REGIONE SICILIA

Provincia di Trapani

COMUNE DI MAZARA DEL VALLO

PROGETTO

IMPIANTO EOLICO " RACASALE" NEL COMUNE DI MAZARA DEL VALLO (TP) DI POTENZA PARI A 37,2 MW E RELATIVE OPERE DI CONNESSIONE ALLA RTN

PROGETTO DEFINITIVO

COMMITTENTE

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WINDFOR® CONSULTING

PRELIMINARY WIND RESOURCE ASSESSMENT

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MAZARA DEL VALLO WIND FARM

MUNICIPALITY OF MAZARA DEL VALLO, LIBERO CONSORZIO COMUNALE DI TRAPANI - ITALY

PRELIMINARY WIND RESOURCE ASSESSMENT

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00	Initial release	11/12/2020	Stefano Liani	Marco Guarneroli
01				
02				
03				

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1. FOREWORD

Limes Italia Srl (in the following the **Customer**) engaged Windfor S.r.l. as "**Technical Advisor**" to perform a preliminary analysis for the definition of the wind resource of the area located in Italy, municipality of Mazara del Vallo, Libero consorzio comunale di Trapani, in Sicilia region to evaluate the potential of the Mazara del Vallo wind farm (the **"Project"**).

The activity consisted in the preliminary estimation of the expected annual energy production of the wind farm, according to the **Technical Advisor**'s analysis on the long-term wind regime representative of the area at the desired hub heights.

The whole study was carried out with professional approach and instruments, as prescribed by the international methodologies for a trustworthy assessment of expected wind farm production.

2. SUPPLIED MATERIAL

The supplied material useful for this preliminary assessment of the wind resource includes:

1. proposed layout for the wind farm.
2. wind turbine models for the proposed wind farm.

Although no information about third-party existing wind farms in the proximity of the **Project** has been provided, from aerial pictures publicly available online it is observed that there are operating turbines in the area that could affect the **Project** with additional wake effects:

- 6 Gamesa G114-2.5 MW at 93 m hub height.

No site inspection has been carried out at this stage in order to verify this or presence of any other obstacle that might affect the **Project**.

2.1 WIND FARM LAYOUT

The metric coordinates of the Mazara del Vallo layout including 6 turbines, as provided by the **Customer**, are shown in the following table.

Table 1: Mazara del Vallo wind farm coordinates

UTM WGS84 – Zone 33			
WTG	Longitudine [m]	Latitudine [m]	Quota [m]
W001	298410	4171209	61
W002	298951	4170675	60
W003	300366	4170515	105
W004	300724	4171090	109
W005	299832	4171742	100
W006	299218	4171731	60

The location of the proposed turbines in red and the operating turbines onsite in blue are shown in Figure 1.

Figure 1: Proposed and operating wind turbines

Technical Advisor's standard requirements for distances between turbines are five rotor diameters in the prevailing wind direction, and three rotor diameters in non-prevailing wind directions. The next table shows the distances separating the wind turbines in meters (on the right side of the table) and in diameters of 170 m (the highest among those indicated) rotor (on the left side of the table).

Table 2: Spacings in rotor diameter and meters of Mazara del Vallo wind farm

D=170 m/ m	W001	W002	W003	W004	W005	W006
W001		760	2075	2317	1519	962
W002	4.5		1424	1821	1384	1089
W003	12.2	8.4		677	1338	1672
W004	13.6	10.7	4.0		1105	1637
W005	8.9	8.1	7.9	6.5		614
W006	5.7	6.4	9.8	9.6	3.6	

2.2 WIND TURBINES

The **Project** will include three turbine types whose power curves have been retrieved from the **Technical advisor**'s database and adjusted at the site air density of 1.19 kg/m^3 according to the IEC 61400-12 method correction.

Table 3: Turbine type, power and Ct curves – SGRE SG 6.0-170 (AM-0, 6.2 MW)

Turbine type		SG 6.0-170 (AM-0, 6.2 MW)	Diameter [m]	170
Rated power [MW]		6.2	Hub height [m]	115.0
Rated wind speed [m/s]		15.0	IEC class	IIIA
Cut-in/Cut-out wind speed [m/s]		3.0/25.0	Air density [kg/m^3]	1.225
Bin wind speed [m/s]	**Power [kW]**	**Thrust coefficient [-]**		
0	0	0		
1	0	0		
2	0	0		
3	89	0.953		
4	328	0.847		
5	758	0.824		
6	1376	0.833		
7	2230	0.837		
8	3351	0.825		
9	4617	0.759		
10	5584	0.620		
11	6028	0.466		
12	6161	0.347		
13	6192	0.266		
14	6199	0.209		
15	6200	0.169		
16	6200	0.139		
17	6200	0.117		
18	6200	0.100		
19	6200	0.087		
20	6200	0.077		
21	5956	0.060		
22	5708	0.051		
23	5460	0.043		
24	5212	0.037		
25	4964	0.032		
26	-	-		
27	-	-		
28	-	-		
29	-	-		
30	-	-		

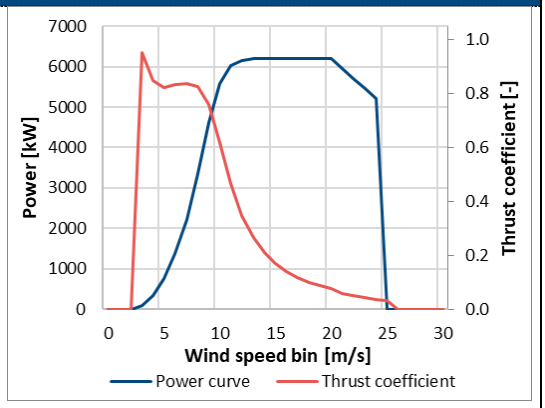


Table 4: Turbine type, power and Ct curves – Vestas V162-5.6 MW

Turbine type		V162-5.6 MW	Diameter [m]	162
Rated power [MW]		5.6	Hub height [m]	119.0
Rated wind speed [m/s]		12.0	IEC class	S
Cut-in/Cut-out wind speed [m/s]		3.0/24.0	Air density [kg/m³]	1.175
Bin wind speed [m/s]	**Power [kW]**	**Thrust coefficient [-]**		
0	0	0		
1	0	0		
2	0	0		
3	23	0.915		
4	274	0.852		
5	639	0.801		
6	1166	0.797		
7	1906	0.795		
8	2885	0.797		
9	4091	0.773		
10	5139	0.641		
11	5560	0.473		
12	5600	0.345		
13	5600	0.263		
14	5600	0.208		
15	5600	0.168		
16	5600	0.138		
17	5600	0.115		
18	5599	0.098		
19	5403	0.081		
20	4874	0.064		
21	4312	0.050		
22	3750	0.039		
23	3191	0.030		
24	2604	0.023		
25	-	-		
26	-	-		
27	-	-		
28	-	-		
29	-	-		
30	-	-		

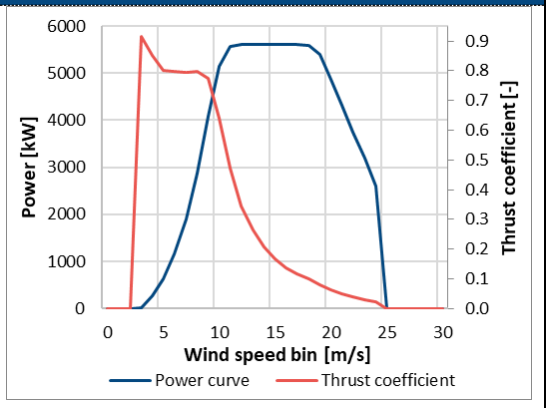
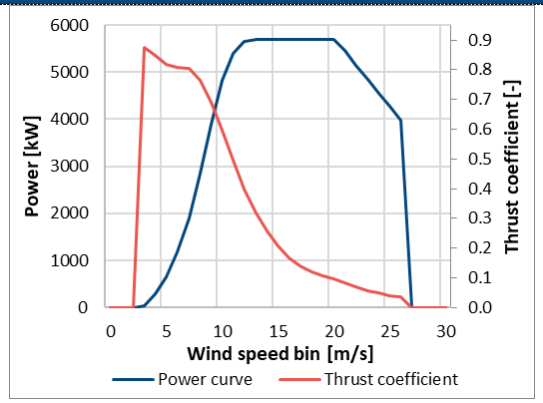


Table 5: Turbine type, power and Ct curves – Nordex N163/5.7

Turbine type		N163/5700	Diameter [m]	163
Rated power [MW]		5.7	Hub height [m]	118.0
Rated wind speed [m/s]		13.0	IEC class	NA
Cut-in/Cut-out wind speed [m/s]		3.0/26.0	Air density [kg/m^3]	1.175
Bin wind speed [m/s]	**Power [kW]**	**Thrust coefficient [-]**		
0	0	0		
1	0	0		
2	0	0		
3	44	0.875		
4	283	0.847		
5	655	0.819		
6	1180	0.809		
7	1905	0.806		
8	2854	0.764		
9	3887	0.691		
10	4825	0.595		
11	5392	0.494		
12	5652	0.397		
13	5700	0.319		
14	5700	0.256		
15	5700	0.206		
16	5700	0.168		
17	5700	0.141		
18	5700	0.121		
19	5700	0.107		
20	5700	0.097		
21	5455	0.082		
22	5153	0.068		
23	4856	0.057		
24	4560	0.048		
25	4269	0.040		
26	3973	0.035		
27	-	-		
28	-	-		
29	-	-		
30	-	-		



3. WIND RESOURCE ASSESSMENT

Considering that a measurement campaign recorded onsite is not yet available, the preliminary estimation of the expected annual energy production of the **Project** is obtained from the analysis of the long-term wind regime representative of the area, at the desired hub heights, based on wind data retrieved from the **Technical Advisor**'s internal database, whose details cannot be disclosed.

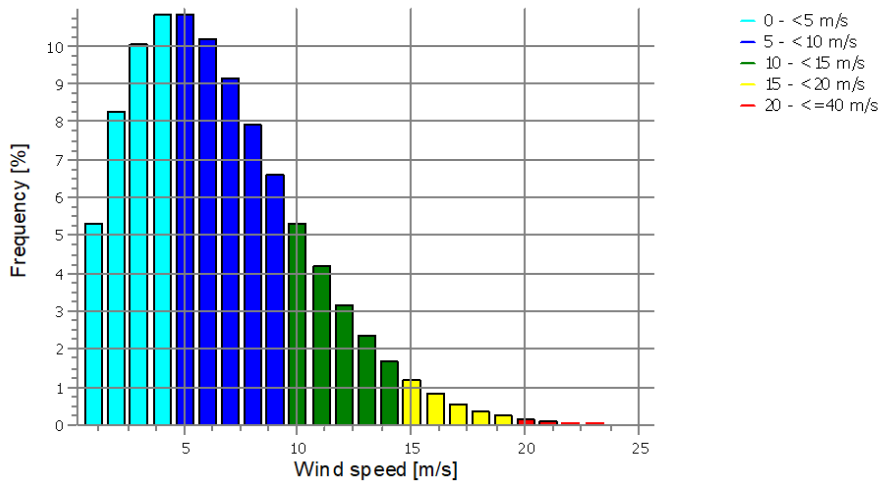
Two met masts at a distance of 5 km from the **Project** have been detected, whose maximum measurement height available is at 80 m. After some checks on the reliability of such measurement campaigns in terms of good representativeness, measurement heights and met masts set-up, both masts, Mast 1 and Mast 2, have been selected as representative of the proposed turbine locations. Nevertheless, it should be noted that results obtained with such datasets are characterized by a high level of uncertainty, especially related to the actual wind speed intensity, wind rose and vertical extrapolation from the measurement to hub height, within the **Project** area. Therefore, it is recommended to install at least one met mast onsite and update the analysis accordingly.

Starting from the measurement campaigns at the selected two mast locations, the long-term wind regime expected onsite has been assessed using one 20-year re-analysis node (ERA5 dataset). By monthly correlations between met masts and long-term series, the average long-term wind speeds at each mast have been evaluated and then extrapolated to a representative location (virtual anemometer) at the proposed hub heights considering the wind shear values measured by the masts Mast 1 and Mast 2. In the figures below, the following wind conditions modelled at the turbine location W001, for a hub height equal to 119 m, are reported:

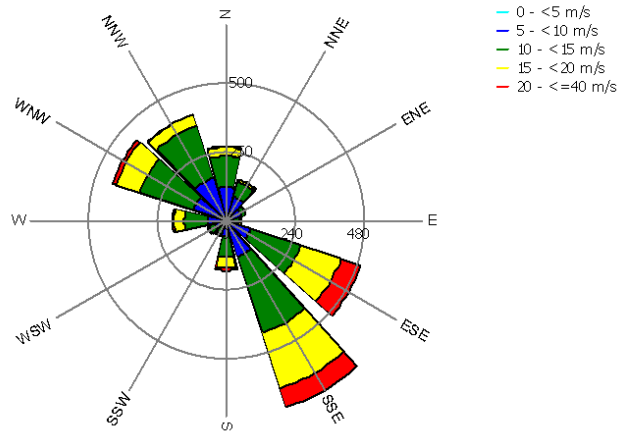
- Weibull distribution split into five wind speed classes
- Energy rose split into five wind speed classes and 12 sectors
- Wind rose split into five wind speed classes and 12 sectors

A site representative long-term wind rose is shown in Figure 2. It is observed the prevailing winds are from NW and SE.

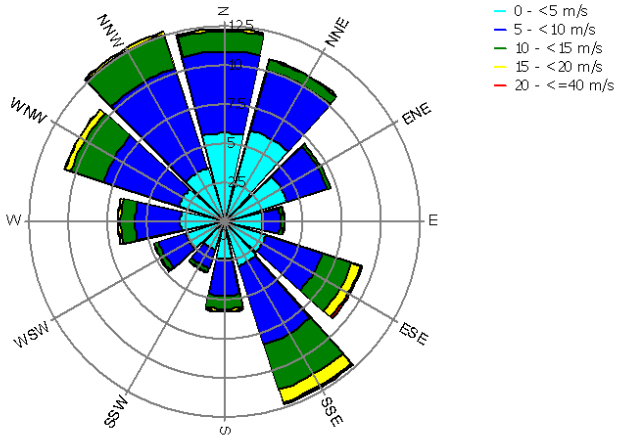
Weibull distribution



Energy rose [kWh/m²/year]



Wind rose [%]



A = 7.3 m/s	k = 1.74	V = 6.5 m/s

Figure 2: Wind conditions at the turbine W001 location

4. EXPECTED ENERGY YIELD ASSESSMENT

The expected energy production of the Mazara del Vallo wind farm has been estimated with the wind turbine configurations requested, using the long-term frequency distribution at the hub heights of masts Mast 1 and Mast 2 and adopting the WAsP 12 model propagation as embedded in WindPRO 3.4.

The tables hereunder contain the following information for each wind turbine:

Site ID: ID number of the wind turbine in the tables

Turbine Type: manufacturer and model of the wind turbine

Site X [m]: E longitude **UTM-WGS84 Zone 33** coordinates

Site Y [m]: N latitude in **UTM- WGS84 – Zone 33** coordinates

Elev. [m]: elevation above sea level (ASL)

HH [m]: hub height

V [m/s]: average wind speed estimated by the model at hub height

Gross [GWh]: expected gross output

Net [GWh]: expected output net of wake losses

Loss [%]: percent of production lost due to wake losses

Net Hours [h]: expected specific production net of wake losses

Table 6: Wind farm energy production – Configuration 1

ID	Turbine Type	X [m]	Y [m]	Elev. [m]	HH [m]	V [m/s]	Gross [GWh]	Net [GWh]	Loss [%]	Net Hours [h]
W001	SGRE SG 6.0 – 170 (AM-0, 6.2 MW)	298410	4171209	61	115.0	6.41	18.99	18.14	4.52	2925
W002		298951	4170675	60	115.0	6.31	18.49	17.36	6.08	2801
W003		300366	4170515	105	115.0	6.59	19.76	18.65	5.65	3008
W004		300724	4171090	109	115.0	6.60	19.83	19.14	3.45	3088
W005		299832	4171742	100	115.0	6.71	20.43	19.50	4.52	3146
W006		299218	4171731	60	115.0	6.31	18.51	17.87	3.45	2883
					Average	**6.49**	**19.34**	**18.45**	**4.61**	**2975**
						Total	**116.01**	**110.67**		

Table 7: Wind farm energy production – Configuration 2

ID	Turbine Type	X [m]	Y [m]	Elev. [m]	HH [m]	V [m/s]	Gross [GWh]	Net [GWh]	Loss [%]	Net Hours [h]
W001	Vestas V162-5.6 MW	298410	4171209	61	119.0	6.47	17.44	16.71	4.22	2984
W002		298951	4170675	60	119.0	6.37	17.01	16.05	5.67	2866
W003		300366	4170515	105	119.0	6.65	18.12	17.18	5.21	3068
W004		300724	4171090	109	119.0	6.66	18.18	17.61	3.17	3144
W005		299832	4171742	100	119.0	6.76	18.69	17.91	4.18	3198
W006		299218	4171731	60	119.0	6.37	17.02	16.49	3.16	2944
					Average	**6.55**	**17.75**	**16.99**	**4.27**	**3034**
						Total	**106.47**	**101.93**		

Table 8: Wind farm energy production – Configuration 3

ID	Turbine Type	X [m]	Y [m]	Elev. [m]	HH [m]	V [m/s]	Gross [GWh]	Net [GWh]	Loss [%]	Net Hours [h]
W001	Nordex N163/5700	298410	4171209	61	118.0	6.45	17.19	16.50	4.01	2895
W002		298951	4170675	60	118.0	6.36	16.75	15.85	5.36	2781
W003		300366	4170515	105	118.0	6.63	17.90	17.02	4.92	2986
W004		300724	4171090	109	118.0	6.64	17.96	17.42	2.99	3056
W005		299832	4171742	100	118.0	6.75	18.46	17.73	3.95	3111
W006		299218	4171731	60	118.0	6.35	16.76	16.26	3.00	2852
					Average	**6.53**	**17.50**	**16.80**	**4.04**	**2947**
						Total	**105.02**	**100.78**		

It should be noted that the energy production presented above accounts only for the losses due to wake effects and no other losses are included. At this preliminary stage, a reasonable assumption of the additional losses related to turbine, B.O.P. and grid availability, electrical plant, environment, turbine performance and excluding any potential curtailment consists of about 10%. A more detailed evaluation could be performed when supply or O&M agreement are in place or even at a discussion phase.

5. CONCLUSIONS

The activity of the current assessment consisted in the preliminary estimation of the expected annual energy production of the Mazara del Vallo wind farm. The study was based on the analysis of the long-term wind regime representative of the area at the desired hub heights, according to the wind datasets retrieved from the **Technical Advisor**'s internal database.

Considering the location and the measurement heights of the available met masts and the complexity of the area, the annual energy production of the **Project** is characterized by a high level of uncertainty and shall be intended as a **preliminary estimation.** In order to reduce the uncertainties and to achieve a bankable project, at least one met mast shall be installed onsite and update the analysis accordingly.
The location of the mast should be selected to be well exposed with respect to the prevailing wind direction and well representative of the turbine locations. The structure of such mast should be sufficiently high to reduce uncertainty related to the vertical extrapolation: a height of at least 2/3 of the proposed hub height is recommended.

Additional information regarding neighbouring wind farms both in operation and under development, such as position, turbine model and hub height, shall be retrieved and provided to the **Technical Advisor** for a comprehensive annual energy estimation including also the external wake effects.

At this preliminary stage, a reasonable assumption of the additional losses related to turbine, B.O.P. and grid availability, electrical plant, environment, turbine performance and including any potential curtailment consists of about 11%. A more detailed evaluation could be performed when supply or O&M agreement are in place or even at a discussion phase.

In addition, it is recommended to verify that the desired wind turbine model will be appropriate for the site according to IEC 61400-1 Standard Ed.3 by defining the site class in terms of the extreme wind speed at hub height with a recurrence period of 50 years averaged over a period of 10 minutes and the representative turbulence levels.