Study of the impact on offshore wind energy of subtropical weather conditions.

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AIRE Project

AIRE Project [1] s*tarted in January 2023 to explore the wind resource at different altitudes and site typologies (onshore-offshore-flat-complex terrain) and enlarge the study including precipitation and sand particles present in the air. With this information the existing models and tools will be improved, and new ones will be developed. This will help to design and control more efficient wind turbines suitable to operate in a wider range of sites and conditions with a special focus on wind turbine blade erosion study and mitigation. The optimization of wind farm operations with weather intelligence will improve wind farms' performance and protection.*

Knowledge & Data Hub:

- Measurements at 8 experimental and commercial sites across Europe.
- Micro Rain Radar, Disdrometers, Lidar
- Radiometer, Particle aerosols (with high volume collector), Meteorological stations
- Solar radiation sensor
- Blade Status & Wind Turbine Scada
- Satellite data calibration

Subtropical Site

One of the AIRE's experimental campaigns is committed to study the impact of subtropical climate conditions on wind energy efficiency. It is performed at Plocan's open ocean test site, where an onshore SG132 wind turbine (Figure 1) is deployed and meteorological conditions are continuously monitored. The particularity of this site is the occurrence of frequent events with high dust concentration that comes from the Saharan Desert [2].

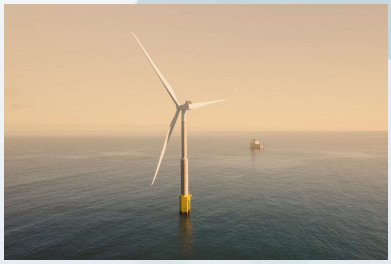

Figure 1. ELICAN experimental wind turbine deployed in Plocan's test site. Coordinates: https://maps.app.goo.gl/Ge6QWuYjqb3joWiU8

The available instrumentation for this test campaign (Figure 2) is:

• Air quality station, Kunak air quality monitor model Kunak AIR Pro. It monitors 5 gas pollutants (NO2, NO, CO, O3 and SO2) and multiple sizes of particles simultaneously (RANGE 0-2.000 µg/m3; PM1.0, PM2.5, PM4, PM10), as well as meteorological variables, providing continuous and real-time data on the ambient air.

• LIDAR, vertical profiling lidar offshore model ZX300M. It records offshore wind measurements (horizontal and vertical speed and wind direction) in the range of 10 to 200 meters.

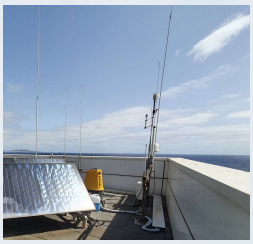

Figure 2. Site instrumentation, LIDAR (yellow equipment) and air quality station (white one)

Results

In the measurement period between May 2023 and June 2024, 21 African dust intrusion events were identified in the Canary Islands. All these events had high concentrations of PM's (particulate matter) that were recorded at the air quality station, see Figure 3.

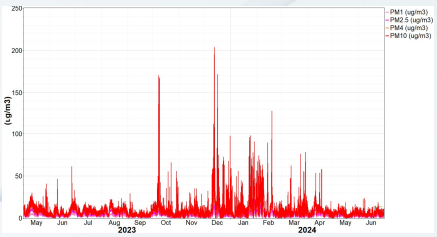

Figure 3. PM's concentrations recorded in Plocan's air quality station.

December 13, 2023, an event in which the maximum PM10 value was recorded at the PLOCAN station (203.83 µgm^{-3}). Figure 4 presents the prediction made with the Multiscale Online Nonhydrostatic AtmospheRe CHemistry model (MONARCH [3]) for that day.

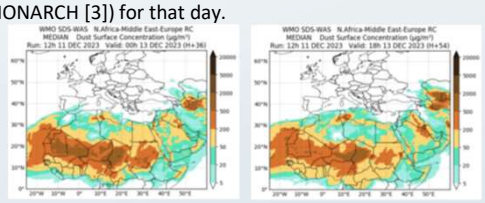

Figure 4. Results of MONARCH (median in µg/m3) for 13 December 2023 at 00h UTC (left) and 18h UTC (right). Sand and Dust Storm Warning Advisory and Assessment System Regional Center for Northern Africa, Middle East and Europe (SDS-WAS NAMEE RC) [4], jointly managed by the State Meteorological Agency [5] and Barcelona Supercomputing Center[6].

At the time of the highest concentration of suspended particles in the data recorded by the LIDAR (Figure 5) it can be observed that the wind speed is below 4 m/s (the wind turbine was not in operation), the wind direction is from the north (although in the previous hours it had been mostly from the SE) and the availability of the lidar drops considerably for all heights.

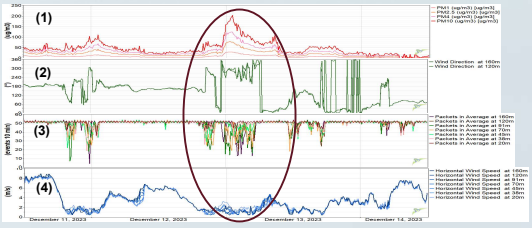

Figure 5. Data recorded in air quality station(1) and LIDAR, wind direction (2) availability (3) and wind speed (4).

Conclusions and next steps

In events with high dust concentrations:

- In the hours prior to the event, the predominant wind direction is S-SE.
- During the moments of greatest concentration, wind speeds are below 4 m/s, which means that the **wind turbine is not in operation**.
- The availability of lidar records decreases during the moments of highest concentrations.

The **next step** in this analysis will be to analyze wind farm production in the moments following situations of high dust concentrations.

References

[1] AIRE web (aire-project.eu/resources).

[2] M. D. Gelado-Caballero, P. López-García, S. Prieto, M. D. Patey, C. Collado, and J. J. Hernández-Brito, "Long-term aerosol measurements in gran canaria, canary islands: Particle concentration, sources and elemental composition," Journal of Geophysical Research: Atmospheres, vol. 117, no. D3, 2012.

[3] https://dust.aemet.es/about us/monarch.

[4] http://sds was.aemet.es.

[5] https://www.aemet.es/es/portada.

[6] https://www.bsc.es/.

AIRE web (aire-project.eu/resources)

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