



# Wind Resource Assessment

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Knockbain Farm

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Report issued by:

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## 1. EXECUTIVE SUMMARY

This report summarises the wind speed, turbulence intensity and energy yield characteristics for the Knockbain Farm site as requested by Agri-Environmental. A combination of wind, terrain, vegetation and man-made features has been used to create a three-dimensional model of the site. The wind statistics have been generated for the site at 100m using a Numerical Weather Prediction (NWP) method. A detailed three-dimensional CFD model of the terrain and ground features was then used to calculate the average wind speed across the site at hub height and accounts for all the effects of vegetation, buildings and other local wind breaks.

The  $W_{50}$  average wind speed is an estimate of the most likely 20 year long term average wind speed. This wind speed has a 50% probability of being exceeded <sup>[1]</sup>.

The  $W_{90}$  average wind speed is a conservative estimate of the 20 year long term average wind speed. This wind speed has a 90% probability of being exceeded <sup>[1]</sup>.

The input information is summarised in the table below:

Number of turbines	1
Type	WTN 250
Wake Analysis	No
Hub height	30 m
Location (Lat Lon)	57.58974N 4.47165W

The results from the CFD analysis at **30 m** hub height can be summarised in the table below. All quantities are 20 year averaged values:

Average wind speed ( $W_{50}$ )	6.5 m/s
Average wind speed ( $W_{90}$ )	6.0 m/s
Average turbulence intensity at 15 m/s	< 16 %
Average annual energy yield ( $P_{50}$ )*	566 MWh
Average annual energy yield ( $P_{90}$ )*	479 MWh

\* Assumes 100% availability and no technical losses

## 2. PROJECT

This report summarises the wind speed, turbulence intensity and energy yield characteristics for the Knockbain Farm site as requested by Agri-Environmental. A combination of wind, terrain, vegetation and man-made features has been used to create a three-dimensional model of the site. The wind statistics have been generated for the site at 100m using a Numerical Weather Prediction (NWP) method. A detailed three-dimensional CFD model of the terrain and ground features was then used to calculate the average wind speed across the site at hub height and accounts for all the effects of vegetation, buildings and other local wind breaks.

### 2.1. PROJECT DELIVERABLES

- Wind and turbulence roses at hub-height
- Wind Speed and Energy Yield maps
- Wind Speed, Turbulence Intensity (at 15 m/s) and Energy Yield at the turbine location

## 3. SITE DESCRIPTION

### 3.1. SITE LOCATION AND COORDINATES

Site name	Knockbain Farm
Site Centre (Lat Lon)	57.58974N 4.47165W
Hub height	30 m

Table 1. Site location

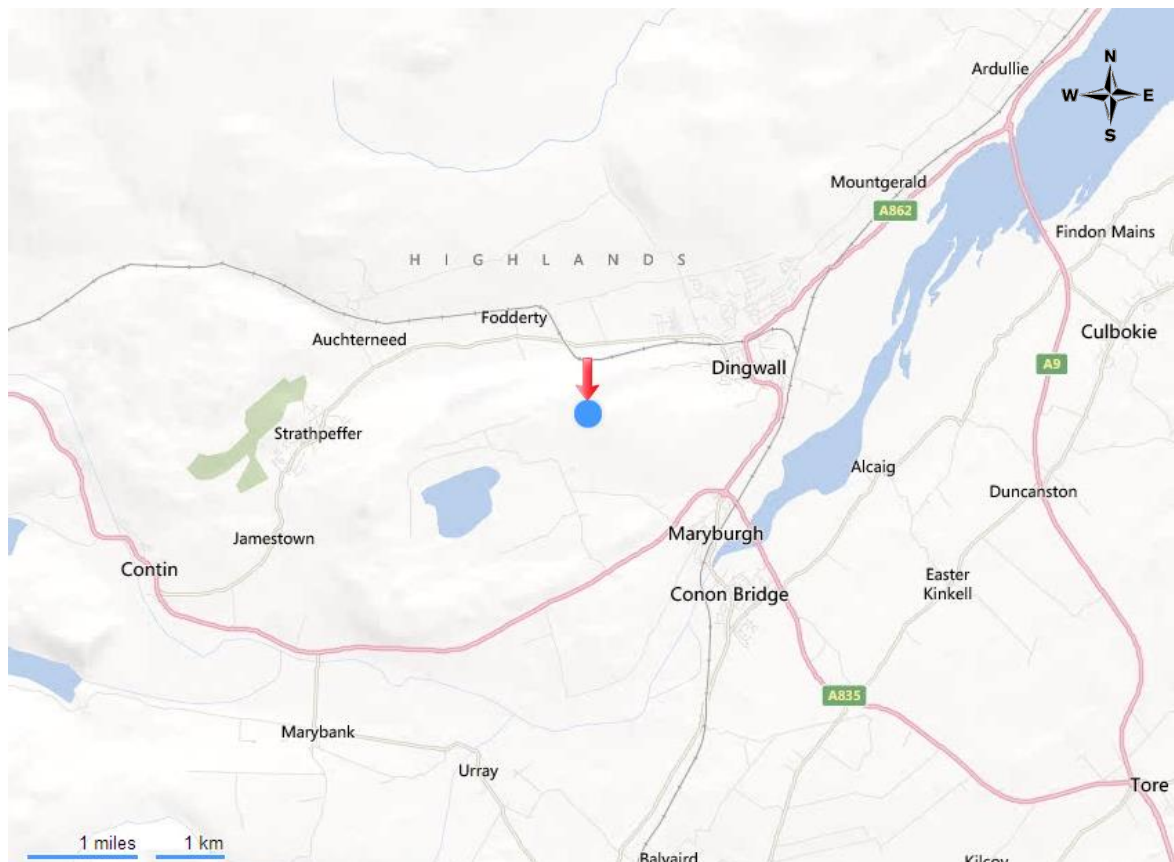


Figure 1. Site map (Ref.: Bing Maps)

## 4. SITE SPECIFIC DATA

### 4.1. TERRAIN HEIGHT DATA

Terrain height data has been extracted from the Ordnance Survey Land-Form Panorama© database.

Source	OS Land-Form Panorama©
Resolution	50m x 50m
Height accuracy	±3m

Table 2. Terrain data information

### 4.2. TERRAIN ROUGHNESS

Information regarding the type of terrain (e.g.: water or land), ground roughness and vegetation type. The terrain surface roughness information has been extracted from two separate sources with different levels of detail.

#### 4.2.1. BACKGROUND ROUGHNESS

Source	CORINE Land Cover
Resolution	45m x 45m

Table 3. Terrain background roughness

#### 4.2.2. LOCAL NATURAL FEATURES AND BUILDINGS

Centre	57.58974N 4.47165W
Area	1km radius
Number of features	Buildings: 29 Vegetation: 36 Water: 0

Table 4. Natural features and buildings

### 4.3. MESO-SCALE WIND DATA

Resolution	3km x 3km
Reference Height	100m
Time Period	20 years

Table 5. Wind rose information

## 5. TURBINE SPECIFIC DATA

### 5.1. LOCATION OF TURBINE(S)

The coordinates of the proposed location for the installation of the turbine are shown below. These locations are used for the prediction of the energy yield and blades peak loads if required. Wind speeds and turbulence are summarised in Section 7 for all of the specified hub heights.

Number of turbines	1
Type	WTN 250
Hub height	30 m
Location (Lat Lon)	57.58974N 4.47165W

Table 6. Turbine information

### 5.2. POWER CURVE

WTN 250	
Speed (m/s)	Power (kW)
0.0	0.0
3.0	0.0
4.0	7.0
5.0	16.2
6.0	27.0
7.0	53.2
8.0	85.1
9.0	115.2
10.0	141.8
11.0	166.7
12.0	194.4
13.0	217.9
14.0	237.1
15.0	250.0
16.0	249.1
18.0	246.7
20.0	242.1
22.0	234.4
25.0	217.1

Table 7. Power curve data

## 6. TERRAIN MODEL, FORESTED AREAS AND BUILDING MODELS

Detailed information about the computational terrain, mathematical models and coefficients for forest modelling and digital buildings included in the assessment is presented in the following sections. On all subsequent plots, the turbine location is indicated with a black dot or red cross.

### 6.1.1. TERRAIN HEIGHT

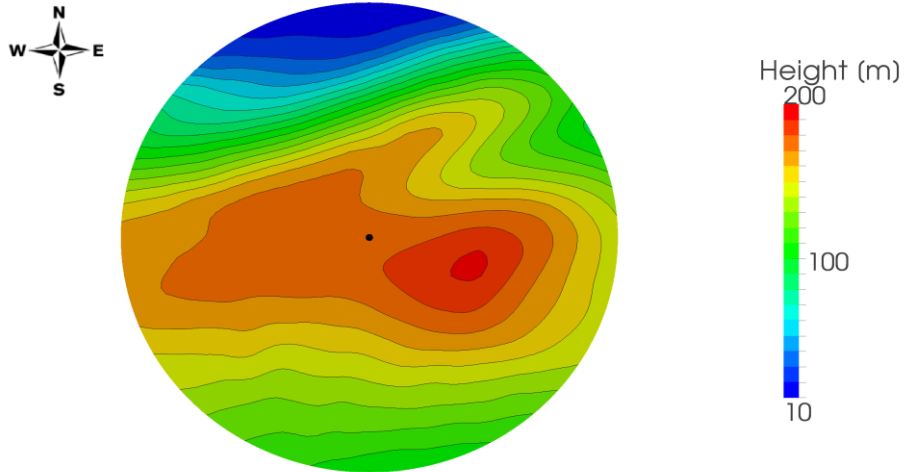


Figure 2. Terrain height map [m]. 1 km radius

### 6.1.2. THREE-DIMENSIONAL VEGETATION AND BUILDING FEATURES



Figure 3. Three-dimensional vegetation and building map for domain, 1 km radius ring shown on picture

### 6.1.3. LOCAL VEGETATION AND BUILDINGS

Vegetation and background roughness	
– Background features height	Up to 22m
– Local features height (within 1km)	10m – 17m
Buildings	
– Local heights (within 1km)	4m –11m

Table 8. Summary of forestry and building model parameters

## 7. HUB HEIGHT WIND AND TURBULENCE ROSES

### 7.1. WIND AND TURBULENCE ROSES AT 30 MM AGL

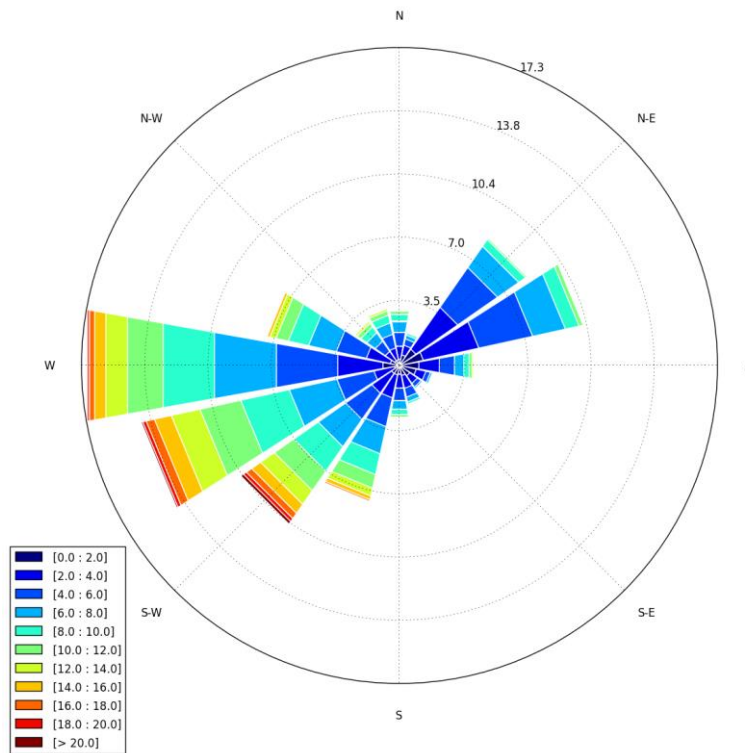


Figure 4. Wind rose at 30 m AGL

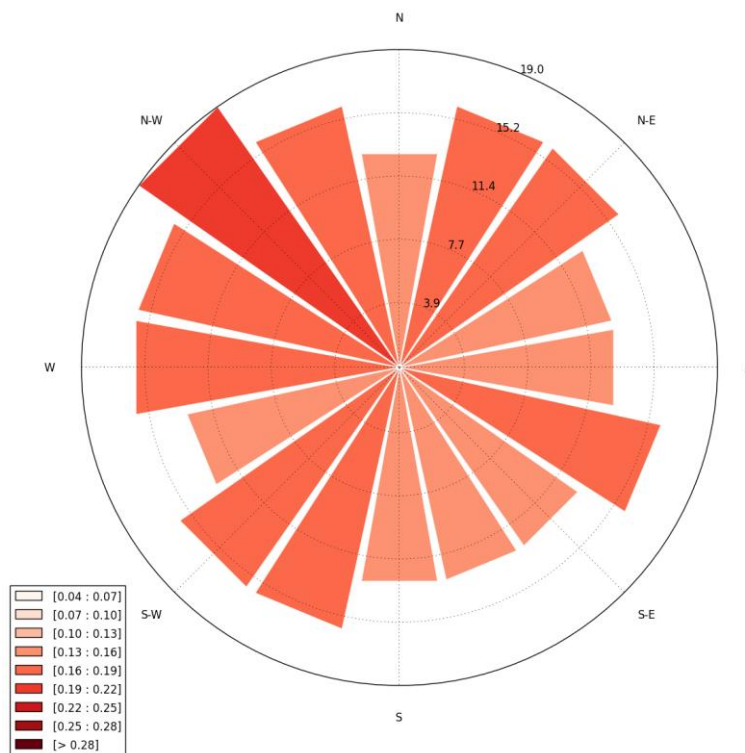


Figure 5. Turbulence rose at 15 m/s at 30 m AGL



## 8. WIND SPEED MAP(S)

### 8.1. WIND SPEED MAP AT 30 MM AGL

A wind speed map for the area of interest at 30 m above ground level is shown below. This shows a 500m x 500m area divided into 50m squares.

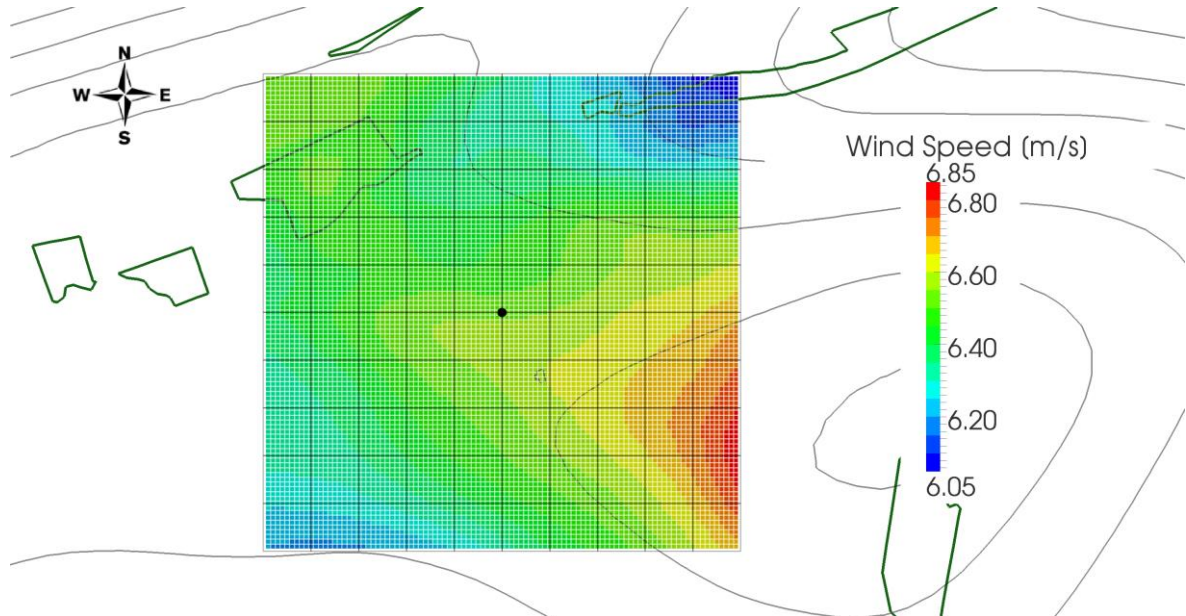


Figure 6. Wind speed map [m/s], 30 m AGL

## 9. ENERGY YIELD MAP(S)

### 9.1. ENERGY YIELD MAP AT 30 M AGL

An energy yield map for the area of interest at **30 m** above ground level is shown below. This shows a 500m x 500m area divided into 50m squares.

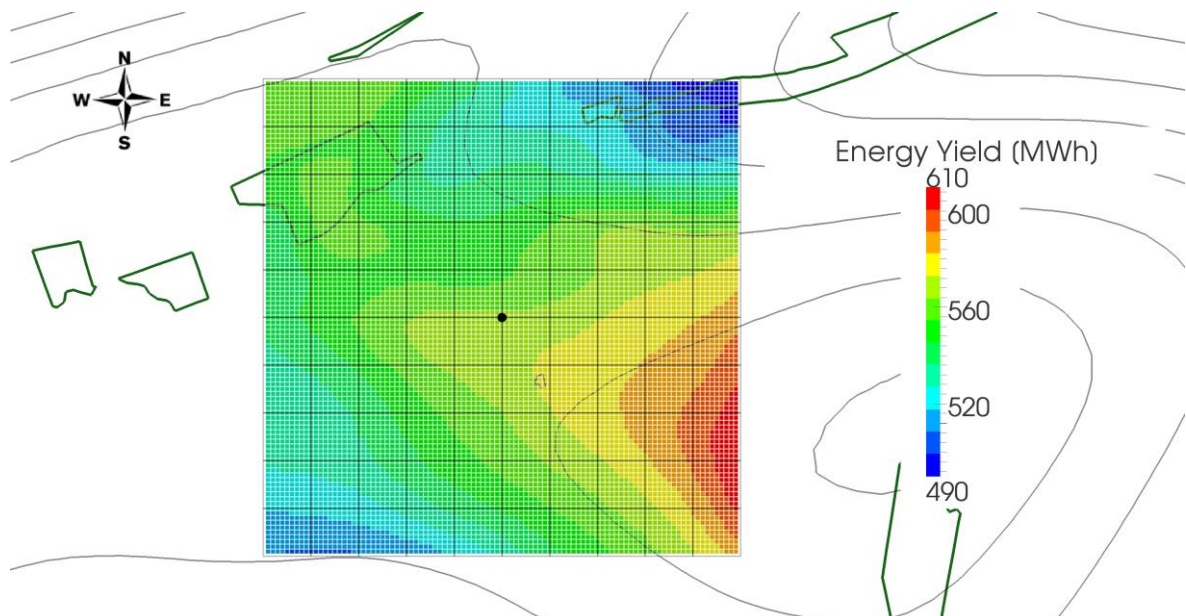


Figure 7. Energy yield map [MWh], 30 m AGL

## 10. WIND, TURBULENCE AND SHEAR AT TURBINE LOCATION

The results from the CFD analysis at **30 m hub height** can be summarised in the table below:

Location (Lat Lon)	57.58974N 4.47165W
Hub height	30 m
Averaged annual wind speed ( $W_{50}$ )	6.5 m/s
Averaged annual wind speed ( $W_{90}$ )	6.0 m/s
Averaged wind turbulence intensity at 15 m/s	< 16 %
Annual energy yield ( $P_{50}$ )*	566 MWh
Annual energy yield ( $P_{90}$ )*	479 MWh

\* Assumes 100% availability and no technical losses

## 11. REFERENCES

[1] “Wind-Validation-Summary-DE.pdf”, Digital Engineering Ltd, Jan 2013

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