REPORT ON SITE VALIDATION & GENERATION ESTIMATE OF PROPOSED WIND FARM AT KURTKOTI VILLAGE OF GADAG DISTRICT IN KARNATAKA

Final Report

Prepared for
M/s. Enercon India Pvt. Ltd., Mumbai

C-WET

An ISO 9001: 2000 Organisation

WIND RESOURCE ASSESSMENT UNIT
CENTRE FOR WIND ENERGY TECHNOLOGY (C-WET)
Chennai 601 302

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CENTRE FOR WIND ENERGY TECHNOLOGY, CHENNAI

EXECUTIVE SUMMARY

M/s. Enercon India Pvt. Ltd, Mumbai has approached Centre for Wind Energy Technology, Chennai for providing an independent appraisal studies on their proposed wind farm project at Kurtkoti village of Gadag district in Karnataka.

M/s. Enercon India Pvt. Ltd, Mumbai have submitted one year data measured at site using a 76 m high mast, digital map of the area (5 m contour interval), turbine data and a micrositing plan (turbine location coordinates) for installation of 39 wind turbines of E 53-800 kW rating.

This study looks at the possibilities in the region and gives a factual report highlighting the wind environment, overall feasibilities in the area. Optimization is not part of this study. C-WET has studied the data, carried out detailed analysis subsequent to the site visit. This document explains the findings of the study.

The Wind Atlas Analysis and Application Program (WAsP 8.3) model was used for the analysis of wind resources and estimation of annual energy production in the proposed wind farm sites.

The C-WET personnel along with M/s. Enercon India Pvt. Ltd, Mumbai has visited the site for site assessment.

The estimations are based on 75 m wind data collected by M/s Enercon. The generations have been estimated from the micro-siting details (as given in the form of a table of coordinates) by the client. The average estimated mean and minimum generation levels are 17.7 lakhs and 15.9 lakhs per machine respectively. Assumptions for estimating these generation values are based on some field experience. The assumption values of turbine availability and utility down time and electrical losses are given by M/s Enercon. The actual values could be collected from the site during the operation of wind farm.

Report on Site Validation & Generation Estimate of Proposed Wind farm of M/s Enercon India Pvt. Ltd, Mumbai at Kurtkoti village of Gadag district in Karnataka

1.0 Introduction:

M/s. Enercon India Pvt. Ltd, Mumbai has approached Centre for Wind Energy Technology, Chennai for providing an independent appraisal report on their proposed wind farm project at Kurtkoti village of Gadag district in Karnataka.

M/s. Enercon India Pvt. Ltd, Mumbai have submitted one year data measured at site using a 76 m high mast, digital map of the area (5 m contour interval) and a micrositing plan (turbine location coordinates) for installation of 39 wind turbines of E 53-800 kW rating. They have also provided standard power curve for the turbine under consideration. This study looks at the possibilities in the region and gives a factual report highlighting the wind environment, overall feasibilities in the area. Optimization is not part of this study. C-WET has studied the data, carried out detailed analysis subsequent to the site visit. This document explains the findings of the study.

2.0 Site Description

The proposed wind farm project is located at Kurtkoti village of Gadag district in Karnataka. The site is situated in Kurtkoti village approximately 2.5 km east of Kurtkoti town and 12 km SSW of Gadad town . The site was visited by C-WET official along with the representative of M/s Enercon India Pvt. Ltd, Mumbai on 06 -04- 2007. The geographical co-ordinates and elevation of the centre of site is approximately as follows.

Latitude: 15 ^{0} 22' N

Longitude: 75^{0} 34' E

Elevation : 700 m amsl

The site is almost a plane with gradual increase in elevation towards eastern side. Wind mast is approximately 4.5 km west of the proposed wind farm site. The geographical co-ordinates and elevation of the mast site is given as follows.

Latitude: 15 ^{0} 21' 14" N

Longitude: 75^0 29' 28" E

Elevation : 660 m amsl

The Region of Interest is shown in the fig 1 and in figure 2

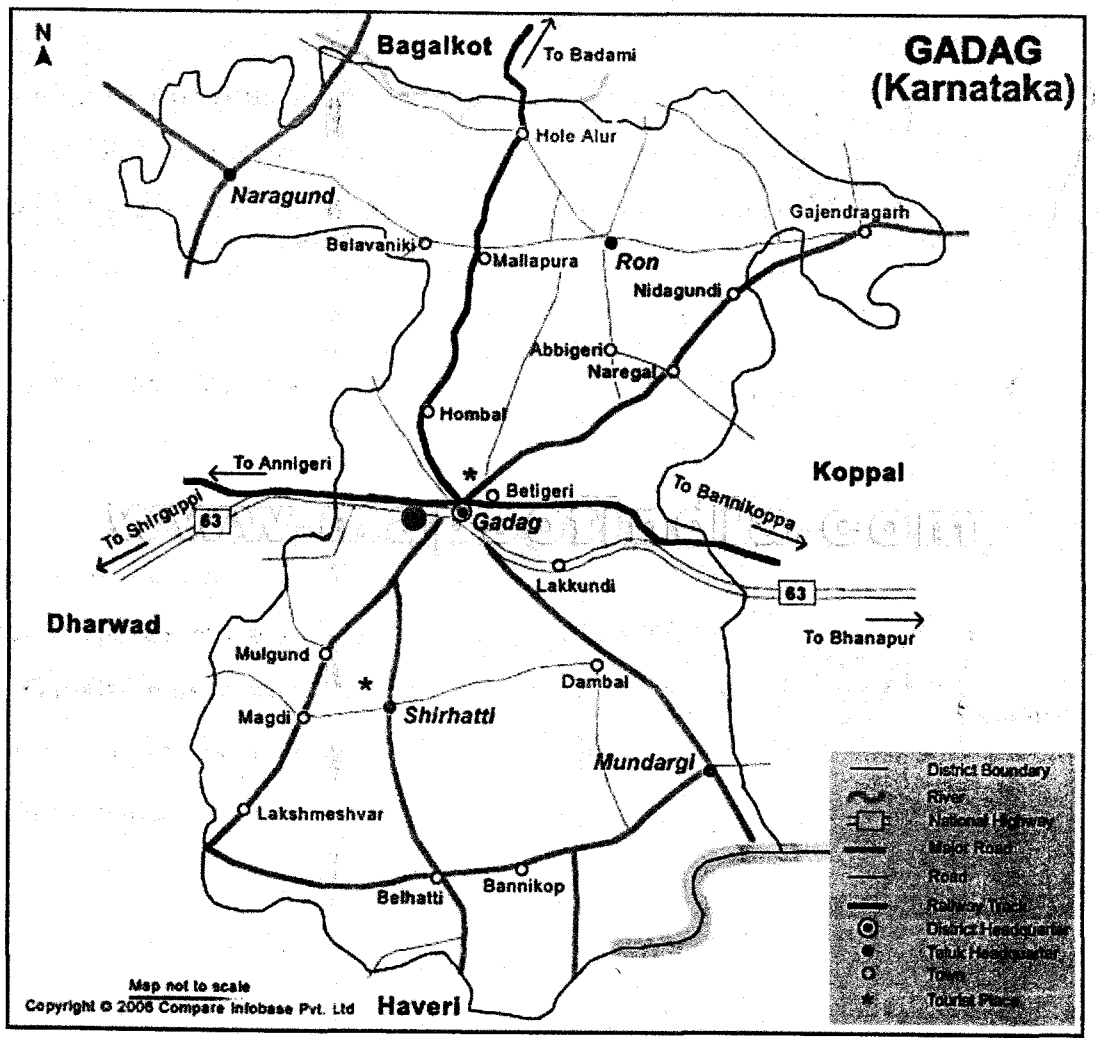


Fig.1 The Region of Interest is shown in green colour

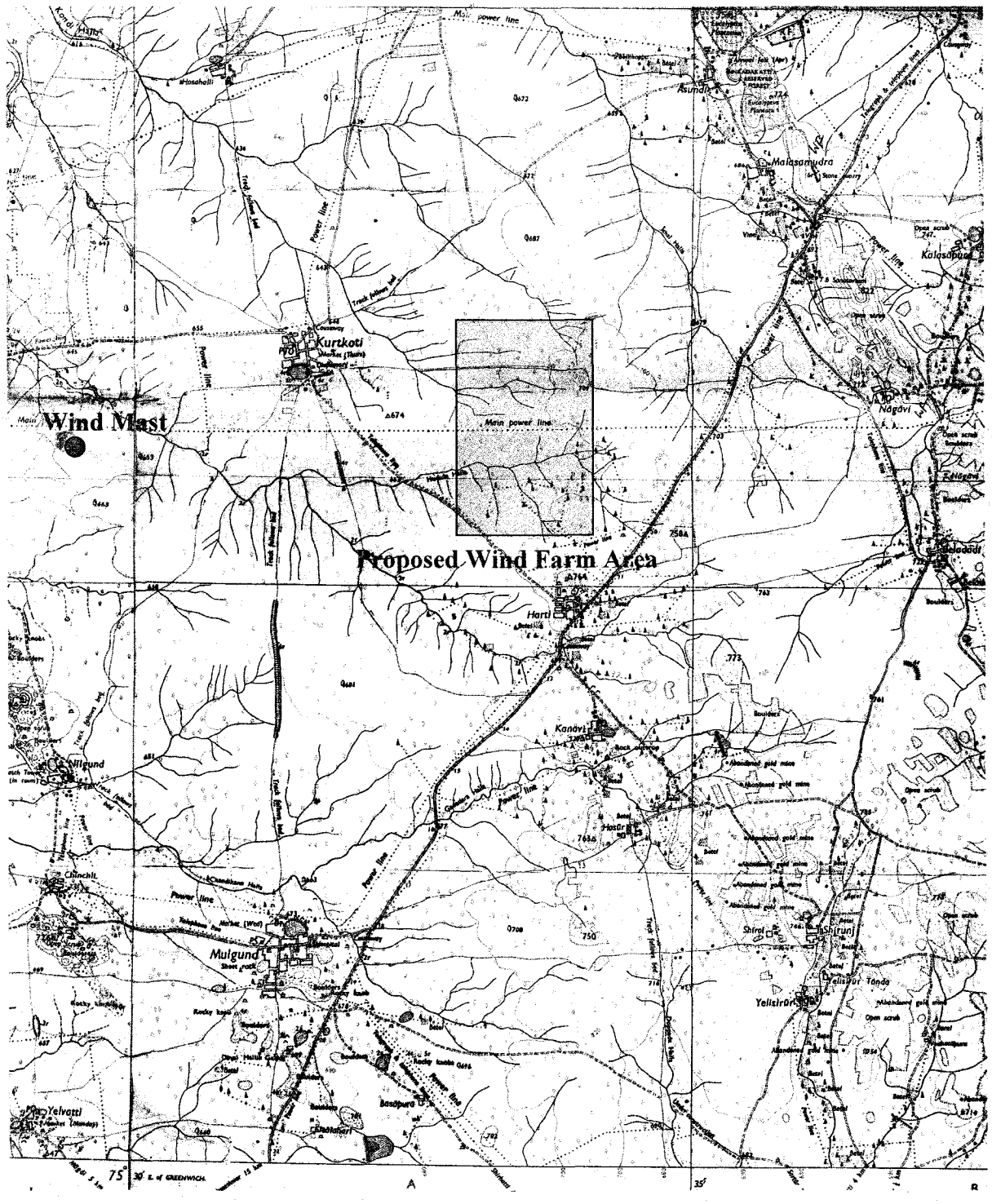


Fig.2 The Region of Interest is shown in the box

3.0 Wind Characteristics of Region of Interest

Winds at the proposed area were monitored using a 76 m tall mast by M/s Enercon India Pvt. Ltd, Mumbai. The sixteen directional frequency distribution of 75 m height a.g.l. has been provided by the client. The average annual wind speed and wind power density observed during the time of measurement were 6.81 m/s and 250 W/m^2 respectively. Site seems to be moderate for wind farming.

The figures shown below (fig 5 & 6) explain the wind characteristics of the site. The predominant wind directions are west, northwest and northeast. Summary of wind characteristics and joint frequency distribution are given in the table 2 and table 3..

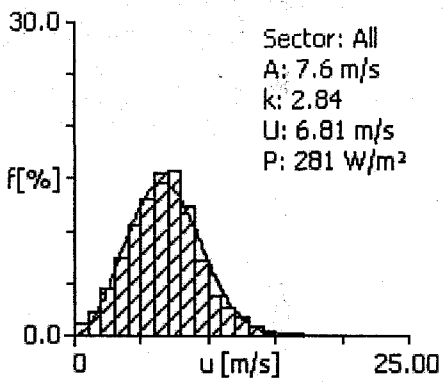


Fig. 5.Wind Speed Frequency Distribution (Actual in Histogram & Weibull)

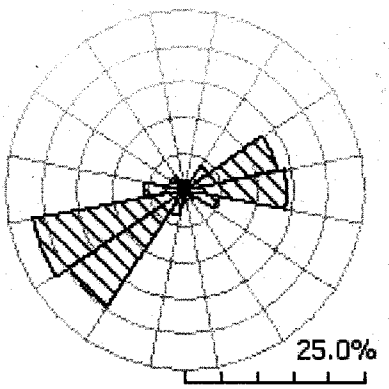


Fig.6 Wind rose

-	0	23	45	68	90	113	135	158	180	203	225	248	270	293	315	338	All
A	5.1	5.2	6.7	7.8	7.5	6.7	4.6	5.3	5.0	6.1	8.2	9.0	6.8	4.9	4.8	5.0	7.6
k	2.28	2.13	2.87	5.60	4.76	3.19	1.94	1.92	1.68	2.00	2.70	2.99	2.15	2.61	2.63	2.33	2.84
U	4.48	4.63	5.97	7.19	6.85	5.97	4.12	4.68	4.45	5.40	7.32	8.04	5.99	4.40	4.29	4.41	6.81
E	93	109	188	256	230	177	84	125	126	184	359	448	235	80	74	87	281
f	1.5	1.2	3.9	13.2	14.1	4.7	1.7	1.2	1.8	3.8	19.6	21.4	5.6	2.3	2.4	1.8	100

Table 2 Summary of Wind Data

U	0	23	45	68	90	113	135	158	180	203	225	248	270	293	315	338	All
1.0	41	40	11	4	3	11	25	45	34	19	5	2	13	45	45	66	11
2.0	86	75	29	8	8	24	83	75	96	38	12	7	30	60	74	84	22
3.0	142	121	57	17	18	68	172	118	137	68	18	21	72	134	139	130	44
4.0	179	182	102	30	39	108	240	192	197	156	48	37	116	196	196	169	75
5.0	174	192	146	60	93	128	201	174	197	202	85	62	147	217	226	203	106
6.0	150	159	173	108	146	170	115	140	112	147	124	102	161	172	176	166	131
7.0	118	98	169	197	203	168	67	85	61	100	168	138	123	107	90	110	155
8.0	58	45	140	276	232	137	35	78	55	78	165	134	109	44	36	54	158
9.0	30	40	93	191	169	114	34	49	46	86	134	133	87	10	9	7	124
10.0	14	35	44	80	68	56	13	8	29	52	88	116	47	7	2	1	73
11.0	1	7	27	22	17	11	8	13	20	24	47	86	34	3	2	2	38
12.0	3	3	6	6	2	5	2	10	8	14	39	69	26	4	2	2	27
13.0	3	2	0	1	0	0	3	9	1	6	31	48	19	1	0	3	18
14.0	1	0	0	0	0	0	1	2	0	4	18	23	12	0	0	1	9
15.0	0	0	0	0	0	0	0	3	1	3	11	10	5	0	1	0	5
16.0	0	0	0	0	0	0	0	0	2	1	5	7	1	0	0	1	2
17.0	0	1	0	0	0	0	0	0	1	1	3	4	1	0	1	0	1
18.0	0	1	0	0	0	0	0	0	2	1	0	1	0	0	0	2	0
19.0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0

Table 3.Wind Speed Frequency Distribution of Pangan Wind Monitoring Station
**A and U are given in m/s, E in W/m²; and the frequencies of occurrence in per mille and per cent (f).*

3.1. Extreme winds:

As per IS 875 part III, the area under consideration is in the lowest extreme wind zone. On extrapolation to hub height of 75 m at the proposed wind farm, it is found to be within 55 m/s.

4.0 WTG Deployment

39 numbers of 800 kW machines (31.2. MW) are distributed in four rows as per the wind turbine location details given by the M/s Enercon India Pvt. Ltd, Mumbai,. Since land has small undulations, a 5 m contour map has been employed for good modeling purpose .The wind turbines located at these sites demonstrate

relatively moderate energy generation. The proposed area has relatively higher elevations in the range of 695 –730 m amsl compared to the wind mast point..

5.0. Estimation of Annual Energy Production

The WAsP model and wind atlas methodology was used for generating the spatial wind environment of the Region of Interest

Wind Atlas Analysis and Application Program (WAsP) is a PC- program developed by the Wind Energy and Atmospheric Physics Department, Riso National Laboratory, Denmark for the vertical and horizontal extrapolation of wind data. It is a powerful tool for wind data analysis, wind atlas generation, wind climate estimation and estimation of wind power potential of a site.

Actual details of the terrain characteristics were collected during the visit to the site and its surroundings. Since there is no significant obstacle offering shelter effect at the point of observation no obstacle file was created.

Based on the digitized 5-m contour map, the wind power density for the region of interest has been computed using a grid of 50 m x 50 m. The results demonstrate that the proposed area do show an appreciable increase in the wind power densities as it is in higher elevation levels.

The standard power curve of air density 1.225 kg/m^3 has been used for the analysis and later adjusted with site air density as given by the client

5.1. Limitation of the Model

The WAsP model has its own limitations. Wind Atlas prepared for Europe using WAsP indicates that the prediction may differ up to +/- 15% or more.

5.2. Wind Farm Energy Loss Factors.

When wind energy estimations have been undertaken, potential source of energy loss must be considered on site-specific basis. Exact losses can vary significantly from project to project and from time to time; for example, some projects with poor transmission access may experience significant line outages or curtailment. For the purpose of this assessment typical values for parameters have been assumed where site specific information was not available at this time.

Assumptions are based on some field experience and actual values could be collected from the site during the operation of wind farm. The assumption values of turbine availability , utility down time , electrical losses are given by M/s Enercon. Specific source of energy loss other than those associated with wake effects are described below.

5.2.1. Electricity Transmission Efficiency.

The electrical transmission efficiency from the terminals at the base of the turbine tower to the wind farm metering point will depend on the site's detailed electrical design. A formal calculation of the electrical loss should be undertaken when the electrical system has been designed. A part from this, loss due to grid frequency fluctuation is also to be considered. A 4 % of loss is expected due to these factors.

5.2.2. Turbine Availability.

Turbine availability is assumed to be 96%.

5.2.2. Utility Down time.

The wind farm will be unable to export energy if the grid is not available. This needs to be considered on a site-specific basis with suitable historic information supplied by the grid operator. In this case, grid availability is assumed as 98%.

5.2.3. Air Density Correction factor.

Air density at the site estimated by the client is given as 1.094 kg/m ^{3}. A loss because of air density difference is taken as 10.7%.

5.2.4 Wind data correction factor.

Discrepancy between actual and model calculated wind characteristics at wind mast point is observed and a correction factor of 5 % is taken for avoiding the error.

5.2.5 Other factors

The losses due to following are not considered in the estimation.

1. High wind hysteresis,

2. Substation maintenance,

3. Temporary "fouling "of turbine blades by dirt, or insects and long term degradation of the blade and

5.2.4 Uncertainty in the production estimate

The uncertainty analysis is an important part of any assessment of the long term energy production of a wind farm. The uncertainty of a production estimate is very dependent on the local wind climate, the topography, the data acquisition system, the period of data collection, the limitations of the software used for the estimate and power curve. To give an exact estimate of the uncertainty is not possible. However an uncertainty factor of 10 % (rms value) has been taken into account while fixing up generation levels in this study. Details are given in the table 4.

Uncertainty factors)	**+/-**
Wind Measurement (sensors, mounting)	3%
Inter annual variation (Only one year data is available)	5%
Horizontal Extrapolation	5%
Input file accuracy (Orography+Roughness)	4 %
Power curve	5 %
RMS Value	10 %

Table 4. Details of Standard correction and uncertainty factors

6.0. Results

The estimations are based on 75 m wind data collected by M/s Enercon India Pvt. Ltd,. The estimated generation figures have been obtained from the micro-siting details (as given in the form of a table of coordinates) by the client.

The estimated annual energy production from 39 numbers of E-53- 800 kW is given in the table 6. Though individual generation figures are given, it is suggested to consider park average for evaluation purposes. The average estimated mean and minimum generation levels are 17.7 lakhs and 15.9 lakhs per machine respectively.

A view of the proposed wind farm site generated by the software is given in the figure 4.

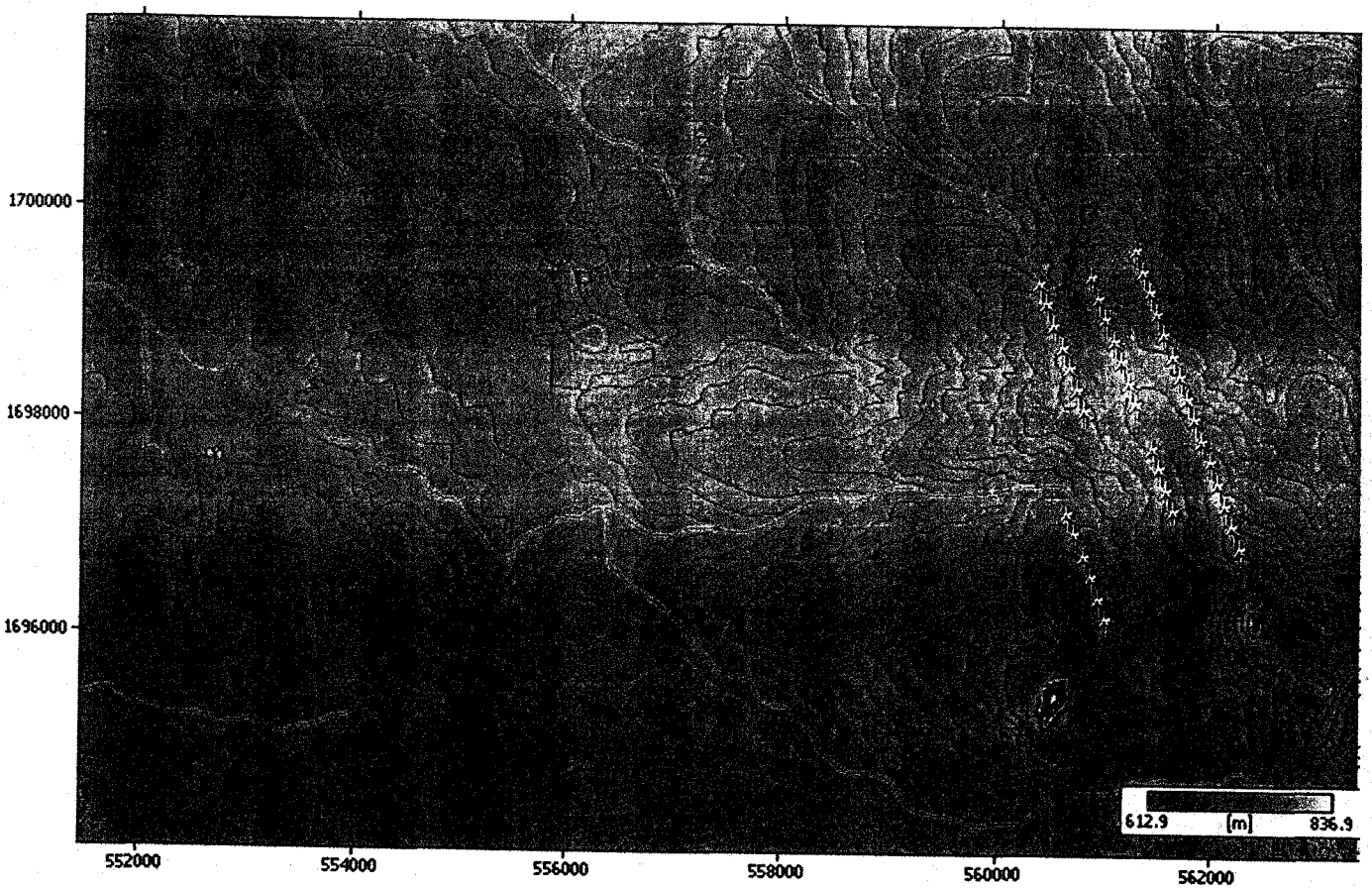


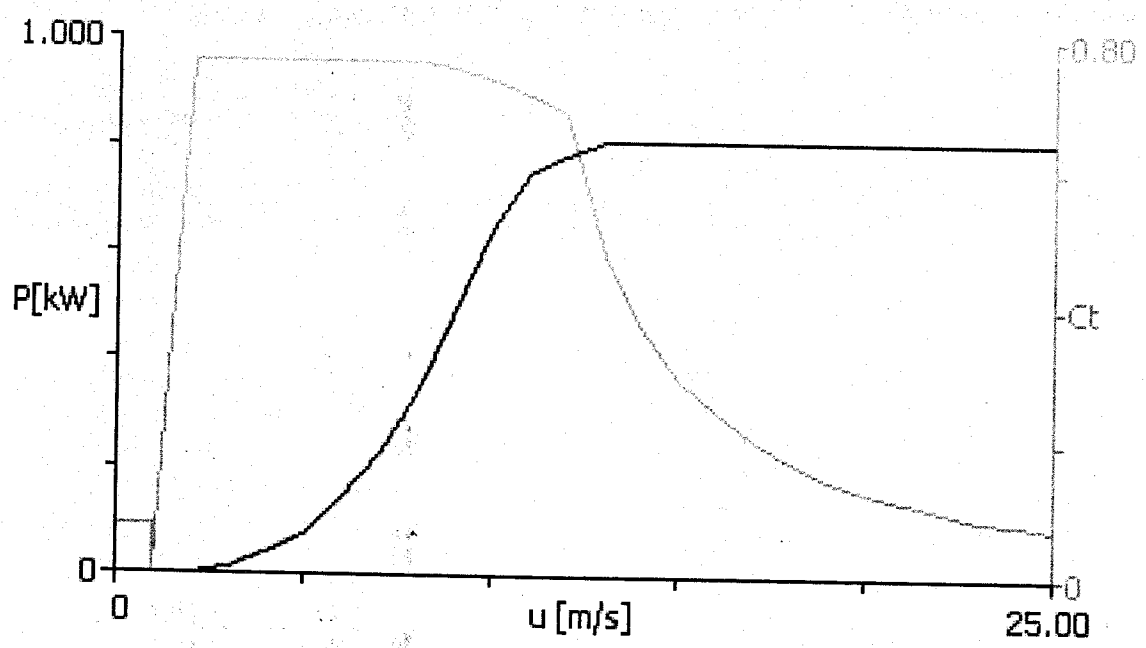
Figure 4. A view of the proposed WF site generated by the software

Site	Location [m]	Elevation [m]	Wake loss [%]	Estimated	Est. Min. G Wh	Est. Max. GWh
Turbine site S136	(561003.6,1696068.0)	711	1.09	1.79	1.61	1.97
Turbine site S137	(560931.1,1696267.0)	710	1.74	1.80	1.62	1.98
Turbine site S138	(560858.6,1696466.0)	707	2.13	1.80	1.62	1.98
Turbine site S139	(560786.1,1696666.0)	703	2.87	1.77	1.60	1.95
Turbine site S140	(560713.6,1696865.0)	699	3.62	1.75	1.58	1.93
Turbine site S141	(560641.1,1697064.0)	695	3.72	1.74	1.57	1.92
Turbine site S163	(560362.3,1699219.0)	696	4.87	1.78	1.60	1.95
Turbine site S164	(560434.9,1699019.0)	701	6.73	1.76	1.59	1.94
Turbine site S165	(560507.4,1698820.0)	704	7.19	1.76	1.59	1.94
Turbine site S166	(560579.9,1698621.0)	705	7.24	1.77	1.59	1.95
Turbine site S167	(560652.4,1698422.0)	705	7.28	1.77	1.59	1.95
Turbine site S168	(560724.9,1698222.0)	705	7.12	1.75	1.57	1.92
Turbine site S169	(560797.4,1698023.0)	703	6.63	1.74	1.57	1.92
Turbine site S170	(561642.6,1697090.0)	712	9.02	1.68	1.51	1.85
Turbine site S171	(561570.0,1697289.0)	710	9.09	1.71	1.54	1.88
Turbine site S172	(561497.5,1697488.0)	709	8.29	1.73	1.56	1.90
Turbine site S173	(561425.0,1697688.0)	709	7.21	1.77	1.59	1.95
Turbine site S174	(561280.0,1698086.0)	710	7.3	1.79	1.61	1.96
Turbine site S175	(561207.5,1698285.0)	710	9.81	1.74	1.56	1.91
Turbine site S176	(561135.0,1698485.0)	707	11.21	1.70	1.53	1.87
Turbine site S177	(561062.5,1698684.0)	706	11.4	1.68	1.52	1.85
Turbine site S178	(560990.0,1698883.0)	705	11.48	1.67	1.50	1.84
Turbine site S179	(560917.4,1699082.0)	705	11.2	1.70	1.53	1.87
Turbine site S180	(560844.9,1699281.0)	701	10.49	1.69	1.52	1.86
Turbine site S226	(561255.1,1699543.0)	700	6.56	1.76	1.59	1.94
Turbine site S227	(561327.6,1699344.0)	701	8.11	1.73	1.55	1.90
Turbine site S228	(561400.1,1699145.0)	701	8.48	1.72	1.55	1.89
Turbine site S229	(561472.6,1698946.0)	701	8.71	1.69	1.52	1.86
Turbine site S230	(561545.1,1698747.0)	704	8.31	1.74	1.56	1.91
Turbine site S231	(561617.6,1698547.0)	705	7.95	1.74	1.57	1.91
Turbine site S232	(561690.1,1698348.0)	707	6.53	1.78	1.60	1.96
Turbine site S233	(561762.6,1698149.0)	710	4.41	1.85	1.67	2.04
Turbine site S234	(561835.1,1697950.0)	713	5.86	1.82	1.64	2.00
Turbine site S235	(561907.6,1697751.0)	715	6.6	1.82	1.64	2.00
Turbine site S236	(561980.1,1697551.0)	717	6.75	1.83	1.65	2.01
Turbine site S237	(562052.6,1697352.0)	721	5.7	1.86	1.67	2.04
Turbine site S238	(562125.1,1697153.0)	725	3.43	1.93	1.73	2.12
Turbine site S239	(562197.7,1696954.0)	728	2.36	1.96	1.76	2.15
Turbine site S240	(562270.2,1696754.0)	729	1.61	1.97	1.77	2.17
		Average		***1.77***	***1.59***	***1.95***
		CF %		***25.3***	***22.7***	***27.8***

Table .5 The estimated annual energy production by 39 x 800 kW

ANNEXXURE

Power & Thrust Curves of E-53 - 800 kW WTG



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