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METOCEAN SPECIFICATIONS FOR WIND DATA BASE ON THE BLACK SEA

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Abstract : In this paper we present the steps to establish a design of floating wind turbine in offshore area. In order to be able to design a floating wind turbine in the offshore area of the Black Sea, data about the wind potential, the potential of waves and sea currents are needed, as well as wave-wind cross-data and other atmospheric data. It is assumed that the location of the floating turbine is the area of the Galata platform, Varna, Bulgaria, located at 25 km south-east of the city of Varna in the South-West Black Sea area. The wind dataset can downloaded from a server in NetCDF file form. The spatial data are used to generate wind maps showing the distribution of the mean wind speed for the full-time distribution (i.e. total time) and for the four seasons, respectively.

Key words : renewable energy, wind speed, floating wind turbine, metocean wind data.

1. INTRODUCTION

Romania could produce 4 times more electricity than it currently produces through all installed capacities, if it capitalized on its wind potential in the Black Sea. Wind farms are sold from the project stage, but investments are blocked by the delay of the law.
Romania's annual electricity production could reach 239 million MWh (239 billion kWh), by exploiting the wind potential of the Black Sea. An output of 54.4 million MWh could be achieved by turbines fixed to the seabed alone, according to a study by the Energy Policy Group (EPG).

The wind energy potential of the Romanian continental shelf of the Black Sea was confirmed in the fall of 2020 by the EPG study, which identifies here a total natural capacity of 94,000 MW (94 million kW) of wind energy in the Romanian offshore sector. Several previous publications have focused on the assessment of Romania's wind offshore resources [1]. These studies come with several elements of novelty, like: new wind database (ERA5) (Fig. 1)[1], [2], wind speed reported to a hub height of 100 m (U100)(Fig. 2)[1],[2], evaluation based on state-of-the-art wind turbine, maritime spatial planning mapping (depth for floating systems more than 50 m) (Fig. 3)[1], [2].

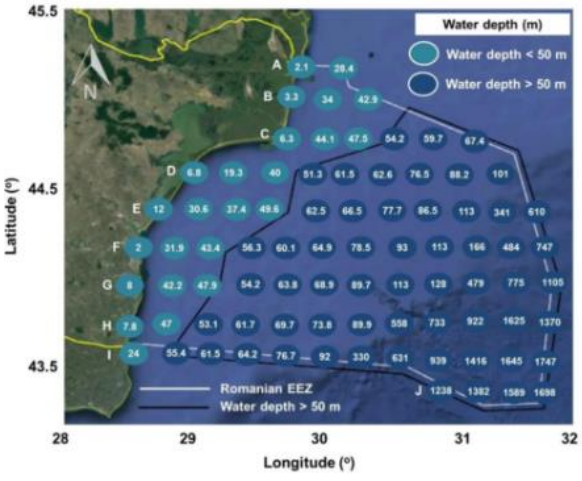

Figure 1. The depths in the exclusive commercial area of the Black Sea, Romania [1], [2]

In order to be able to design a floating wind turbine in the offshore area of the Black Sea, data about the wind

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potential [3], the potential of waves [4] and sea currents are needed [5], as well as wave-wind cross-data and other atmospheric data [6], [7], [8]. It is assumed that the location of the floating turbine is the area of the Galata platform, Varna, Bulgaria, located at 25 km south-east of the city of Varna in the South-West Black Sea area [9].

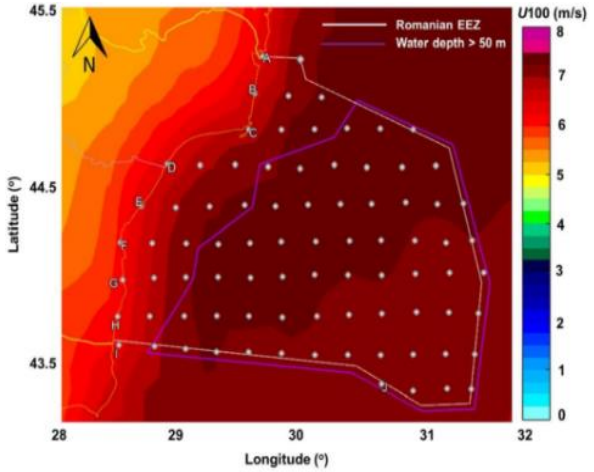

Figure 2. Wind speed at 100 m height [1], [2]

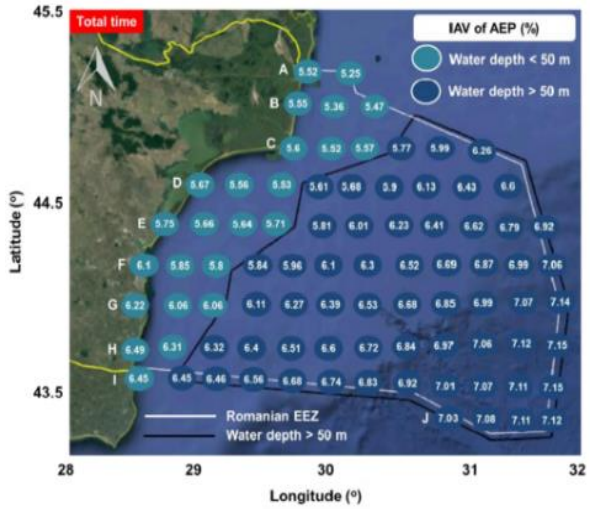

Figure 3. Black Sea's energy production [1], [2].

The wind dataset can downloaded from a server in NetCDF file form. The spatial data are used to generate wind maps showing the distribution of the mean wind speed for the full-time distribution (i.e. total time) and for the four seasons, respectively.

2. BASIC METEOROLOGICAL DATA

For this metocean data study, we will take the Galata oil and gas station as the GPS reference point (Fig. 4), Table 1[10]:

Table 1. GPS location

Latitude	43.044528°
Longitude	28.193333°

Figure 4 Galata platform location [9]

The status of seas can obtain with different operational forecast systems [11]. We don't have much information on GALATA platform, EuxRo01, EuxRo03 and CG Meteo sensors (Fig.5)[10].

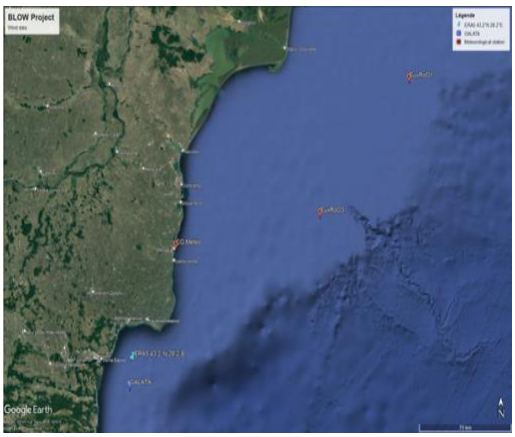

Figure 5. Location of the points with available wind data.[10]

For this study the reference data is ERA5. We must validate the coherence and area representativeness of ERA5 data (Fig. 6)[10], [12].

Regarding ERA5, we use a long-term period of 15 years (2008-2022), looking at the point 43.2°N 28.2°E that have the highest daily correlation with GALATA wind speed measurement. ERA5 combines vast amounts of historical observations into global estimates using advanced modelling and data assimilation systems.

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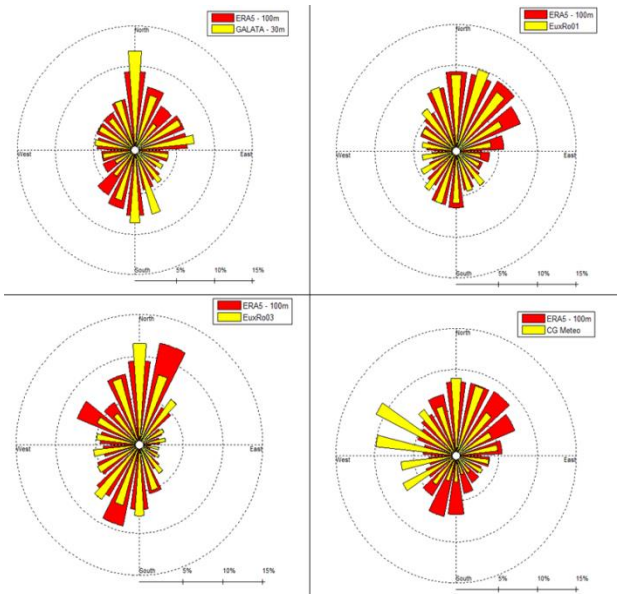

Figure 6. Wind rose of different wind data sources [10], [12]

During period 2008-2022 the wind rose at 100m hub height of wind turbine is presented below (Fig. 7) [12]:

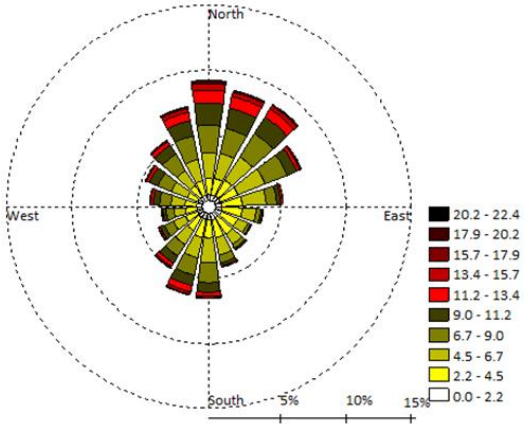

Figure 7. Wind rose over the study area - 100m [12].

Finally, can conclude that ERA5 wind direction is coherent with wind direction measured at GALATA platform and at EuxRoO1 and EuxRoO3 buoy, excepting some slight deviation in certain sectors. ERA5 is not coherent with the wind direction measured at CG Meteo, but as this point is located near shore (less than 2km from the cost), the wind is impacted by ground effect and we can conclude that this meteorological station is not representative of the GALATA offshore wind condition.

We will also can compare the results from data wind described to scientific publication dealing with Black Sea at different height of hub (Fig. 8)[9], [13]-[15].

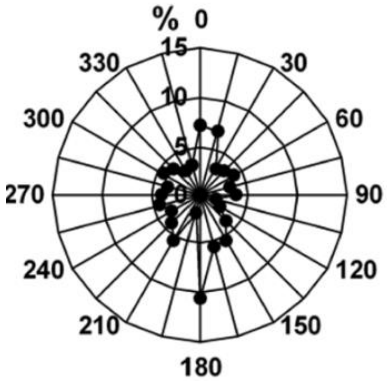

Figure 8. Wind rose from GALATA platform for the winter 2006-2007 at 30m height [9].

This wind rose presents main wind direction from the South (around 180°) and the North (around 5°).

3. WIND VELOCITY DISTRIBUTION

- *Long term wind speed*

We use in this section only the wind data measured at GALATA station and ERA5 data because the wind speed measured at EuxRoO1 and EuxRoO2 are not well correlated to the wind speed of ERA5 in daily values (<60% correlation). GALATA station and ERA5 data have 81% correlation in daily wind speed during the year 2008 (Fig. 9).

Figure 9. GALATA old station

The wind speed measured at GALATA platform (Fig. 10) is 5.5 m/s at 30m during the year 2008 (Fig. 11).

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Figure 10 GALATA Platform (photo)

Figure 11.Testing the position of the wind, pressure, precipitation, solar radiation sensor system (photo)

With a MCP method (Measure-Correlate-Predict) with ERA5 daily data, we find that the long-term wind speed is 5.7 m/s at 30m at GALATA platform for the 15 years long-term period 2008-2022.

- *Vertical wind speed profile*

Different sources give us information about the wind speed in the area: atlas from Global Wind Atlas (GWA), New European Wind Atlas (NEWA), Vortex, reanalysis from ERA5 and measured data from GALATA platform. From the different sources, we can estimate the mean wind speed at 100m on the area of the GALATA platform at 6.5 m/s with a quite high uncertainty of 0.4 m/s. Based on ERA5 wind data during the period 2000-2019, the wind speed at 100m can be evaluated around 5 m/s [17]. With other sources of data, [18] wind speed between 5.5 and 6.5 m/s at 10m for the period 1987-2009. The evaluation of wind speed is more precise studying measured data on site like the GALATA platform measurements.

The long-term wind speed over a 15 years period 2008-2022 is evaluated with GALATA in situ measurements and ERA5 data around 5.7 m/s at 30m and around 6.5 m/s at 100m (probabilistic, Weibull distribution)[19, 20, 22].

- *Extreme wind*

In this case study was used the information of wind speed from ERA5 data from 1996 to 2022, corrected to compute 6.5 m/s over the GALATA area at 100m. Over this 27 years period, the maximum wind speed value in a 1-hour resolution is 23 m/s.

This time series allow us to evaluate the extreme values adjusting the generalized extreme value distribution to the data. There are several models for calculating extremes, here we have based our analysis of extremes on one model: GEV.

The return periods are the following, for a 1-hour mean wind speed (Table 2)[12]:

Table 2. Generalized extreme value of wind speed at 100m

Return period [year]	1	5	10	25	50	100
Wind speed [m/s]	16,3	20,7	21,4	22,3	22,9	23,6

It can observe that the extreme wind speed is evaluated at 21.4 m/s for a 10 years period and 23.6 m/s for a 100 years period.

4. CONCLUSIONS

The results are presented for ERA5 data at 100m for the period 2008-2022 and for GALATA data measured at 30m for the year 2008 with 1 hour resolution data.
As we don't have much information on the configuration of the sensor on GALATA platform, we can't evaluate if it is shadowed by the platform in certain sectors and we advise to use ERA5 data information.

- The main wind direction observed are the Northern sector (from 315° to 75°) and from the Southern sector (from 165° to 235°). The highest wind speeds are distributed over all those wind directions.
- The long-term wind speed is 5.7 m/s at 30m at GALATA platform for the 15 years long-term period 2008-2022.
- that the extreme wind speed is evaluated at 21.4 m/s for a 10 years period and 23.6 m/s for a 100 years period.

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6. REFERENCES

[1] EPG, ROMANIA'S OFFSHORE WIND ENERGY RESOURCES , https://enpg.ro/wp-content/uploads/2022/03/EPG_Wind-Offshore-report_Final_Nov-16.pdf https://cursdeguvernare.ro/parcuri-eoliene-marea-neagra-legislatie-investitii-se-vand-din-faza-de-proiect-putere-instalata.html

[2] Akhipkin, V. (2014). *Wind wave in the Black Sea : results of hindacast study*, Nat. Hazards Earth Syst. Sci. Discuss., 2, 1193–1221, 2014 www.nat-hazards-earth-syst-sci-discuss.net/2/1193/2014/ doi:10.5194/nhessd-2-1193-2014. Accesed https://nhess.copernicus.org/preprints/2/1193/2014/nhessd-2-1193-2014.pdf

[3] Divinsky, B. (July 2019). *Extreme wind waves in the Black Sea*, Oceanologia, Volume 62, Issue 1, January–March 2020, Pages 23-30, https://doi.org/10.1016/j.oceano.2019.06.003

[4] I.Medvedev. (June 2018). *Tide in the Black Sea observation and numerical modelling*, Pure and Applied Geophysics 175(6):1951–1969, DOI:10.1007/s00024-018-1878-x

[5] M.Bernardino, L. &. (March 2020). *Evaluation of storm waves in the Black Sea*, Journal of Operational Oceanography, Volume 14, 2021 - Issue 2, page 114-128. Accesed https://www.tandfonline.com/doi/full/10.1080/1755876X.2020.1736748?scroll=top&needAccess=true&role=tab

[6] Bosneau, R. (s.d.). *Physical – Geographical conditions influence on the Black Sea climatic factors evolution*, https://crossculturenvironment.files.wordpress.com/2016/05/art-7-romeo-bosneagu.pdf

[7] Rusu, L., Raileanu, A. B., & Onea, F. (2018). *A comparative analyss of the wind and wave climate in the Blanck Sea along the shipping routes*, Water 2018, 10(7),924; https://doi.org/10.3390/w10070924.

[8] Palazov A., Ciliberti S.A., Peneva e., et.all.(2019).*Black sea Observing System*, Frontieres in marine sciences, DOI: 10.3389/fmars.2019.00315

[9] Valorem L'Energie D'Agir, (2023). *Processing basic meteorological data in order to obtain integrated data of the "standard metocean*",Constanta, Romania

[10] https://skyclear.ro/seastate.html, accesed 13.02.2023

[11] CMU, BLOW project, (2023)

[12] Antonia Kokalova, (2023, Jan 26). *First offshore wind project in Bulgaria to power Petroceltic gas field*, SOFIA. Accesed https://seenews.com/news/first-offshore-wind-project-in-bulgaria-to-power-petroceltic-gas-field-812489.

[13] Bajo M. and Umgiesser G., (2010). *Storm surge forecast through a combination of dynamic and neural network methods*. Ocean Modelling, Vol. 33 (1-2), 1-9, doi:10.1016/j.ocemod.2009.12.007.

[14] http://kassandra.ve.ismar.cnr.it:8080/kassandra/model-description.

[15] http://kassandra.ve.ismar.cnr.it:8080/kassandra/black-sea, accesed 13.02.2023.

[16] Raileanu, A. B., Onea, F., & Rusu, E. (2020). *Implementation of Offshore Wind Turbines to Reduce Air Pollution in Coastal Areas - Case Study Constanta Harbour in the Black Sea.* Journal of Marine Science and Engineering, *8*(8), 550; https://doi.org/10.3390/jmse8080550.

[17] Toderascu, R. (2013). *Evaluation of the circulation patterns in the Black Sea using remotely sensed and in situ measurement.* International Journal of Geosciences > Vol.4 No.7, September 2013, DOI: 10.4236/ijg.2013.47094

[18] R. Toderascu and L. Rusu, (2012). "*Study on the Currents Variability and Patterns in the Black Sea*," 12th International Multidisciplinary Scientific GeoConference SGEM 2012, 17-23 June 2012, pp. 825-832.Accessed: http://sgem.org/sgemlib/spip.php?article2190

[19] R. Toderascu and E. Rusu, (2012). "*Implementation of a Global Circulation Modeling System for the Black*

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ISSN (Print): 1844-6116
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https://www. jmte.eu

Sea Basin," 12th International Multidisciplinary Scientific GeoConference SGEM 2012, 17-23 June 2012, pp. 739-746. Accesed http://sgem.org/sgemlib/spip.php?article2179&lang=en

[20] E. Rusu and S. Macuta, (2009). "*Numerical Modelling of Longshore Currents in Marine Environment*," Environmental Engineering and Management Journal, Vol. 8, No. 1, 2009, pp. 147-151.

[21] G. Korotaev, T. Oguz, A. Nikiforov and C. Koblinsky,(2003). "*Seasonal, Interannual, and Mesoscale Variability of the Black Sea Upper Layer Circulation Derived from Altimeter Data*," Journal of Geophysical Research, Vol. 108, No. C4, 2003, p. 3122. doi:10.1029/2002JC001508

[22] Vasilescu M.V., Dinu D.,(2020). *Wind energy capturing devices with possible implementation on container ships*.Journal of Marine Technology and Environment, issue.2, page 49-52, https://jmte.eu/wp-content/uploads/2021/07/JMTE-vol.-II-2020.pdf