Izzy projects

TELEFOON E-MAIL

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Summary

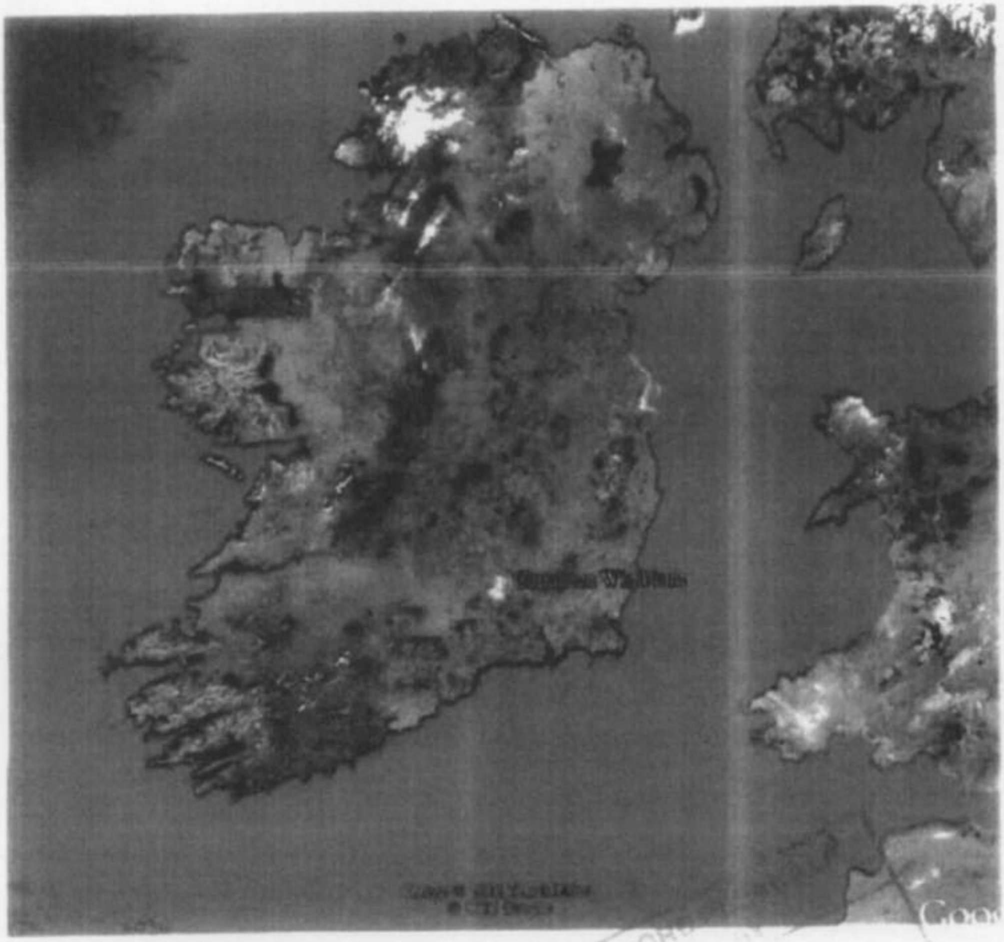
IZZY Projects is developing the Curranheen wind farm in Ireland with an installed capacity of 24 MW and has consigned an internal energy assessment for the proposed wind farm. Izzy projects has carried out an internal wind resource assessment, the optimization of wind turbine layout and the energy production estimation. Further details of the methodology and analysis are included in the following content. The tables below summarize the key data of the report.

Curraheen Wind Farm	
Total Capacity [MW]	24
Number of Turbines	8-11
Proposed Turbine	2MW class (2 -3MW)
Gross Output [GWh/yr]	
Losses[%]	
Wake Loss	
Other Losses	Depening on lay-out around 11%
Net Output [GWh/a]	73,1 – 89,6
Net capactity factor	

Table 0-1 project summary

Site Information

The wind energy project is located on a west-east ridge in the south region of Monaghan Province of Ireland, approximately 18 km east of the city of Clonmel, as shown in Figure 2.1.



In order to evaluate the wind conditions at the proposed wind farm site, the measurement mast 8923# has been installed at the wind farm, shown in Figure 2.2.

According to the document of the mast provided by the developer, more details of the mast are listed in table 2.1.

Item	**Detailed Information**
Name	8923#
Location Coordinate (Irish Grid Zone 29)	239868E 128998 N
Altitude [m]	255
Tower Height [m]	50
Anemometer Sensor [m]	50/40/30
Vane Sensor [m]	50/40
Temperature Sensor [m]	5
Air Pressure Sensor [m]	--
Measurement Period	06-21-2006 to 11-03-2007

Table 0-1 details of the measurement mast

Wind Resource Analysis

The wind data recorded from 06-21-2006 to 11-03-2007 at mast 8923# were provided by the client in the form of raw NRG "RWD" data files. Daily wind data including average (Ave), maximum (Max), minimum (Min) and standard deviation (SD) were collected in a 10-min interval.

Then it is necessary to perform the validation of the measured wind data to increase the data availability. According to the verified wind data, the monthly data availabilities of the mast 8923# are represented in Figure 3.1. As seen from the figure, the overall data availability is 99.4% at the measurement height 50 m, so it is suitable to use the wind data for the wind resource analysis.

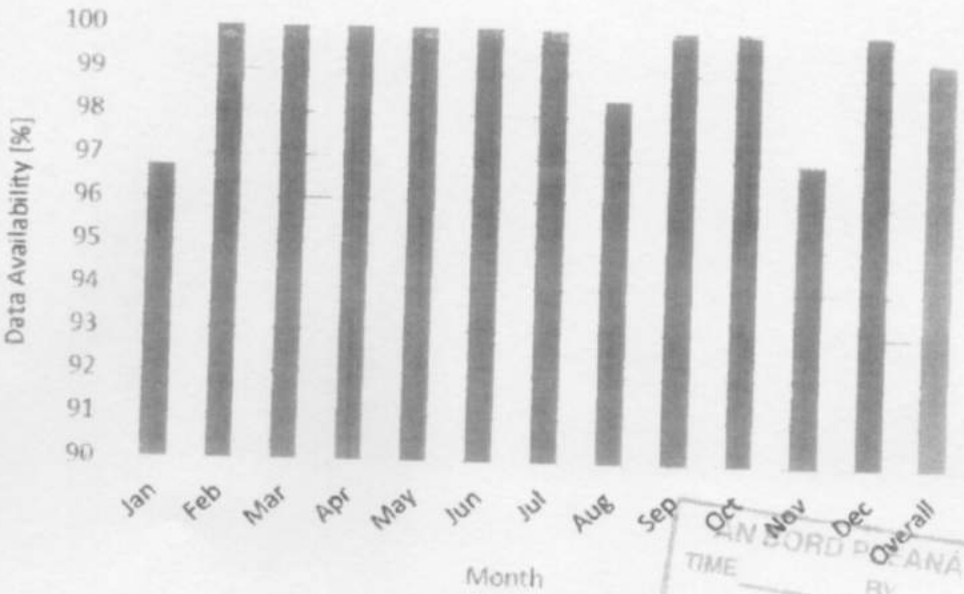


Figure 0-1 data availbility

The measurement period of mast 8923# is about 16 months and the wind data during the period of a whole year (10-01-2006 to 09-30-2007) is selected for the following analysis.

The on-site temperature is available from the sensors at the mast. The statistical results of the temperature are given in Table 3.2 The mean, max and min temperature are 11.2ºC, 24.1ºC and -0.9ºC respectively. So the wind turbine generator (normal climate temperature) can be selected for the wind farm.

Month	Temperature [ºC]		
Jan	7.2	13.7	-0.9
Feb	7.0	13.5	-0.9
Mar	7.5	14.9	-0.3
Apr	12.0	20.0	2.9
May	12.2	22.4	4.0
Jun	14.6	23.7	7.0
Jul	14.7	20.8	9.7
Aug	15.1	23.4	9.6
Sep	14.1	24.1	4.3
Oct	12.9	17.8	6.7
Nov	8.8	14.0	2.1
Dec	7.9	13.7	1.7
Overall	11.2	24.1	-0.9

Table 3.2 Temperature at the site

Air density is not available directly, but the temperature and altitude data are recorded at the mast, so air density can be calculated out based on temperature and altitude by the following equation.

Where:

$$\rho = \frac{353.049}{T} e^{(-0.034\frac{Z}{T})}$$

ρ s the air density [kg/m3]

Z is the height above sea level [m]

T is the annual mean absolute air temperature [K]

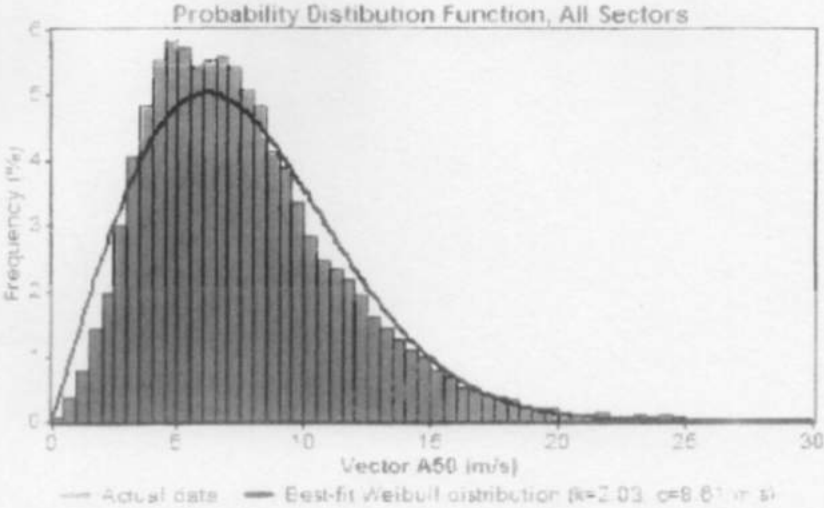
Based on the average temperature 11.2 ºC and altitude 260 m, the air density on the site evaluates to **1.203** kg/m3.

The wind speeds and Weibull parameters at different measurement heights of the mast during the chosen monitoring period are showed in Table 3.3 and figire 3.4 represents the weibull fit for the measurement period.

Height [m]	**Mean Wind Speed [m/s]**	**Weibull Parameters**	
		A [m/s]	k
30	6.67	7.55	1.97
40	7.13	8.06	1.98
50	7.61	8.61	2.03

Table 0-2 readings from the measurement mast

The Weibull curve, presented for the distribution is a good fit to the wind data and the Weibull scale parameter A and shape parameter k are 8.61 and 2.03, respectively.



Presented in Figure 3.2 are the frequency distribution of wind direction at 50 m height of the mast. The prevailing wind direction over the monitoring period is predominately from the west and south.

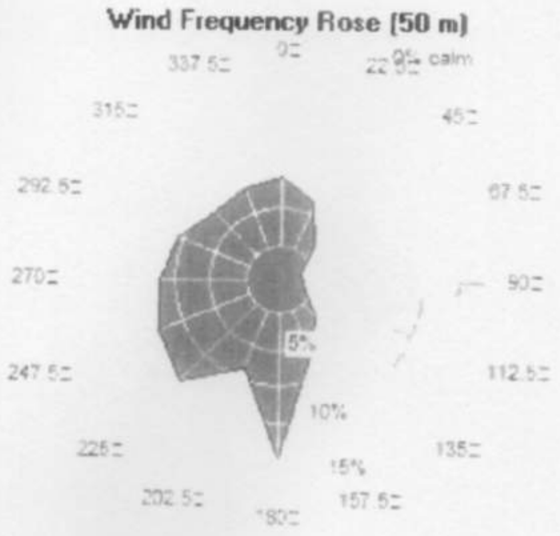
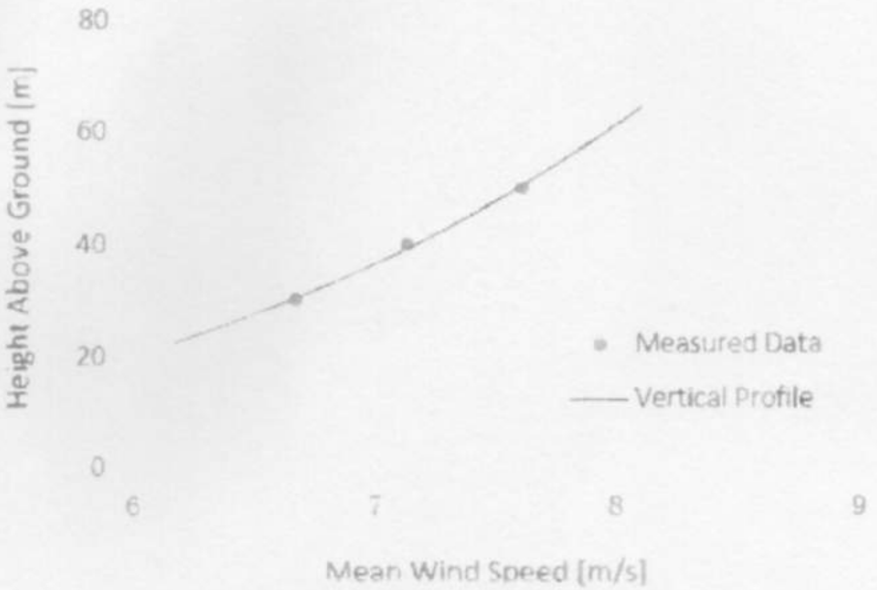


Figure 0-2 wind speed distribution

The wind speed varies with height above ground level and the vertical wind profile is defined to describe this phenomenon. Accurately predicting the vertical profile of wind speed variation is an important part of a wind resource assessment, especially when the measurement height is lower than the hub-height of the proposed wind turbine.

Based on the measured wind data, the synthesized vertical wind profile at the mast is shown in figure 3.3 and the vertical wind shear exponent on the site is calculated at 0.255.



Turbulence Intensity (TI) is one of the important parameters that define the wind turbine class according IEC 61400-1(Ed3). The turbulence intensity I15 is defined as turbulence intensity at average wind speed of 15m/s. Defined in IEC 61400-1(Ed3) are the maximum values for the turbulence intensity that a wind turbine must withstand.

Presented in table 3.4 are the measured mean and representative TI at 15m/s at each measurement height of the mast. figure 3.7.1 below shows the representative turbulence intensity (compared to IEC61400-1 Ed3) at 50 m measurement height of the mast.

	Measurement heights [m]		
	30	40	50
Mean TI	0.148	0.136	0.116
Representative TI	0.190	0.175	0.163

Table 0-4 turbulence intensity

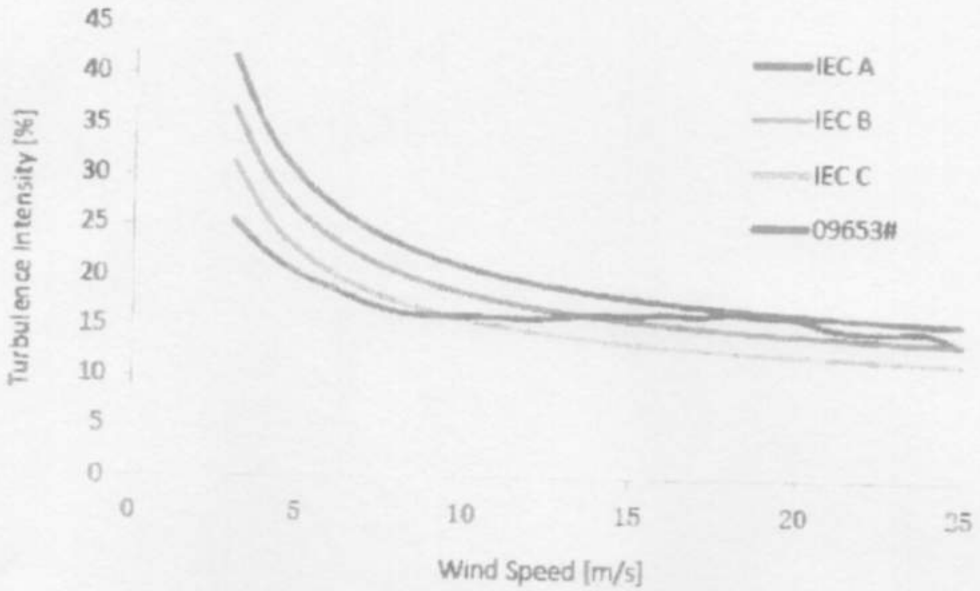


Figure 0-4 TI development versus IEC classes

As seen from the graph above, the representative TI at 50 m measurement height of the mast is below IEC-A standard. In general, the turbulence intensity of the wind speed becomes weak as height above ground increases. So, it is reasonable that the representative TI at the higher hub-height may be lower.

Estimated Energy Yield

The wind turbine model selected for analysis in the project are:

- Enercon E82, 2.3 and 3MW
- Sinovel SL3000
- Vestas V90, 3MW

For the energy yield estimation, the verified wind data and the power curve (10% TI) of air density 1.225kg/m3 and turbulence intensity 10% have been used in the analysis. By use of the software WindPRO, the wind farm has been modelled and wind regime at the wind farm site has been simulated and then the gross energy yield has been estimated. At this stage, the power curve is corrected individually to the air density at each single turbine location within the wind farm domain.

The influence of the surrounding wind turbines, which may reduce the total energy production and are called wake loss, shall be considered in the wake model. For net energy estimation, some extra losses in addition to wake loss must be taken into account.

The maps of wind speed and wind power density distribution at 90 m hub-height above ground level at the wind farm are shown in Figure 4.1 and Figure 4.2 respectively.

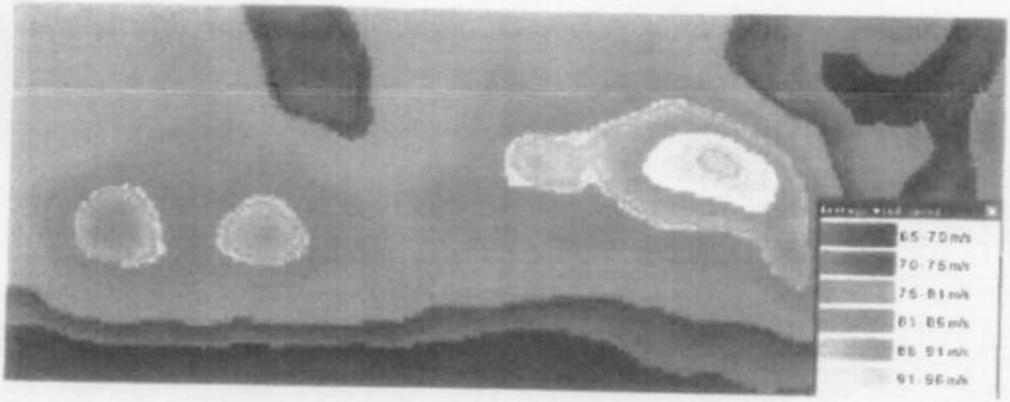


Figure 0-1 resource grid

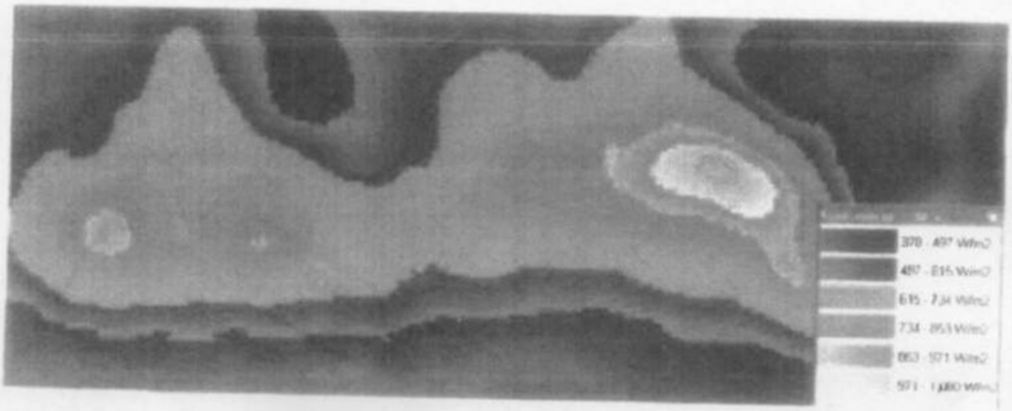


Figure 0-2 energy grid

Due to the available grid connection the project has a cap of 24MW. Whith deploying state of the are turbine technology this means that the project should accommodate between 8 and 11 turbine positions, depending on the size of the generator. The project is optimised so that it minimises the wake losses (array where possible and distance between turbines) and making use of the better wind spots as defined by the local wind atlas.

In Figure 4.2.1 a full layout is given for 11 turbines, the distance between each turbine with the nearest turbine is 453m~706m, and other distance requirement of houses and ring forts are all considered.

In the actual operating process of the wind farm, there are some additional factors which occur along the whole energetic transformation chain from the rotor to the substation's delivery point and lead to some losses in energy production of the whole wind farm. In order to estimate the net energy yield (P50) of the wind farm, losses in the chain (eg power curve, availability, electrical losses and curtailment) are taken into account amongst the wake losses in the project. Table 4.1 summarises the losses in the project.

Loss Factors	Enercon E82 [%]	Sinovel 3000	Vestas V90
Wake losses	3,3	2,3	
Sum of other losses	8,7	8,7	
Total	11,8	10,9	

Table 0-1 loss analyes

The net energy production, mean wind speed and wake loss of each wind turbine are listed in Table 4.4.1. The net AEP here is calculated to the exclusion of the wake loss1 .9% and other additional losses 8.71%.

all in GWh/a	Enercon E82	Sinovel 3000	Vestas V90
Gross production	82,9	100,2	
Losses	9,8	10,9	
Estimated production P50	73,1	89,6	
Uncertainty			
P90 exceedance	66,2	82,0	

[illegible] P50 and P90 exceedance

Conclusion

Izzy has performed the wind energy assessment for Curranheen wind farm with 24 MW planned capacity. According to the data from the client, we have conducted a layout with 8 wind turbines of SL3000/113/HH90 and calculated the energy output considering the wake loss and other losses. The wake loss and additional losses are 1.9% and 8.71% respectively. The net energy of the wind energy project is is ranging between 73,1 GWh/a and 89,6 GWh/a depending on the project configuration