CITTA' METROPOLITANA DI CAMPOBASSO

REGIONE MOLISE

COMUNE di COLLETORTO

COMUNE di SAN GIULIANO

PROGETTO DEFINITIVO PER LA REALIZZAZIONE DI UN PARCO EOLICO NEI COMUNI DI COLLETORTO E SAN GIULIANO DI PUGLIA, CON OPERE DI CONNESSIONE IN SANTA CROCE DI MAGLIANO E ROTELLO

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ANALISI DELLA PRODUCIBILITA'

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COLLETORTO WIND FARM

MUNICIPALITY OF COLLETORTO AND SAN GIULIANO DI PUGLIA

PROVINCE OF CAMPOBASSO

ITALY

PRELIMINARY WIND RESOURCE & ENERGY YIELD ASSESSMENT SUMMARY REPORT

DISCLAIMER

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00	Initial release	29/10/2021	Nell Franchi	Marco Guarneroli
01				
02				
03				

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1. FOREWORD

GR Value Management 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 and expected production of the Colletorto wind farm (the **"Project"**) located in Italy, municipality of Colletorto and San Giuliano di Puglia, Campobasso Province, Molise region.

The activity consisted in the preliminary estimation of the expected wind statistics at the site extrapolated from a Virtual Met Mast downscaled to a location deemed as representative of the wind farm, according to the **Technical Advisor**'s analysis on the long-term wind regime representative of the area at the desired height of 115 m above ground level.

As requested by the **Customer**, the **Project** will involve the following configuration:

Table 1: Project configuration

Configuration	Turbine model	Hub height [m]	Total rated capacity [MW]
1	7 x SGRE SG 6.0-170 (AM 0)	115.0	43.4

As requested by the **Customer**, the current document will present only the key figures of the preliminary wind regime and energy yield assessment undertaken on the proposed Colletorto wind farm, in the form of summary tables.

It is stressed that this summary report is not intended to be a thorough report, therefore the details of the analysis undertaken, and any related assumptions are not provided herein, as this is beyond the agreed scope of work.

2. SUPPLIED MATERIAL

The supplied material useful for this preliminary assessment of the wind resource and energy yield of the Colletorto wind farm under development includes:

1. Proposed layout for the wind farm featuring n. 7 wind turbines
2. n. 1 wind turbine model for the proposed wind farm

No information about third-party existing wind farms in the proximity of the **Project** has been provided. From aerial pictures publicly available online and the **Technical Advisor**'s database it is observed that there are operating turbines in the area but at distance of more than 20 rotor diameters, whose impact has been deemed as negligible.
It is observed that no site inspection has been carried out at this stage in order to verify the conditions at site, such as the orography, the roughness or the presence of any obstacles that might affect the **Project**.

2.1 WIND FARM LAYOUT

The metric coordinates of the **Project** featuring 7 turbines, as provided by the **Customer**, are shown in the following table. To be noted that five turbines are located in the administrative boundaries of the township of Colletorto and two turbines in those of San Giuliano di Puglia.

Table 2: Colletorto wind farm coordinates

UTM WGS84 – Zone 33				
WTG	**Longitude [m]**	**Latitude [m]**	**Elevation [m]**	**Municipality**
COL01	499842	4614788	540	San Giuliano di Puglia
COL02	500926	4614345	392	Colletorto
COL03	501017	4613607	336	Colletorto
COL04	501777	4612841	298	Colletorto
COL05	501899	4613486	310	Colletorto
COL06	502454	4613088	281	Colletorto
COL07	503033	4613412	316	San Giuliano di Puglia

The location of the proposed turbines in red are shown in Figure 1.

Figure 1: Map of the site with the proposed 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 rotor (on the left side of the table).

Table 3: Spacings in rotor diameter and meters of Colletorto wind farm

RD=170m\Meter	COL01	COL02	COL03	COL04	COL05	COL06	COL07
COL01	-	1171	1666	2745	2434	3116	3475
COL02	6.9	-	744	1728	1298	1979	2304
COL03	9.8	4.4	-	1079	890	1528	2025
COL04	16.1	10.2	6.3	-	656	721	1380
COL05	14.3	7.6	5.2	3.9	-	683	1136
COL06	18.3	11.6	9.0	4.2	4.0	-	663
COL07	20.4	13.6	11.9	8.1	6.7	3.9	-

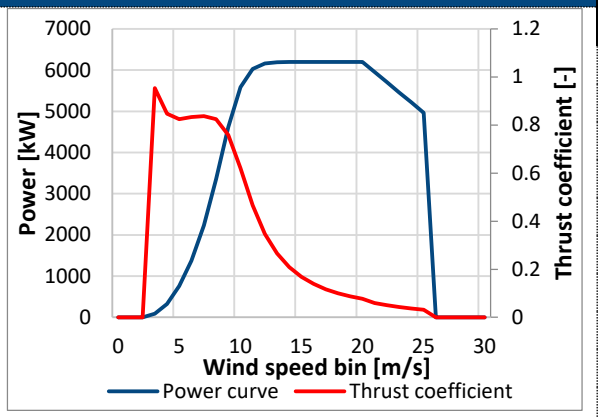
All turbines are separated by at least three rotor diameters. For further steps of development of the **Project** it is recommended to obtain the turbine manufacturer's Mechanical Load assessment and site suitability Analysis (MLA), in order to ensure that the fatigue loads, resulting from the wind conditions onsite and acting on the turbine main components, are within the design load envelope.

2.2 WIND TURBINE MODEL

The energy yield assessment has been carried out with the requested wind turbine model, SGRE SG 6.0-170 (AM-0, 6.2 MW). The power curve has been retrieved from the **Technical Advisor**'s database at the air density of 1.15 kg/m^3 and adjusted to the site air density at each turbine's location according to the IEC 61400-12 method correction.

Table 4: Turbine type, power and Ct curves – SGRE SG 6.0-170 (AM-0, 6.2 MW)

Turbine type		SG 6.0-170	Diameter [m]	170.0
Rated power [MW]		6.2	Hub height [m]	115.0
Rated wind speed [m/s]		15.5	IEC class	IIIA/IIIB
Cut-in/Cut-out wind speed [m/s]		3.0/25.0	Air density [kg/m^3]	1.150
Bin wind speed [m/s]	**Power [kW]**	**Thrust coefficient [-]**		
0	0	0		
1	0	0		
2	0	0		
3	82	0.953		
4	302	0.847		
5	706	0.824		
6	1286	0.833		
7	2089	0.837		
8	3144	0.825		
9	4363	0.765		
10	5390	0.640		
11	5940	0.493		
12	6135	0.371		
13	6186	0.284		
14	6197	0.223		
15	6199	0.180		
16	6200	0.148		
17	6200	0.124		
18	6200	0.106		
19	6200	0.093		
20	6200	0.082		
21	5956	0.064		
22	5708	0.054		
23	5460	0.046		
24	5212	0.039		
25	4964	0.034		
26	-	-		
27	-	-		
28	-	-		
29	-	-		
30	-	-		



3. WIND RESOURCE ASSESSMENT

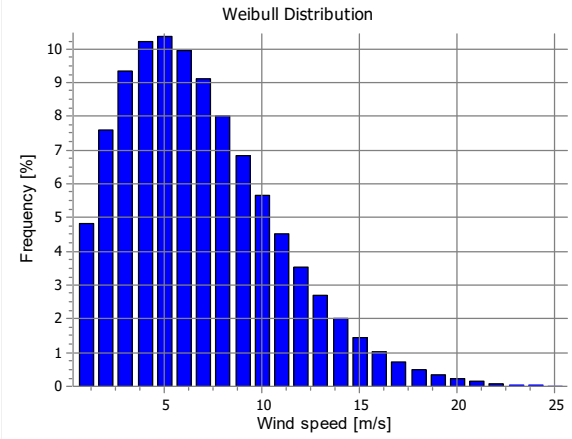
Since no measurements are currently available for the site, the preliminary estimation of the expected wind statistics at the site is extrapolated from a Virtual Met Mast scaled to a location deemed as representative of the **Project**. The statistics of the Virtual Met Mast are obtained using the sources available in the immediate area considered representative of the **Project**, such as measured wind data and mesoscale data.

It is necessary to emphasize that the Virtual Met Mast does not replace a traditional on-site measurement mast and therefore any assessment of the energy production will have a high uncertainty. Therefore, the results shall be intended as a **preliminary estimation only.**

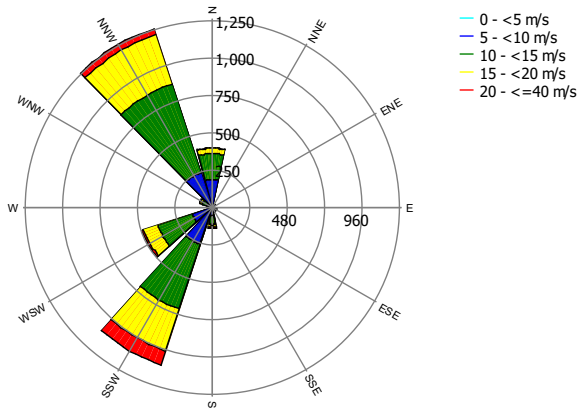
The long-term wind regime expected at the site was evaluated using two reanalysis nodes over a 20-year period (ERA5 Rectangular and Gaussian Grid) and through monthly correlations the long-term average speed was extrapolated to the Virtual Anemometer. In the figures below, the following wind conditions modelled at the Virtual Met Mast location at the height of 115 m above the ground, are reported:

- Weibull distribution
- Energy rose
- Wind rose

Weibull distribution



Energy rose [kWh/m²/year]



Wind rose [%]

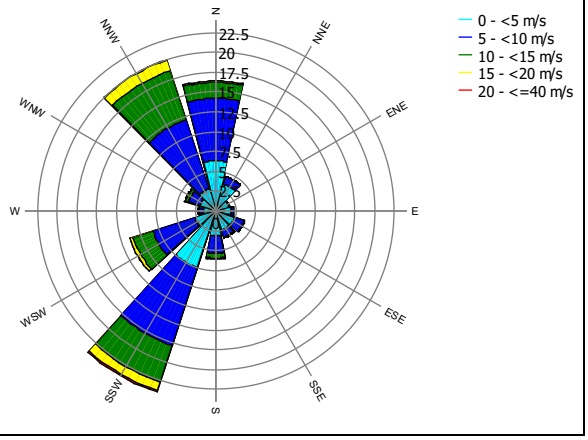


Figure 2: Wind conditions at Virtual Met Mast at 115 m

4. EXPECTED ENERGY YIELD ASSESSMENT

Being the assessment based on a Virtual Met Mast characterized by a higher level of uncertainty compared to a measurement on site, the presented energy figures shall be considered only as preliminary, and they should be updated when a full year measurement campaign onsite is available.

The expected energy production of the wind farm has been estimated with the wind turbine configuration requested, using the long-term frequency distribution at the proposed hub height and adopting the WAsP 12 model propagation as embedded in WindPRO 3.5. The so-called "time-varying calculation concept" has been selected in order to avoid the influence of the Weibull fit.

The wake model implemented in the analysis is the N. O. Jensen (RISO/EMD) based on the onshore standard wake decay of 0.075, constant for all the sectors.

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

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

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

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 5: Wind farm energy production - SGRE SG 6.0-170 (AM-0, 6.2 MW)

ID	X [m]	Y [m]	Elev. [m]	HH [m]	V [m/s]	Gross [GWh]	Net [GWh]	Loss [%]	Net Hours [h]
COL01	499842	4614788	540	115	6.8	20.12	19.95	0.82	3218
COL02	500926	4614345	392	115	6.1	17.46	17.21	1.43	2776
COL03	501017	4613607	336	115	5.9	16.63	15.62	6.08	2520
COL04	501777	4612841	298	115	6.1	17.44	16.17	7.26	2609
COL05	501899	4613486	310	115	6.0	17.04	16.14	5.27	2604
COL06	502454	4613088	281	115	6.0	16.98	16.00	5.76	2580
COL07	503033	4613412	316	115	6.3	18.53	17.56	5.26	2832
				Average	**6.2**	**17.74**	**16.95**	**4.55**	**2734**
					Total	**124.21**	**118.67**		

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.

The following table summarizes the preliminary results obtained:

Table 6: Gross and net energy production

Configuration	Wind Farm Rated Power [MW]	Gross Production (at generators' terminals)		Net Production (deliverable to grid)	
		[GWh/year]	[h/year]	[GWh/year]	[h/year]
SGRE SG 6-0-170 (AM-0, 6.2 MW)	43.40	118.67	2734	106.80	2461

5. CONCLUSIONS

The activity of the current assessment consisted in the preliminary estimation of the expected wind statistics at the site extrapolated from a Virtual Met Mast scaled to a location deemed as representative of the wind farm. The study was based on the **Technical Advisor**'s analysis on the long-term wind regime representative of the area at the desired height of 115 m above ground level.

It is necessary to emphasize that the Virtual Met Mast does not replace a traditional on-site measurement mast and therefore any assessment of the energy production will have a high uncertainty. Therefore, the results shall be intended as a **preliminary estimation only.**

In order to reduce the uncertainties and to achieve a bankable project, at least one met mast shall be installed onsite and the analysis updated 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 tower 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 any neighbouring wind farms in operation or authorized, shall be retrieved and provided to the **Technical Advisor** for a comprehensive energy estimation including all 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 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.
In particular, no energy loss has been included for any curtailment at this stage, related to wind sector management strategy or grid curtailment. However, it is recommended to verify this topic with the turbine supplier and obtain Mechanical Load assessment and site suitability Analysis (MLA), in order to ensure that the fatigue loads, resulting from the wind conditions onsite and acting on the turbine main components, are within the design load envelope, with any wind sector management strategy to be included in a more detailed energy assessment.

In addition, for further steps of development of the **Project**, it is recommended to verify that the desired wind turbine model is suitable 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.