REGIONE SARDEGNA
Provincia del Sud Sardegna
COMUNI DI SAN NICOLÓ GERREI, ARMUNGIA, BALLAO, ESCALAPLANO, ESTERZILI, SEUI E SILIUS

IMPIANTO EOLICO DENOMINATO "ENERGIA MONTE TACCU"

Oggetto	PROGETTO DEFINITIVO	FORI-SNG-A2
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San Niccolò Wind Farm

Indicative Wind Resource Assessment

15 March 2022

1275426/A

Commercial in Confidence

Fred. Olsen Renewables Italy S.R.L.

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Contents

1. Summary

At the request of Fred. Olsen Renewables Italy S.R.L. (FORI) (the Client), an indicative wind resource assessment was carried out to gain an understanding of the predicted wind resource at the proposed San Niccolò Wind Farm project located between the communes of San Niccolò Gerrei to the west and Armungia to the east, in the province of South Sardinia, Italy.

This assessment provides an estimate of the wind resource ahead of on-site monitoring. The Client has provided details of the site location and boundary which have been reviewed by Natural Power in order to assess the complexity of the site. A preliminary layout consisting of ten turbines has also been provided by the Client. The San Niccolò site is located in a hilly and mountainous region, surrounded by steep slopes and hills. The site area identified loosely follows a ridge running north to south. The terrain is mostly covered in low-lying Mediterranean scrub vegetation with some areas of sparse small trees. Several communes and areas of agricultural land surround the site area.

Due to the highly complex terrain across the site and surrounding area, a 'Tier 2' wind resource assessment has been carried out to predict the wind resource through the application of the VENTOS/2® CFD model (VENTOS). Additionally, the VORTEX MAST product has been utilised in conjunction with the VENTOS flow model to estimate the wind climate at the San Niccolò site. The VORTEX MAST data was extracted from a location at the centre of the site as shown in Figure 2.2. The wind climate data obtained from the VORTEX MAST has been used in conjunction with the VENTOS modelling to analyse the wind speeds, and their variance across the project site, with a view to informing if the wind resource at the site is suitable for wind power development. Due to the indicative nature of this assessment, no consideration has been given to forestry growth or felling but given the topography of the site and nature of the existing vegetation, significant forestry growth is not anticipated.

The expected direction frequency distribution (wind rose), as derived from the VORTEX MAST, is presented in Figure 2.1 showing a predominance of winds from the north-west with a lesser component from the south-east.

The final hub height at the San Niccolò site has not yet been determined however for the purposes of this analysis, wind speed maps at 100 m and 125 m above ground level (AGL) have been produced. These maps are shown in Figure 2.2 and Figure 2.3 and highlight the variation in wind speed across the site.

In the absence of available nearby measurement data or suitable reference data sets, no correction to the wind speeds calculated by the VORTEX MAST have been applied. It should be noted that these speeds should be treated as highly indicative, and it is strongly recommended that they are validated through on-site monitoring. Validations of the VORTEX model has indicated that the model has a tendency to both under and over predict wind speeds across Italy. Therefore, it is not possible to determine if the MAST speeds are likely to be higher or lower than the on-site climate.

Areas of the project site which are not considered suitable for development due to elevated shear, turbulence, and inflow angle have been marked on the accompanying constraints maps, Figure 2.4 and Figure 2.5. These were derived through the use of the VENTOS model considering the parameters outlined in Section 2.3.

2. Results

2.1. Wind rose

Figure 2.1 presents the wind rose for the San Niccolò site at 100 m AGL, as predicted by the VORTEX MAST model. Natural Power strongly recommends that this is verified through the use of on-site measurements and that such measurements feed into any layout design process. It is noted that there could be significant variations in the wind direction distribution vertically and horizontally throughout the site, in addition to considerable veer, due to the terrain complexity.

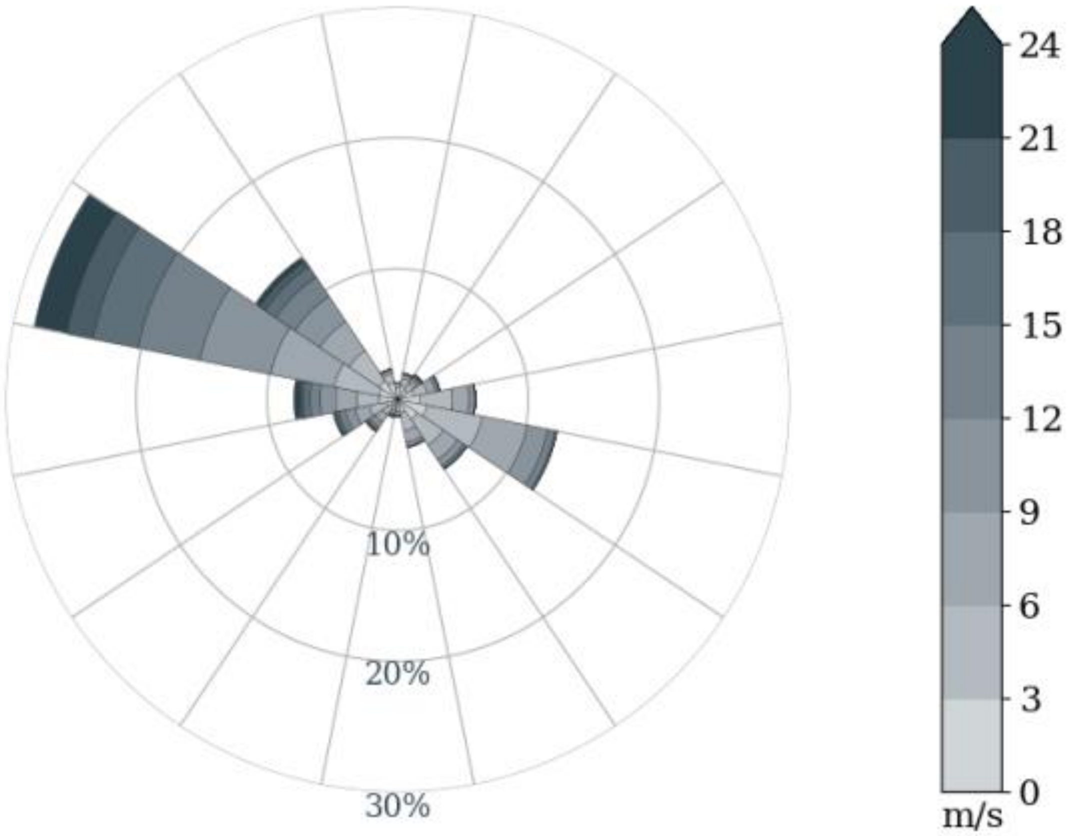

Figure 2.1: Long term wind rose at 100 m AGL predicted by VORTEX MAST

2.2. Wind speed map

For a georeferenced version of Figure 2.2 and Figure 2.3, please see documents 1275427 and 1275428, respectively. The site boundary as provided by the Client is represented by the single red line. The indicative turbine layout, as provided by the Client is indicated by the green markers.

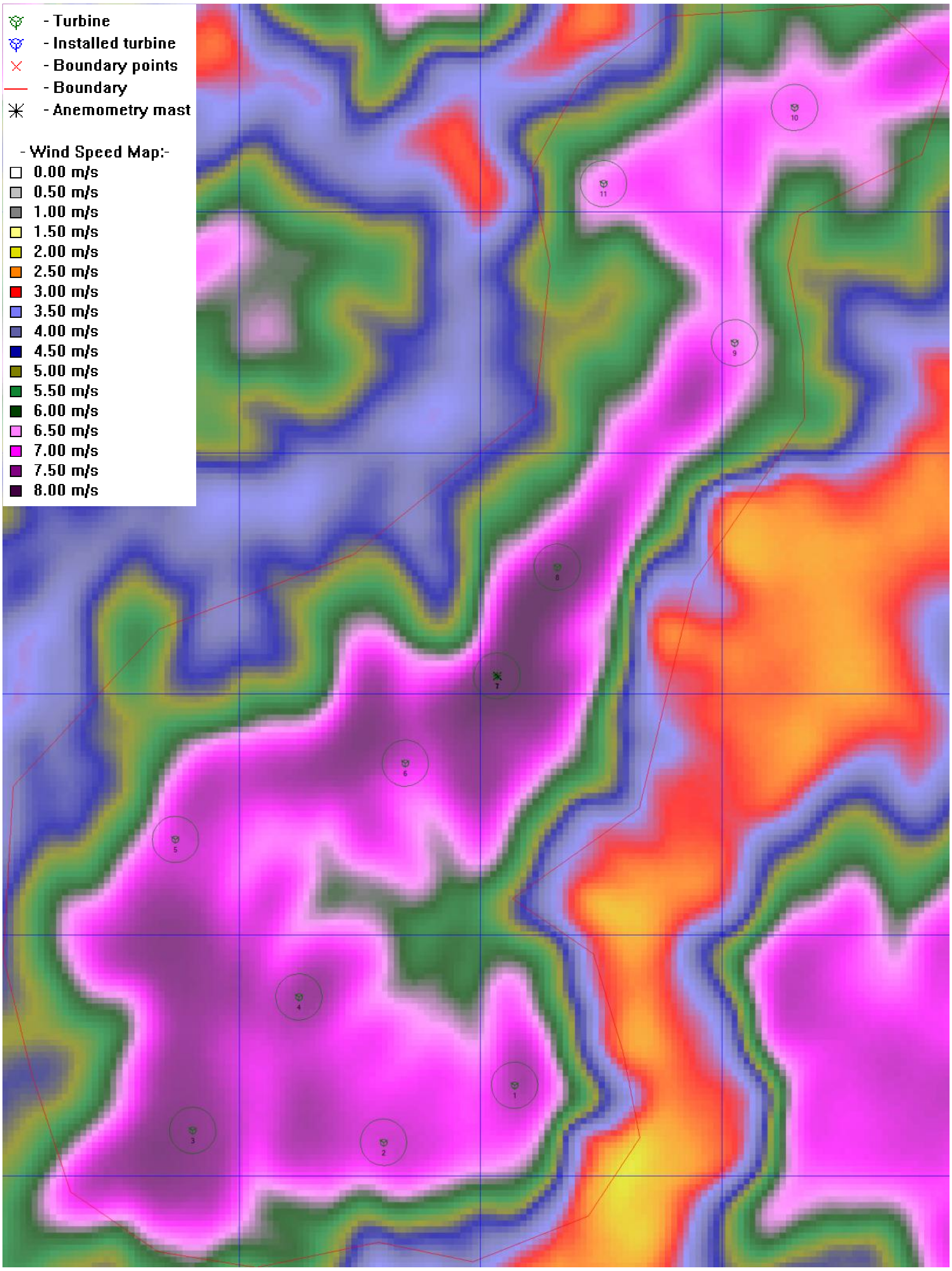

Figure 2.2: Wind speed map at 100 m AGL, anemometry mast denotes location of VORTEX MAST

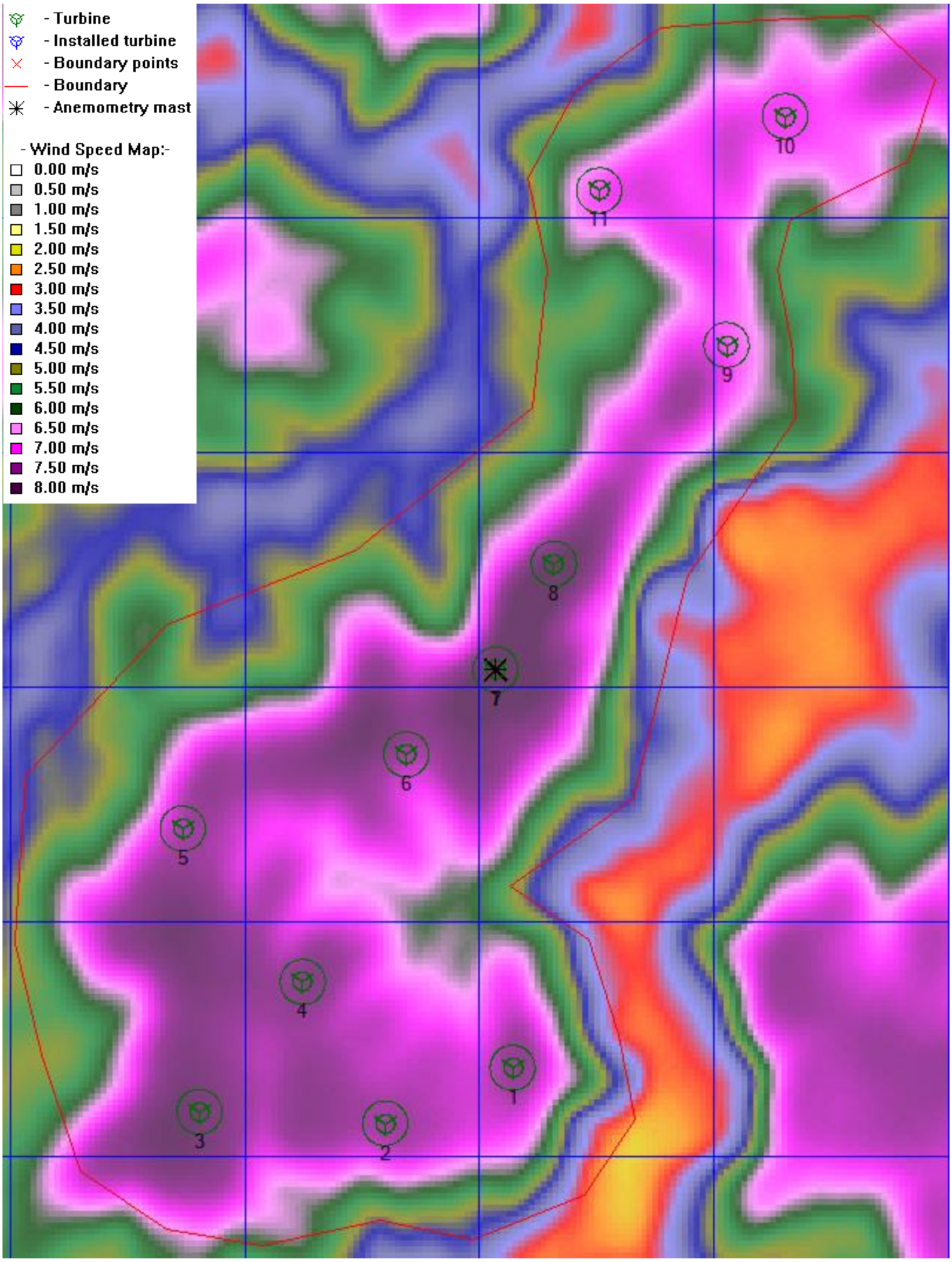

Figure 2.3: Wind speed map at 125 m AGL, anemometry mast denotes location of VORTEX MAST

2.3. Wind constraints map

The following wind constraints map has been produced by applying the following constraints at 100 m AGL to the outputs of the VENTOS Roughness model:

- Maximum inflow angle (vertical): 8 degrees
- Mean turbulence 18%
- Shear limit: 0.3
- Veer: +/- 90 degrees

The above constraint limits have been set as these generally align with the operational limits of most megawatt scale wind turbines available on the market. By considering the lower of the two hub heights under consideration, we are likely to see the worst-case scenario as wind flow complexity is generally higher closer to ground level.

Flow constraints have been analysed for two scenarios; firstly with all direction sectors considered (Figure 2.4) and secondly with only prevailing wind sectors (112.5, 292.5, 315.0 degrees) considered (Figure 2.5). Areas of the project site which are subject to wind flow conditions outside of the above constraints are coloured black. Based on the indicative analysis, these areas should be considered potentially unsuitable for the placement of many turbine models and should therefore be carefully considered when performing the site layout design. As expected, turbulence and shear conditions are expected to be highest across the steep slopes and at the edges of the plateaus. Flow conditions on the top of the plateaus and away from the edges are expected to be more reasonable. If only the prevailing sectors are considered, more of the site is classified as having operable wind flow conditions. It is noted that several turbines within the array provided by FORI are located in areas predicted to have complex flow conditions or on the edge of these areas, and should therefore be analysed in more detail once on-site data is available.

It is recommended that FORI engage early with turbine suppliers to determine what turbulence levels they would deem acceptable for operation of their turbines. It is also recommended that on-site monitoring is performed in order to more accurately understand the shear and turbulence at the site.

For georeferenced map versions of Figure 2.4 and Figure 2.5, please see documents 1275429 and 1275430.

Figure 2.4: Wind constraints map at 100 m AGL with San Niccolò boundary in red (all sectors considered). White denotes areas which are viable for turbine placement.

Figure 2.5: Wind constraints map at 100 m AGL with San Niccolò boundary in red (prevailing sectors considered). White denotes areas which are viable for turbine placement.

3. Recommendations

The results from this assessment are indicative only and are not supported by on-site wind climate measurements. It is recommended that if the development of the San Niccolò project progresses, on-site monitoring is conducted in order to gain a more accurate representation of the wind climate and wind flow conditions. It is noted that due to the complexity of the site, wind conditions can be expected to vary across the development area, therefore it may be necessary to monitor in several locations to understand the conditions across the whole site.

Whilst the wind constraints map provided allows an indicative assessment of areas which may be suitable for turbine placement within the site boundary, it is highly recommended, given the site complexity that the model is refined with on-site data when available. Further investigation work is required following the availability of on-site measurements in order to first confirm the assessed shear and turbulence values and then subsequently assess which turbine models on the market are able to operate within these constraint limits. Turbine locations within the array that are currently within wind flow constrained areas should be examined in more detail once on-site data is available.

It is recommended that the information obtained from this analysis be applied to a layout optimisation for the site, considering any other known constrains for the site. Natural Power recommends that FORI engages with turbine OEMs at the earliest possible stage to confirm wind flow conditions at the site are suitable for turbine operation.

It is recommended that the information obtained from this analysis be applied to a layout optimisation for the site, considering any other known constrains for the site.

Appendices

A. List of accompanying documents

- SanNiccolo_SAR238_100m AGL_Wind Speed Map (1275427)
- SanNiccolo_SAR238_125m AGL_Wind Speed Map (1275428)
- SanNiccolo_Wind Flow Constraints_All Sectors_100m AGL (1275429)
- SanNiccolo_Wind Flow Constraints_Prevailing Sectors_100m AGL (1275430)

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