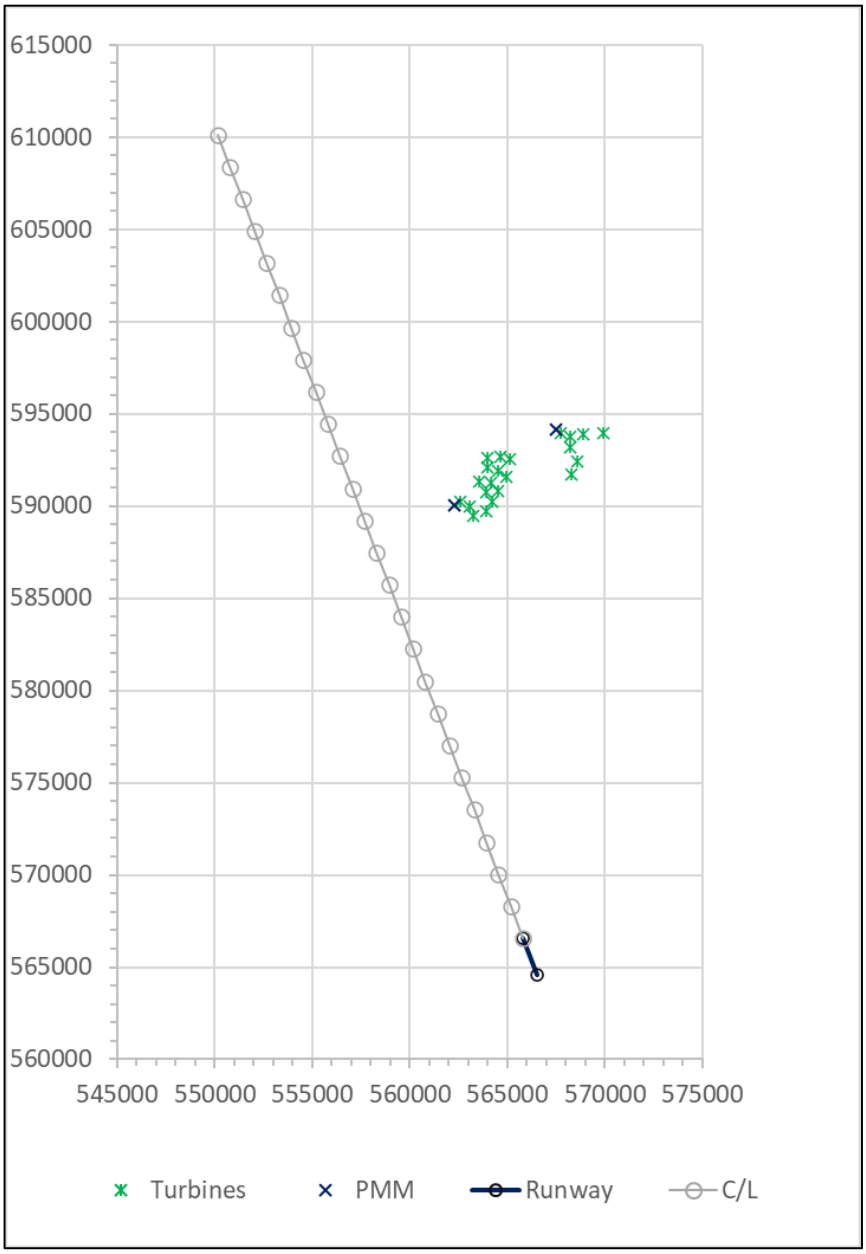

Figure 1 Chart showing extended centre line, turbines and met masts

1.2 Cork Airport

The diagram on the preceding page shows the relative locations of the turbines; the permanent meteorological masts; the runway and its extended centre line. The marks on the extended centre line have a spacing of 1 nautical mile.

Cork Airport has a range of radio transmitters which pilots use to navigate - one of these systems being an Instrument Landing System (ILS). The Irish Aviation Authority (IAA) has raised concerns that the wind farm could affect periodic test flights that are used to calibrate and check the ILS.

1.3 Test Flights

These test flights fly a range of trajectories which either fly towards the airport or in an arc, or orbit, centred on the runway threshold[1]. The IAA has provided a schedule of ILS checks and their associated flight trajectories.

1.4 Assessment

The aircraft altitude (or height) has no impact on the horizontal separation between wind turbine and aircraft. Similarly the wind turbine altitude (or height) has no impact on horizontal separation.

In this analysis only the horizontal clearance between aircraft and the turbines has been considered. This means that the results of this analysis apply for aircraft flying at any altitude profile on the specified horizontal trajectory. Similarly the results apply for any turbine height.

A software tool has been used to calculate the minimum horizontal separation between each specific (horizontally defined) trajectory and the nearest wind turbine or permanent meteorological masts.

1.5 Trajectories beyond 2 Nautical Miles[2]

Most trajectories will not be affected by the proposed wind farm and are more than 2 nautical miles away.

Aircraft flying Centre Line approaches will be at least 2.4 nautical miles from the proposed wind farm with permanent meteorological mast 1 being closest.

Aircraft flying approaches 8 degrees right[3] of the runway extended centre line will be at least 4.3 nautical miles from the proposed wind farm with permanent meteorological mast 1 being closest.

Aircraft flying approaches 8 degrees left of the runway extended centre line, commencing at 10 nautical miles or less, will be at least 2.5 nautical miles from the proposed wind farm with turbine 3 being closest.

---

[1] In practice the arcs are centred on the Runway 16 threshold which is the zero reference point for the DME (Distance Measuring Equipment) associated with the Instrument Landing System

[2] 2 nautical miles = 3.7 kilometres

[3] To the west of

Aircraft flying orbits of 6 nautical miles will be at least 6.4 nautical miles from the proposed wind farm with turbine 3 being closest.

Aircraft flying orbits of 17 nautical miles will be at least 2.04 nautical miles from the proposed wind farm with turbine 23 being closest.

Aircraft flying orbits of 25 nautical miles will be at least 10.04 nautical miles from the proposed wind farm with turbine 23 being closest.

1.6 Trajectories within 2 Nautical Miles

One trajectory, however, passes less than 2 nautical miles[4] from the proposed wind farm.

1.7 Eight Degree Left Slice Approach

Aircraft flying an eight (8) degree left[5] slice approach pass 0.562 nautical miles west of the proposed wind farm with permanent meteorological mast 1 being closest. The mast is highlighted on the diagram below:

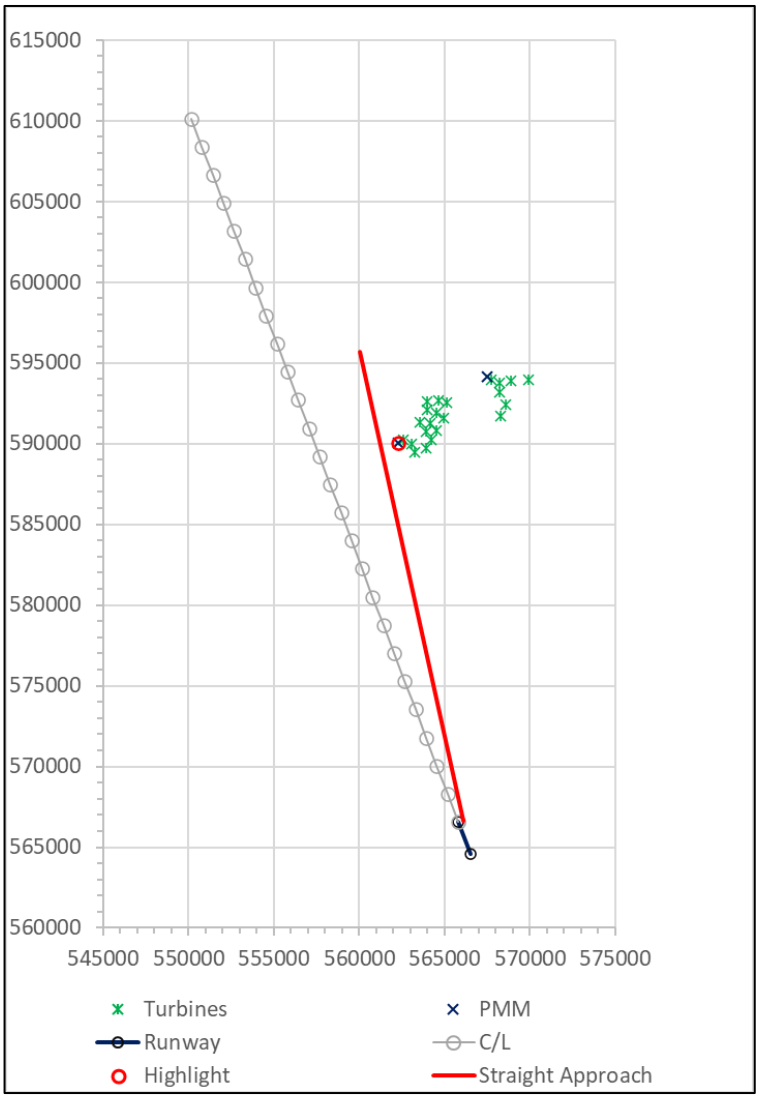

Figure 2 Chart showing proximity of turbines to 8 degree left slice approach

[4] The 2 nautical mile distance has been selected arbitrarily as a cut-off distance for assessment purposes. It significantly exceeds the 150 metre obstacle separation distance required for VFR flights.

[5] To the east of the extended centre-line

Note that this trajectory is flown in commissioning checks but not during routine calibration checks.

1.8 Visual Flight Rules

Test flights are conducted under Visual Flight Rules (VFR) whereby pilots fly visually rather than with instruments. When flying VFR pilots must ensure that they do not fly within 150 metres of any structure[6].

Wind turbines are complex structures with large moving rotors. The clearance distances in the analysis above relate to the wind turbine bases rather than the entire wind turbine structure. It is necessary to consider the rotor radius of 70 metres when evaluating the calculated clearances.

All trajectories are 0.562 nautical miles or more from the proposed wind turbine towers and permanent meteorological masts. One nautical mile is 1852 metres which means that all trajectories are 1,041[7] metres from the proposed towers.

1.9 Overall Impact

The horizontal clearance between aircraft flying the test trajectories and the turbines is more than seven times the minimum horizontal clearance distance of 150 metres applicable for VFR flights in Ireland. The proposed turbines will therefore not affect aircraft flying ILS test trajectories and will therefore not have a significant impact on ILS test flights.

1.10 Mitigation

Whilst the proposed development will not impede aircraft flying the test trajectories it would nevertheless be prudent to ensure that pilots of test aircraft are fully aware of the presence of wind turbines, and any associated anemometry masts, before undertaking any test flights. The following mitigation measures are therefore recommended:

- All turbines and meteorological masts having a height of 100m or more are promulgated in the Irish Air Navigation Obstacle database
- The extremities of the wind farm are lit
- Meteorological masts are lit
- Locations of meteorological masts having a height of less than 100m are promulgated to the pilots of test aircraft[8]
- Test aircraft are fitted with Terrain Awareness and Warning System (TAWS)
- Test aircraft TAWS obstacle databases are regularly updated

1.11 Conclusions and Recommendations

It is recommended that this report is shared with the Irish Aviation Authority.

---

[6] Irish Aviation Authority (Rules of the Air) Order, 2004 – Rule 3
[7] 0.562 x 1852 = 1,042
[8] This could be via the Aeronautical Information Publication or directly to pilots

1.12 Other Reports

There are three assessments that have been undertaken – two as a result of consultation with the Irish Aviation Authority.

These reports are:

- Aviation Risk Assessment
- ILS Calibration Flight Impact Assessment
- Radar Vectoring Area Assessment

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ABOUT PAGER POWER

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

2 INTRODUCTION

2.1 Overview

The developer provided a proposed layout of 22 wind turbines for this assessment. Each turbine will have a maximum height of 169 metres above ground level with tip altitudes rising to approximately 1,890 feet above mean sea level. The proposal lies north of Cork and its centre is 27 kilometres (14.5 nautical miles) from Cork Airport.

Wind turbines can impact aviation. This report identifies potential impacts on flights checking the airport's Instrument Landing System (ILS).

2.2 Units of Measurement and Coordinate Systems

Units of measurement and coordinate systems normally used by the aviation and wind farm development industries differ. These differences are set out in the table below:

Parameter	Aviation	Onshore wind – Ireland	Conversion
Distance	Nautical Mile (nm)	Kilometre (km)	1nm = 1.852km
Height	Feet (ft)	Metres (m)	1ft = 0.3048m
Location	WGS84 Lat/Long	ITM Eastings and Northings	Specialist tool required

Table 1 Units of measurement and coordinate systems

3 WIND FARM INFORMATION

3.1 Wind Farm Chart

A 22 turbine wind farm layout has been assessed. This is shown on the aerial photograph[9] below.

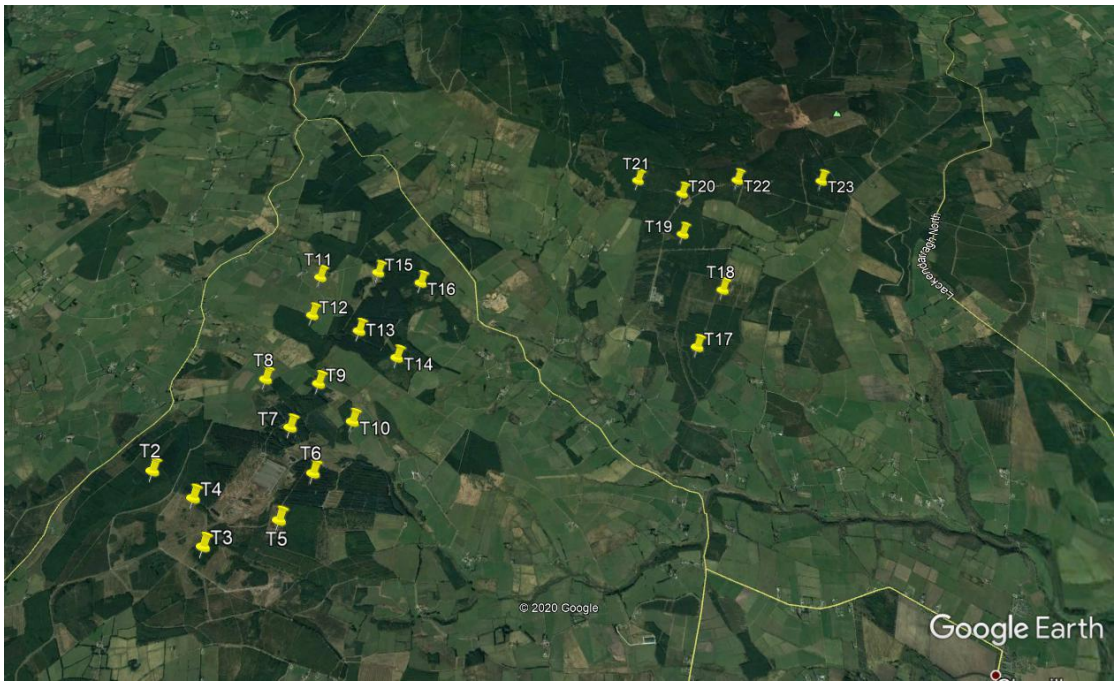

Figure 3 Aerial photograph showing individual turbine locations and numbers

3.2 Wind Turbine Coordinates

ID	X (ITM)	Y (ITM)
T2	562583	590234
T3	563227	589449
T4	563039	589951
T5	563936	589713
T6	564212	590214
T7	563907	590734

[9] Copyright © 2020 Google

ID	X (ITM)	Y (ITM)
T8	563567	591306
T9	564146	591247
T10	564550	590806
T11	564002	592625
T12	563969	592119
T13	564515	591909
T14	564961	591567
T15	564661	592686
T16	565156	592556
T17	568267	591705
T18	568612	592430
T19	568206	593139
T20	568229	593738
T21	567708	593928
T22	568905	593906
T23	569943	593950

Table 2 Wind Turbine Coordinates

3.3 Permanent Meteorological Masts

A permanent meteorological mast (PMM1) is planned at ITM coordinates 562291 590024. The mast will have a maximum height of 100 metres on ground that has an elevation of approximately 289 metres making the maximum mast altitude approximately 389 metres which is 1,276 feet. This is approximately 500 feet lower than the tip of turbine T22.

A further permanent mast (PMM2) is planned at ITM coordinates 567498 594127. This 100 metre mast will have a maximum altitude of approximately 456 metres which is 1,496 feet. This is 295 feet lower than the tip of turbine T22.

The chart below shows the proposed turbine and permanent meteorological mast locations.

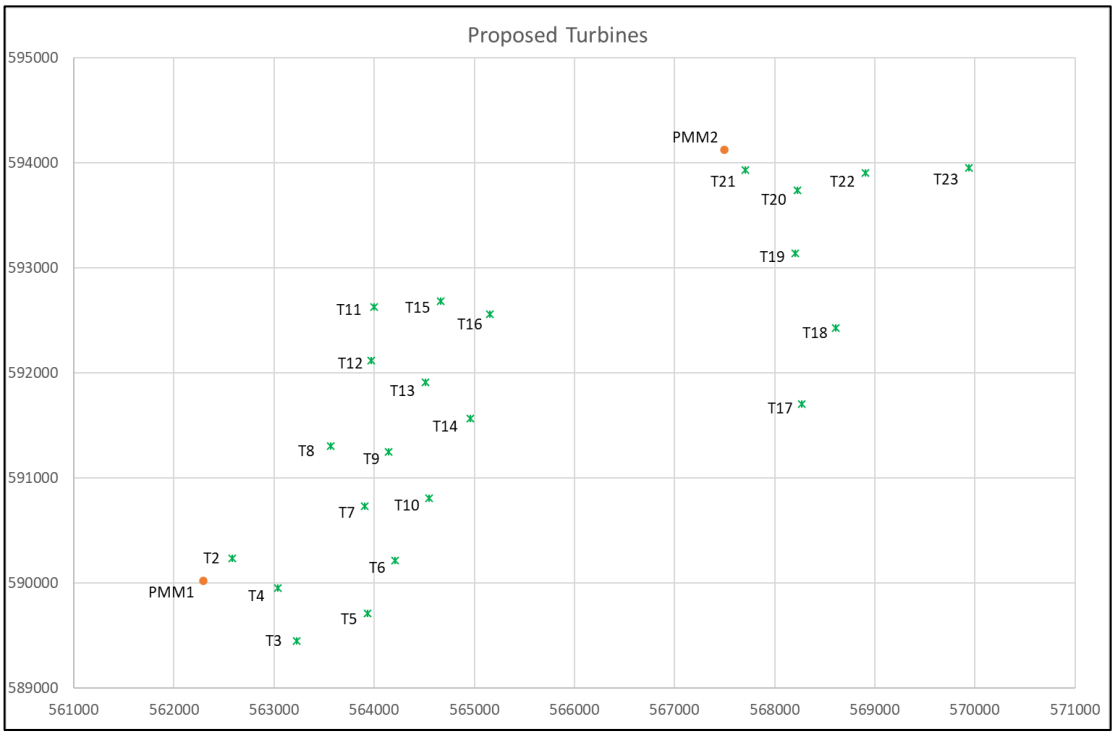

Figure 4 Chart showing Proposed Turbine and Meteorological Mast Locations

4 CORK AIRPORT

4.1 Airport Information

Cork Airport is an Irish Aviation Authority (IAA) licensed aerodrome used predominately by private and commercial jet and fixed wing propeller aircraft. An ATC Tower is present on the airport.

4.2 Runway Details

Cork Airport has two physical runways. The main runway 16/34 measures 2,133m by 45m. The runway is shown on the aerodrome chart in Figure 5[10] below.

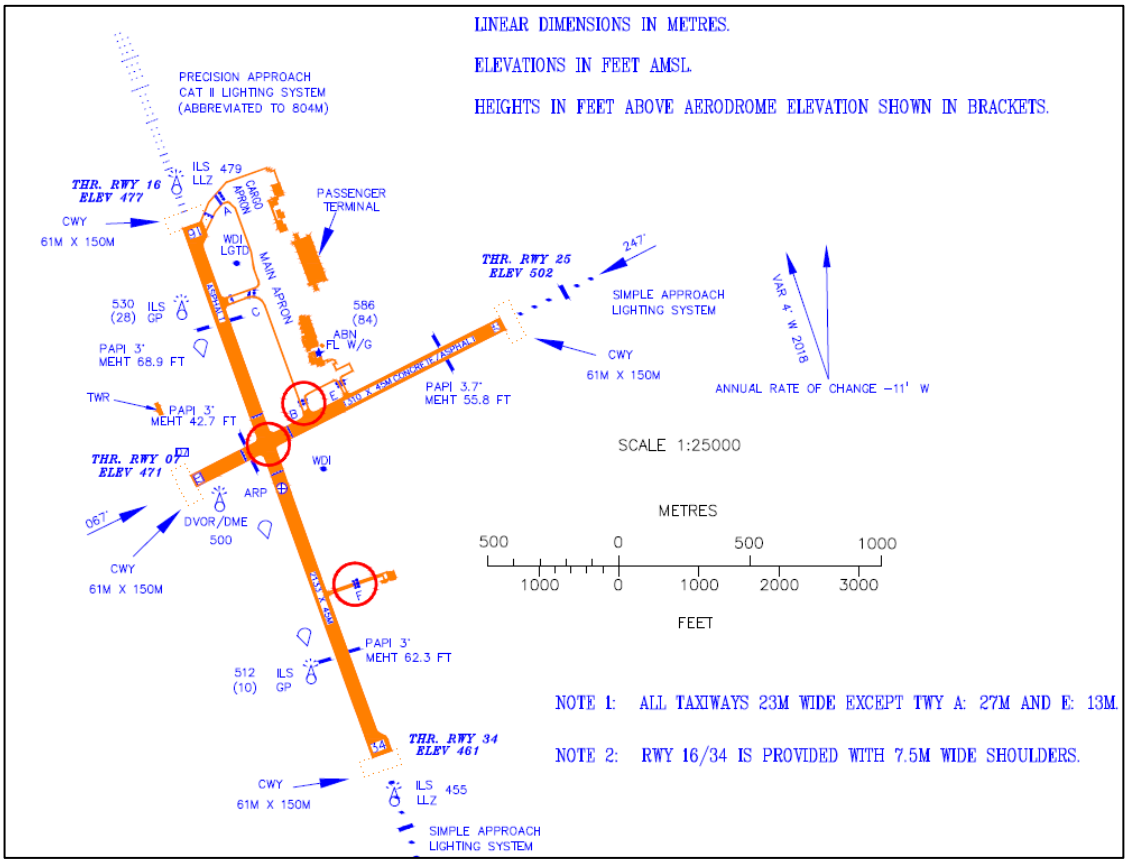

Figure 5 Cork Airport aerodrome chart

[10] Source: Irish Aviation Authority IAP.

4.3 Instrument Landing System

Specific parameters pertaining to the Runway 16 Instrument Landing System are shown in the Irish Aviation Authority Aeronautical Information Publication (AIP).

Parameter	Units	Value
ILS Category	n/a	Cat II
Slope	Degrees	3
Threshold Elevation	Feet	461
Distance to ILS Point A	Nautical Miles	4
Distance to ILS Point B	Nautical Miles	0.57

Table 3 Instrument Landing System Parameters

5 IAA FLIGHT CHECK SCHEDULE

ILS flight check profiles

4.2 Routine ILS Inspection Profile Requirements

Note: Where only 1 transmitter is checked on a routine, subsequently the other transmitter will be checked on the next routine.

Section	Profile	Description	Procedure	Notes	TX
9.1.1	01	Centreline Approach	10NM-Threshold 3000'	Course Structure, Alignment, GP Angle & RF measurement	1or2
9.1.3	04	Loc Orbit	6NM 1500' +35-35°	Clearance	1or2
9.1.1	05	Centreline Approach Cat III only	2NM to Point E level 50ft down runway Centreline	Loc Course Structure, Alignment	1or2
9.1.1	12	Top Edge	1 NM required between 4NM-Point B 1800'	(75μA) 90Hz width	1or2
9.1.1	13	Bottom Edge	1 NM Required between 4NM-Point B 1500'	(75μA) 150Hz width	1or2
9.1.2	14	Slice for 3° GP	0.3θ ≈12NM-Threshold 1000'	Clearance	1or2
9.1.2	15	Left Slice for 3° GP	10NM-0.45θ 1000'	Coverage 8° of Centreline Both transmitters if M Array	Alt 1or2
9.1.2	16	Right Slice for 3° GP	10NM-0.45θ 1000'	Coverage 8° of Centreline Both transmitters if M Array	Alt 1or2
	All	Ident Loc/DME	Co-Pilot listens/Fl	Check ident and synchronization	1or2
9.1.1	01	DME	4NM-1NM 1500'	DME Range Error	1or2

4.3 Annual ILS Inspection Profile Requirements

Section	Profile	Description	Procedure	Notes	TX
9.1.1	01	Centreline Approach	10NM-Threshold 3000'	RF, Course Structure, Alignment Angle GP & Loc	1&2
9.1.1	01	Centreline Approach	DOC or 10NM-Threshold on GP	Course Structure, Alignment Angle GP & Loc	1or2
9.1.1	01	Centreline Approach	10-4NM on GP & Loc	Power Ratio check (Two Freq Only) Course Line TX OFF	1or2

			C/L		
9.1.3	04	Loc Orbit	6NM 1500' +35-35°	Clearance	1&2
9.1.3	04	Loc Orbit	17NM 1500' +35-35°	Clearance & Coverage	1or2
9.1.3	04	Loc Orbit	25NM 2000' +10-10°	Clearance & Coverage	1or2
9.1.2	14	Loc Range Run	DOC or 25NM 2000'	Clearance	Alt 1or2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course Only (Two Freq Only)	1or2
9.1.1	05	Centreline Approach Cat III only	10NM to Point E level 50ft down runway Centreline	Course Structure, Alignment, GP Angle & RF measurement	1&2
9.1.1	12	Top Edge	4NM-Point B 1800'	(75μA) 90Hz width	1or2
9.1.1	13	Bottom Edge	4NM-Point B 1500'	(75μA) 150Hz width. See Note	1or2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course, Clearance & Coverage	1&2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course Only (Two Freq Only)	1or2
9.1.2	15	Left Slice for 3° GP	10NM-0.45θ 1000'	Coverage 8° of Centreline	Alt 1or2
9.1.2	16	Right Slice for 3° GP	10NM-0.45θ 1000'	Coverage 8° of Centreline	Alt 1or2
9.1.1	11	Centreline Approach	4NM-Threshold 1500'	Low & Wide, then Low & High Angle Alarm	1or2
9.1.1	12	Top Edge	4NM-Point B 1800'	Low & Wide then Wide & Narrow Alarm	1or2
9.1.1	13	Bottom Edge	4NM-Point B 1500'	Low & Wide, then Wide & Narrow Alarm	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Low & Wide Alarm for Clearance	1or2
9.1.2	14	Slice	DOC or 10NM-THD @ 1000'	Normal	1or2

9.1.1	01 *	Centreline Approach	4NM-Threshold 1500'	Fly Left & Right Alarms	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Wide Alarm	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Narrow Alarm	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Normal Check	1or2
	All	Ident LOC/DME	Co-Pilot/FI listens	Check ident and synchronisation	1&2
9.1.1	01	DME	4NM-1NM 1500'	DME Range Error	1or2
9.1.4		Promulgated procedure	Procedure-Threshold	Pilot comments	1 or2
9.1.5		Promulgated procedure & DME IFPs	Procedure-Threshold	Pilot comments	1or2

4.4 Commissioning ILS Inspection Profile Requirements

Section	Profile	Description	Procedure	Notes	TX
9.1.1	01	Centreline Approach	DOC or 10NM-Threshold on GP	RF, Course Structure, Alignment Angle GP & Loc	1&2
9.1.1	01	Centreline Approach	2000' 25NM-Threshold	Course Structure, Alignment Angle GP & Loc	1or2
9.1.1	01	Centreline Approach	10-4NM on GP & Loc C/L	Power Ratio check (Two Freq Only) Course Line TX OFF	1or2
9.1.1	01*	Centreline Approach	4NM-Theshold on GP & Loc C/L	Polarisation Check Roll 20° Left & Right	1or2
9.1.1	02	Left Edge	4NM-Point B 1500'	(150µA) 90Hz course width	1&2
9.1.1	03	Right Edge	4NM-Point B 1500'	(150µA) 150Hz course width	1&2
9.1.3	04	Loc Orbit	6NM 1500' +35-35°	Clearance & Coverage	1&2
9.1.3	04	Loc Orbit	17NM 1500'	Clearance & Coverage	1or2

			+35-35°		
9.1.3	04	Loc Orbit	25NM 2000' +10-10°	Clearance & Coverage	1or2
9.1.2	14	Loc Range Run	DOC or 25NM 2000'	Clearance	Alt 1or2
9.1.1	05	Centreline Approach Cat III only	2NM to Point E level 50ft down runway Centreline	Loc Course Structure, Alignment	1&2
9.1.1	12	Top Edge	4NM-Point B 1800'	(75µA) 90Hz width	1&2
9.1.1	13	Bottom Edge	4NM-Point B 1500'	(75µA) 150Hz width	1&2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course, Clearance & Coverage	1&2
9.1.2	14	Slice for 3° GP	0.3θ DOC or 12NM-Threshold 1000'	Course Only (Two Freq Only)	1or2
9.1.2	15	Left Slice for 3° GP	16NM-0.45θ 1000'	Coverage 8° of Centreline	1&2
9.1.2	16	Right Slice for 3° GP	16NM-0.45θ 1000'	Coverage 8° of Centreline	1&2
9.1.1	11	Centreline Approach	4NM-Threshold 1500'	Low & Wide, then Low & High Angle Alarm	1or2
9.1.1	12	Top Edge	4NM-Point B 1800'	Low & Wide then Wide & Narrow Alarm	1or2
9.1.1	13	Bottom Edge	4NM-Point B 1500'	Low & Wide, then Wide & Narrow Alarm	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Low & Wide Alarm for Clearance	1or2
9.1.2	14	Slice	DOC or 10NM-THD @ 1000'	Normal	1or2
9.1.1	01 *	Centreline Approach	4NM-Threshold 1500'	Fly Left & Right Alarms	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Wide Alarm	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Narrow Alarm	1or2
9.1.3	04 *	Loc Orbit	6NM 1500' +35-35°	Normal Check	1or2
9.1.3	20	Orbit	5NM @1500' 360°	DME Coverage check 20° only on 2nd TX	1&2
9.1.4		Promulgated procedure	Procedure-Threshold	Pilot comments	1or2
9.1.5		Promulgated procedure	Procedure distance spot checks for:-	IFP's, Missed Approach, Direct arrivals, Hold, En-Route	1or2

4.5 Additional Commissioning ILS Inspection Profile Requirements

For Side Band Reference & M Array Glide Paths

	Profile	Description	Procedure	Notes	TX
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Dephase Upper Antenna with monitor in Alarm	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Dephase Lower Antenna with Monitor in Alarm	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Advance Middle Antenna	1or2
9.1.2	14	Slice	DOC or 10-2NM @ 1000'	Retard Middle Antenna	1or2

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Radar Vectoring Area (Cork) Assessment

Brookfield Renewable Ireland Limited

Coom Green Energy Park

August, 2020





ADMINISTRATION PAGE

Job Reference:	9296D
Date:	August, 2019
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Issue	Date	Detail of Changes
1	12 August, 2019	Initial issue
2	19 December, 2019	Updated to include Permanent Met Masts
2.1	27 December, 2019	Updated with new site diagram
3	August, 2020	Updated with revised layout

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1 KEY FINDINGS

1.1 Background

Brookfield Renewable Energy is developing a proposed wind farm named Coom Green Energy Park which lies north of Cork and approximately 27 kilometres from Cork Airport in southern Ireland. The wind development is also referred to as Nagle Mountain.

1.2 Cork Airport Radar

Aircraft using Cork Airport are controlled by radar. Air traffic controllers direct pilots to ensure that aircraft are separated with no risk of collision.

1.3 Radar Vectoring Area Chart

Cork Airport will have a published Radar Vectoring Area Chart that shows the minimum altitude that pilots can be directed to fly in the vicinity of the airport. The Irish Aviation Authority (IAA) has provided an interim version of the chart which is reproduced below:

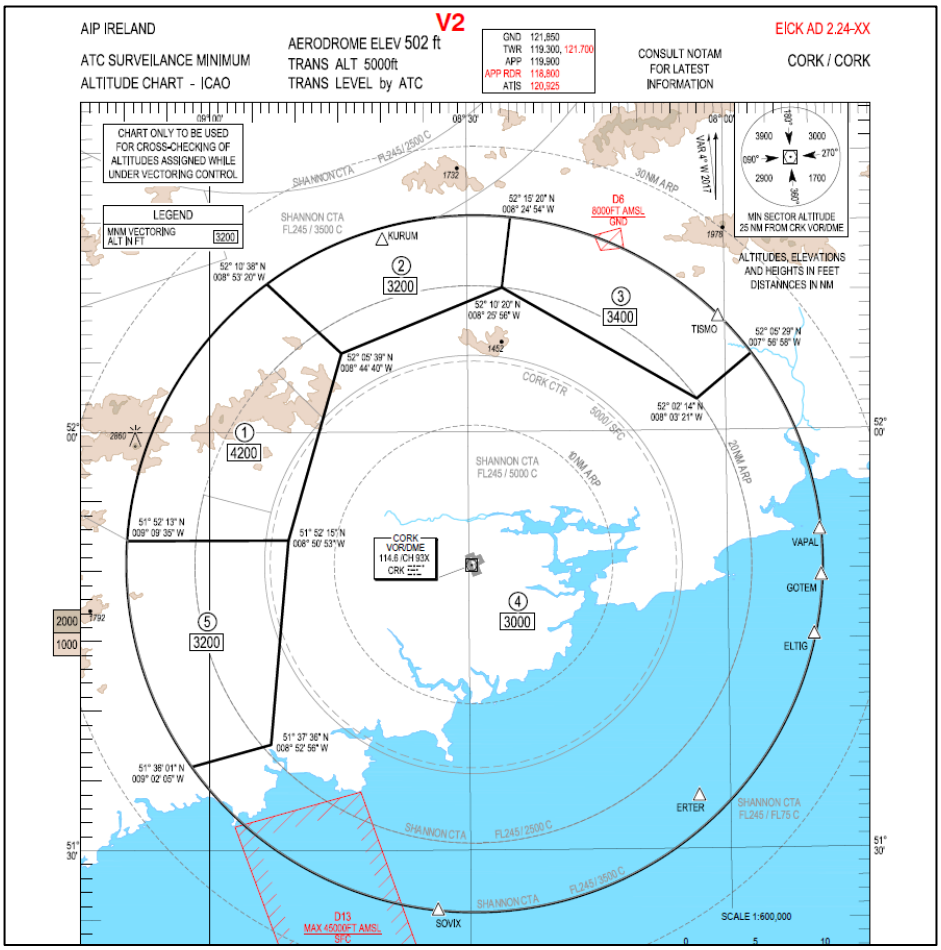

Figure 1 Cork Airport Radar Vectoring Area (Interim Chart)

1.4 Assessment Requirement

The proposed turbines will be located on high ground beneath airspace used to vector aircraft arriving and departing Cork. There have been ongoing discussions with the Irish Aviation Authority (IAA) regarding the proposed development's potential impact on operations at Cork Airport.

Of specific concern is the potential impact of the wind turbines on aircraft under radar control. Pager Power has therefore been invited to assess whether the development could affect aircraft under radar control.

1.5 Assessment Methodology

There are published rules for designing Radar Vectoring Areas and their associated charts. The proposed turbines have been assessed in accordance with these rules to determine whether aircraft flying within the Radar Vectoring Area will have sufficient vertical clearance above the proposed turbines.

The assessment, in this case, consists of the following steps.

1. Determining the maximum altitude of any part of the highest wind turbine or permanent meteorological mast.
2. Determining the minimum altitude aircraft can be directed to fly when under radar control.
3. Confirming that the minimum aircraft altitude is higher than the maximum turbine altitude.
4. Calculating the vertical clearance between the minimum aircraft altitude and the maximum altitude of any wind turbine part.
5. Determining the required vertical clearance according to Irish Aviation Authority (IAA) and International Civil Aviation Organisation (ICAO) guidance material.
6. Confirming the calculated vertical clearance exceeds the required vertical clearance.

1.6 Maximum Wind Turbine Tip Altitude

There are 22 proposed wind turbines each having a maximum tip height of 169 metres above ground level. The wind turbine layout is shown on the aerial photograph[1] below:

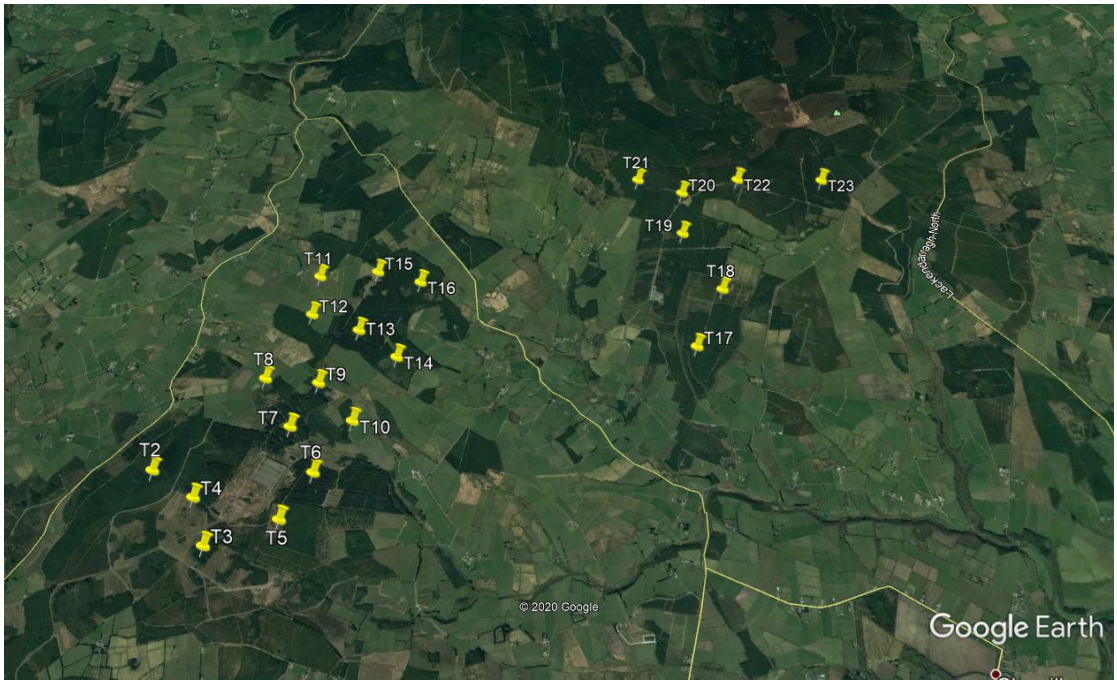

Figure 2 Proposed wind farm layout

Turbine elevation and altitude data is shown in the table below:

Turbine ID	Longitude	Latitude	Base Elevation (m)	Blade Tip Altitude (m)	Blade Tip Altitude (feet)
T2	-8.545682	52.062794	294	463	1519
T3	-8.536206	52.055781	261	430	1411
T4	-8.539001	52.060281	260	429	1407
T5	-8.525896	52.058201	260	429	1407
T6	-8.521924	52.062722	257	426	1398
T7	-8.526425	52.067377	250	419	1375

[1] Copyright © 2020 Google

Turbine ID	Longitude	Latitude	Base Elevation (m)	Blade Tip Altitude (m)	Blade Tip Altitude (feet)
T8	-8.531446	52.072496	245	414	1358
T9	-8.522992	52.072005	245	414	1358
T10	-8.517056	52.068065	227	396	1299
T11	-8.525240	52.084380	245	414	1358
T12	-8.5256684	52.0798295	241	410	1345
T13	-8.5176811	52.0779771	256	425	1393
T14	-8.5111397	52.0749315	248	417	1367
T15	-8.5156318	52.0849705	270	439	1439
T16	-8.5083962	52.0838334	234	403	1321
T17	-8.462927	52.076371	190	359	1178
T18	-8.4579612	52.0829075	237	406	1331
T19	-8.4625076	52.0893977	263	432	1417
T20	-8.463671	52.0946427	332	501	1643
T21	-8.4712923	52.0963204	344	513	1683
T22	-8.453821	52.096191	377	546	1791
T23	-8.4386761	52.096644	310	479	1573

Table 1 Turbine Altitude Data

Turbine T22 is most elevated having a maximum blade tip altitude of 1791 feet.

There are two permanent meteorological masts.

A permanent meteorological mast (PMM1) is planned at ITM coordinates 562291 590024. The mast will have a maximum height of 100 metres on ground that has an elevation of approximately 289 metres making the maximum mast altitude approximately 389 metres which is 1,276 feet. This is approximately 500 feet lower than the tip of turbine T22.

A further permanent mast (PMM2) is planned at ITM coordinates 567498 594127. This 100 metre mast will have a maximum altitude of approximately 456 metres which is 1,496 feet. This is 295 feet lower than the tip of turbine T22.

Both meteorological masts are shorter and lower than turbine T22 and will therefore have no significant impact.

1.7 Minimum Aircraft Altitude

The Minimum Altitude shown on the Radar Vectoring Area Chart is 3,000 feet.

This is more than the maximum tip altitude of 1,791 feet.

The vertical clearance is 1,209 feet.

1.8 Applicable Guidance

Applicable IAA guidance includes Air Services Advisory Memorandum (ASAM) no. 13 and no. 15 which relate to obstacle data.

Applicable International Civil Aviation Organisation (ICAO) guidance includes ICAO Doc 8168 PANSOPS 8168, Vol II, Section 2, Chapter 6 which specifies a minimum vertical clearance requirement of 984 feet.

1.9 Assessment

The minimum actual vertical clearance of 1,209 feet exceeds the minimum required clearance of 984 feet by 225 feet.

The proposed turbines will therefore not adversely affect aircraft flying under radar control.

1.10 Conclusions and Recommendations

It is recommended that this report is shared with the Irish Aviation Authority.

1.11 Other Reports

There are three assessments that have been undertaken – two as a result of consultation with the Irish Aviation Authority.

These reports are:

Aviation Risk Assessment
ILS Calibration Flight Impact Assessment
Radar Vectoring Area Assessment

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

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

2 CORK AIRPORT

2.1 Airport Information

Cork Airport is an Irish Aviation Authority (IAA) licensed aerodrome used predominately by private and commercial jet and fixed wing propeller aircraft. An ATC Tower is present on the airport.

2.2 Runway Details

Cork Airport has two physical runways. The main runway 16/34 measures 2,133m by 45m. The runway is shown on the aerodrome chart in Figure 3[2] below.

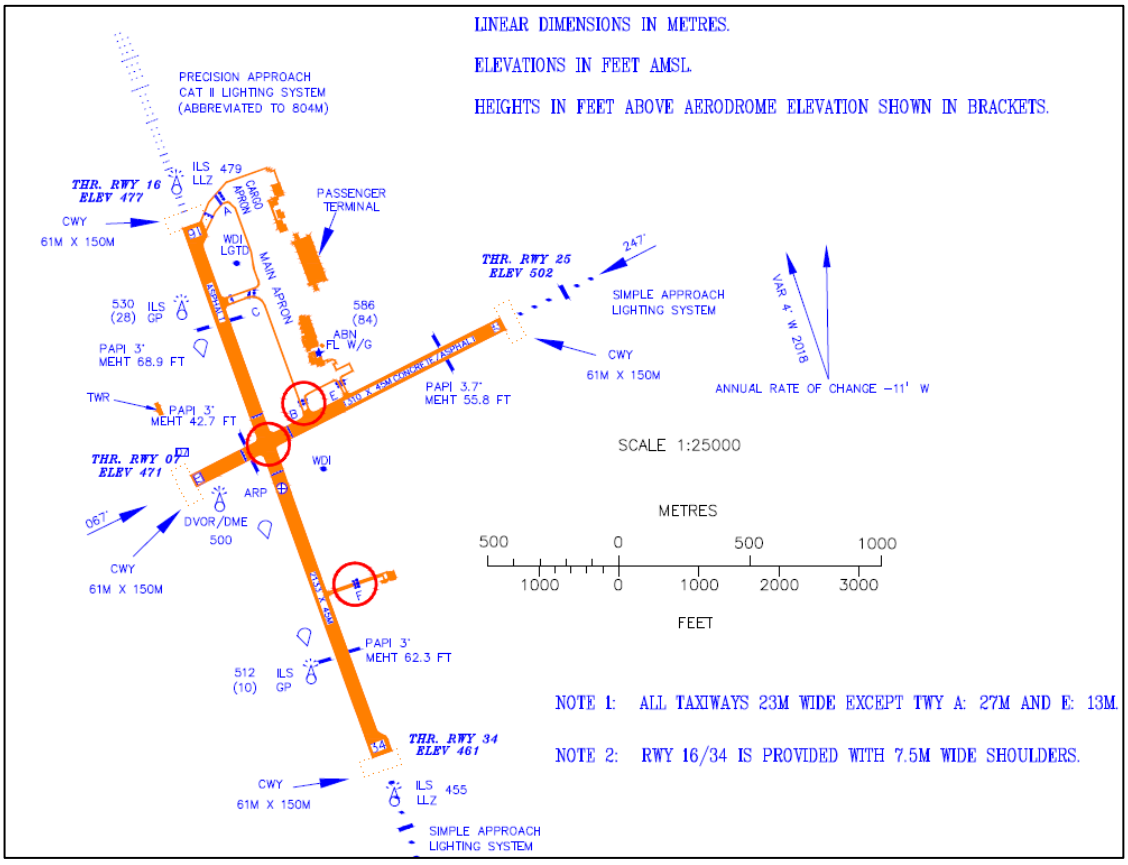

Figure 3 Cork Airport aerodrome chart

[2] Source: Irish Aviation Authority IAP.

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