Validation of time-history data through in-situ measurements on a FOWT installed in the Cantabrian Sea

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INTRODUCTION AND ABSTRACT

This poster presents a comprehensive study on the validation of wind time history data and the wind resource estimation methodology, using measuring devices installed on an operational wind turbine in the Cantabrian Sea in Spain, DemoSATH floating wind demonstrator. The research includes an analysis of the accuracy and reliability of wind resource assessment methods, highlighting the importance of using on-site measurements to improve the precision of wind energy predictions. The findings provide valuable insights on the renewable energy sector, aiding in the optimization of wind farm performance and energy generation, crucial for achieving an accurate Levelized Cost of Energy (LCOE) model.

In addition to this device, the study has been expanded to a location further off the coast, which represents a more realistic operational scenario for a commercial wind farm. The data used for this analysis comes from wind measurements using an anemometer installed on the 'La Gaviota' gas platform, also in the Cantabrian Sea.

OBJECTIVES

- Validate the estimated wind profile at the DemoSATH site.
- Quantify the deviations in the wind speed estimation at the hub height.
- Quantify this deviation effect on wind energy.
- Analyse the wind profile in 'La Gaviota', a site that is further off the coast.
- Correlate 'La Gaviota', DemoSATH and GEROA.
- Quantify deviations from the initial wind speed calculation with "open source" data.
- Analyse the influence of wind direction on the profile.

DATA SOURCE VALIDATION

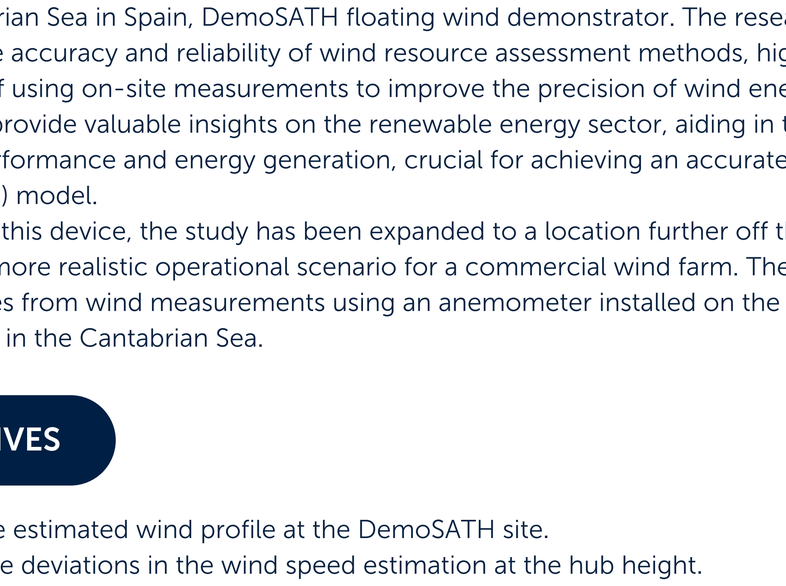


Figure 1. Different data sources location [2][3]

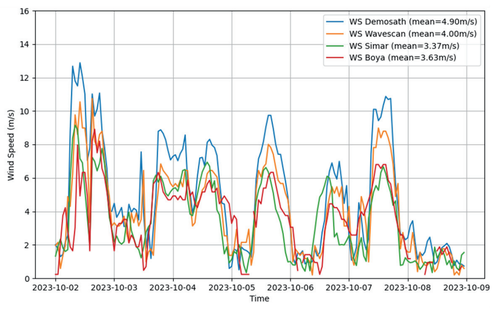


Figure 2. Comparison of wind speed raw data for different sources (DemoSATH)

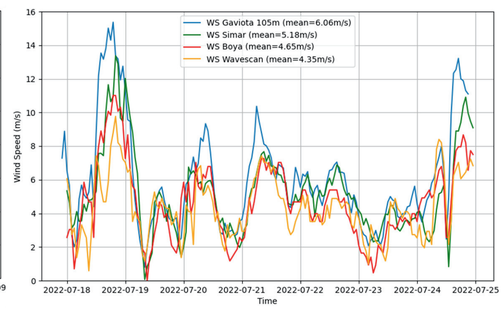
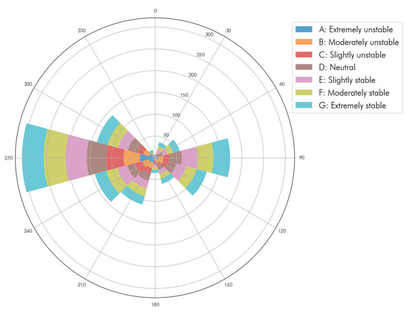


Figure 3. Comparison of wind speed raw data for different sources ('La Gaviota')

WIND PROFILE ANALYSIS

Atmospheric Stability



Wind Direction (º)	A Extremely unstable	B Moderately unstable	C Slightly unstable	D Neutral	E Slightly stable	F Moderately stable	G Extremely stable	Total (%)
0,00	0,00	0,00	0,00	0,08	0,16	0,16	0,16	**0,58**
30,00	0,08	0,16	0,16	0,41	0,74	0,74	0,74	**3,05**
60,00	0,25	0,25	0,41	0,66	0,99	1,07	1,24	**4,86**
90,00	0,66	0,91	1,24	2,31	2,97	3,05	3,13	**14,26**
120,00	0,66	0,99	0,99	1,65	1,90	1,98	1,98	**10,14**
150,00	0,41	0,58	0,66	0,74	0,82	0,91	0,99	**5,11**
180,00	0,16	0,33	0,41	0,41	0,49	0,49	0,58	**2,89**
210,00	0,99	1,07	1,07	1,40	1,48	1,48	1,65	**9,15**
240,00	1,24	1,24	1,40	1,57	1,98	2,14	2,23	**11,79**
270,00	2,89	3,05	3,30	3,71	4,04	4,12	4,12	**25,23**
300,00	1,15	1,15	1,15	1,90	1,90	2,06	2,06	**11,38**
330,00	0,08	0,08	0,08	0,25	0,25	0,33	0,49	**1,57**
Total (%)	**8,57**	**9,81**	**10,88**	**15,09**	**17,72**	**18,55**	**19,37**	**100,00**

Figure 4. Atmospheric stability class with vertical temperature gradient [2],[3].

Validation of wind profiles in DemoSATH & 'La Gaviota'

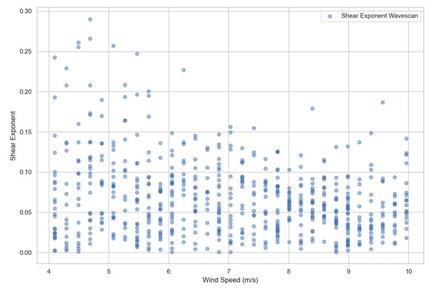


Figure 5. Shear exponent values versus wind speed in DemoSATH

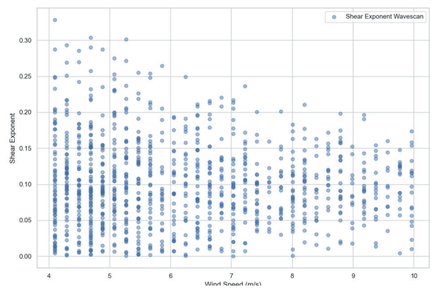


Figure 6. Shear exponent values versus wind speed in 'La Gaviota'

Wind shear exponent directionality analysis

Figure 7. Wind shear coefficient breakdown by direction

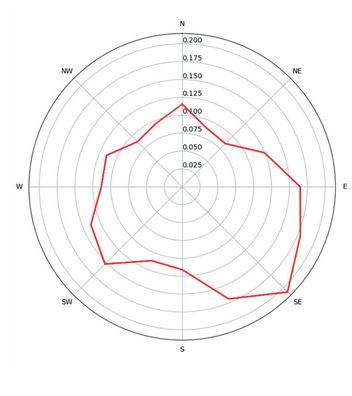


Figure 8. Mean wind shear coefficient by direction

Validation of wind profiles in DemoSATH & 'La Gaviota'

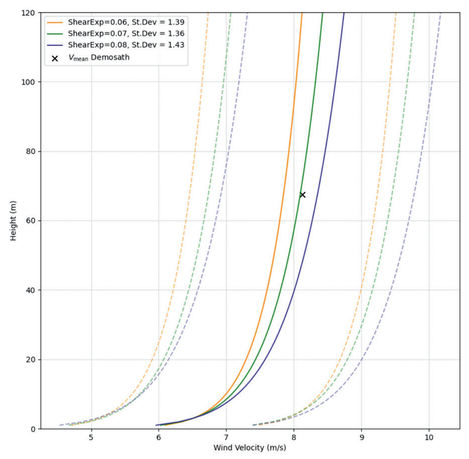


Figure 9. Vertical wind profile estimation in DemoSATH

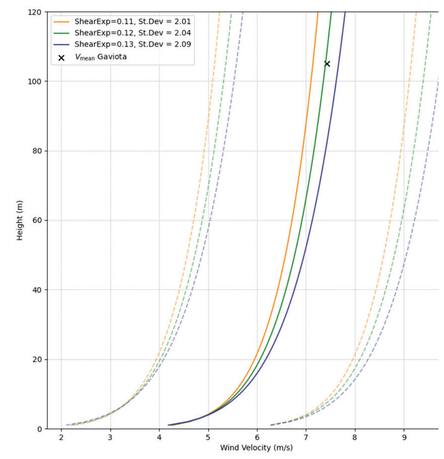


Figure 10. Vertical wind profile estimation in 'La Gaviota'

Production analysis

Table 1. Production variability

Site	α_{Real}	$\alpha_{standards}$	AEP deviation
DemoSATH	0.07	0.14	23%
La Gaviota	0.12	0.14	7%

* Shear exponent (α) of 1/7 is commonly assumed for offshore conditions and is also recommended for neutral atmospheric stability conditions by the IEC61400-2IEC standard [4]. However, this value is not applicable to all site conditions, as demonstrated.

CONCLUSIONS

- The data from the different sources has been validated:
  - The trend of the wind speeds are higher in higher altitudes, as expected.
  - The directionality difference between sources reach ±15º deviation in the measurements taken at a greater distance.
- Atmospheric stability has been analysed, concluding that neutral scenario is only reached at the 15% of the total time studied. Moreover, the stability is very variable. Longer period of measuring time would be of need to make better conclusions. It will be done in later studies.
- A high variability shear exponent has been outcomed. The data has been cleaned and wind speeds over 4m/s have only been considered due to the large disturbance produced by lower wind speeds data, which presented extreme shear components when being analysed.
- Higher shear exponent values have been obtained for winds coming from southern direction than northern. This is consistent with previous shear coefficient studies carried out in the same zone.
- It has been proven that the wind profile is less vertical the greater the distance from the coast is. At 'La Gaviota' site, 8 km off the coast, the shear exponent is 0.12 while at DemoSATH, 4 km off the coast, it is 0.07.
- In view of the observed trend, and in the absence of in-situ measurement data, for GEROA project, a precommercial wind farm that is being developed by Saitec Offshore Technologies and that will be located 10km off the same coast, the use of 1/7 shear exponent will be considered as an acceptable approach.
- It has been demonstrated the importance on the correct estimation of the wind profile looking at the production results. The use of the standard 1/7 shear exponent can lead to big deviations from reality in the production estimation. In the case of DemoSATH data, the wind resource would be overestimated in a 23% if the recommended shear exponent was used. However, in the case of 'La Gaviota', only in a 7%. This is why it is crucial to have real measurements data and to make a good and comprehensive site analysis to finally ensure the correct estimation of the AEP, influencing directly the LCOE of the project.

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