ECAS 2020
The 3rd International Electronic Conference on Atmospheric Sciences
16–30 NOVEMBER 2020 | ONLINE
atmosphere MDPI

WIND ENERGY ASSESSMENT DURING HIGH IMPACT WINTER STORMS IN THE IBERIAN PENINSULA

Ana Gonçalves[1,2]*, Margarida L. R. Liberato[2,3], Raquel Nieto[1]

[1]Environmental Physics Laboratory (EPhysLab), CIM-UVigo, Universidade de Vigo, Ourense, Spain
[2]Instituto Dom Luiz, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal
[3]Universidade de Trás-os-Montes e Alto Douro, UTAD, Quinta de Prados, 5000-801, Vila Real, Portugal
*Correspondence: ana.redondo.goncalves@uvigo.es

MOTIVATION

- **Wind energy** is one of the fastest growing technologies to produce **renewable energy**, the wind resource has proven to be a **renewable**, **efficient** and **clean energy source**, with a high potential for reducing greenhouse gas emissions [1].

- **Iberian Peninsula**, the two countries, **Portugal and Spain**, is one of the regions of the world with **more installed wind power** per capita and where wind energy plays a key role in the **renewable energy mix** [2].

- In **Spain**, wind production remains the main renewable source during the year 2019, with an installed capacity of 25 799 MW and represented 20.8% of total production of energy [3].

- In **Portugal**, wind energy has a 5 457 MW of installed capacity [4] which contributes with 27.5% of total electricity generation, corresponding to 12.3 TWh [5].

MOTIVATION

- During the December months of 2017, 2018, and 2019, IP was affected by several named high impact storms [7 -10]:
  - in **December 2017**, three named high impact storms (**Ana, Bruno**, and **Carmen storms**);
  - in **December 2018**, other three storms affected IP (**Etienne, Flora**) and **Oswald** or **Deirdre**;
  - in **December 2019,** three additional storms (**Daniel, Elsa**, and **Fabien storms**) affected IP with strong windstorms associated.

- This work aims provide a first assessment of **the available wind resource** and **wind energy potential (WEP)** during the considered December months (2017, 2018 and 2019).

DATA AND METHODS

- ERA5 Reanalysis [11] for the Iberian Peninsula region (35°N–45°N; 10°W–4°E):
  - the **10m wind components (10-meter U and V wind components)** for the three months of December (2017, 2018, 2019)
  - the fields were extracted at 00, 06, 12 and 18 UTC (6-hourly data)

- **Wind resource** available and the **wind energy potential (WEP)** is assessed for the three months separately.
  - the results are compared to the climatological average of 6-hourly values for the December months of the 30-year (1981-2010) period

- ERA5 10 m wind velocities (V_{10}) are extrapolated for the turbine height by:
  - the **logarithmic law**, where V is the windspeed at height H (135 m), V_{10} is the windspeed at height H_0 (often a reference height of 10 m), and z (0.03) is the roughness length coefficient [12, 13].

$$\boxed{\frac{V}{V_{10}} = \frac{\ln\left(\frac{H}{z}\right)}{\ln\left(\frac{H_0}{z}\right)}}$$

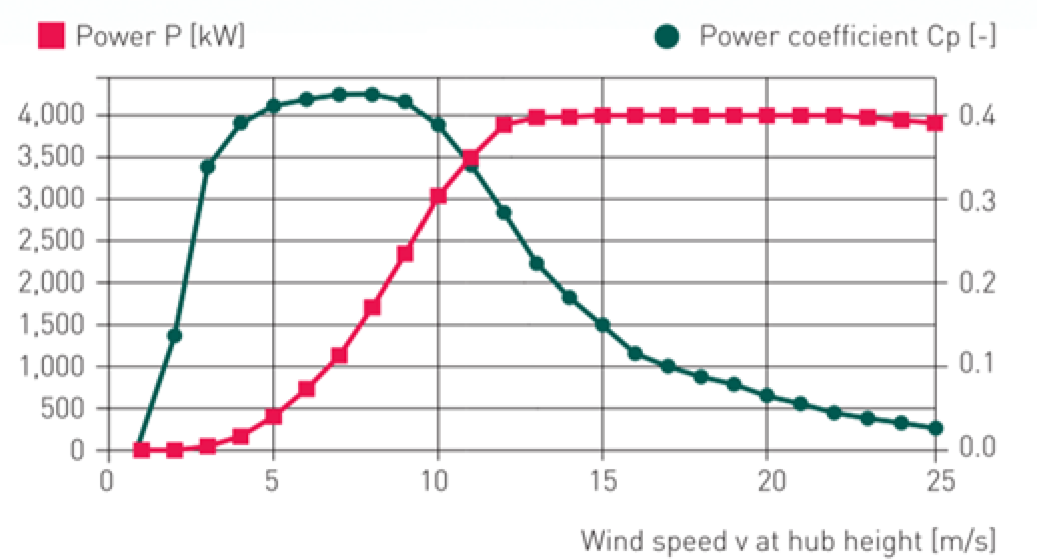
DATA AND METHODS

- The power output of a wind turbine (*Pout*), or **wind potential** (WP):

$$P_{out} = \frac{1}{2} C_p \rho \pi R^2 V^3$$

- The **wind energy potential** (WEP), or gross energy output (E), for a considered period (t):

$$\mathrm{WEP} = P_{out} \times t$$



Rated power	**4000 kW**
Wind rated speed	**13 m.s^{-1}**
Rotor diameter	**127 m**
Cut-in velocity	**3 m.s^{-1}**
Cut-out velocity	**25 m.s^{-1}**

Figure 1. Power curve (in kW) of the selected wind turbine (4 MW E-126 EP3, ENERCON) for wind speed ranging from 0 to over the cut-out velocity (25 ms^{-1}). Note the rated (maximum) power of 4000 kW, wind rated speed of 13 ms^{-1} (outlined by the vertical dotted line), rotor diameter of 127 m and cut-in velocity of 3 ms^{-1}. Adapted from: [14, 15].

RESULTS AND DISCUSSION

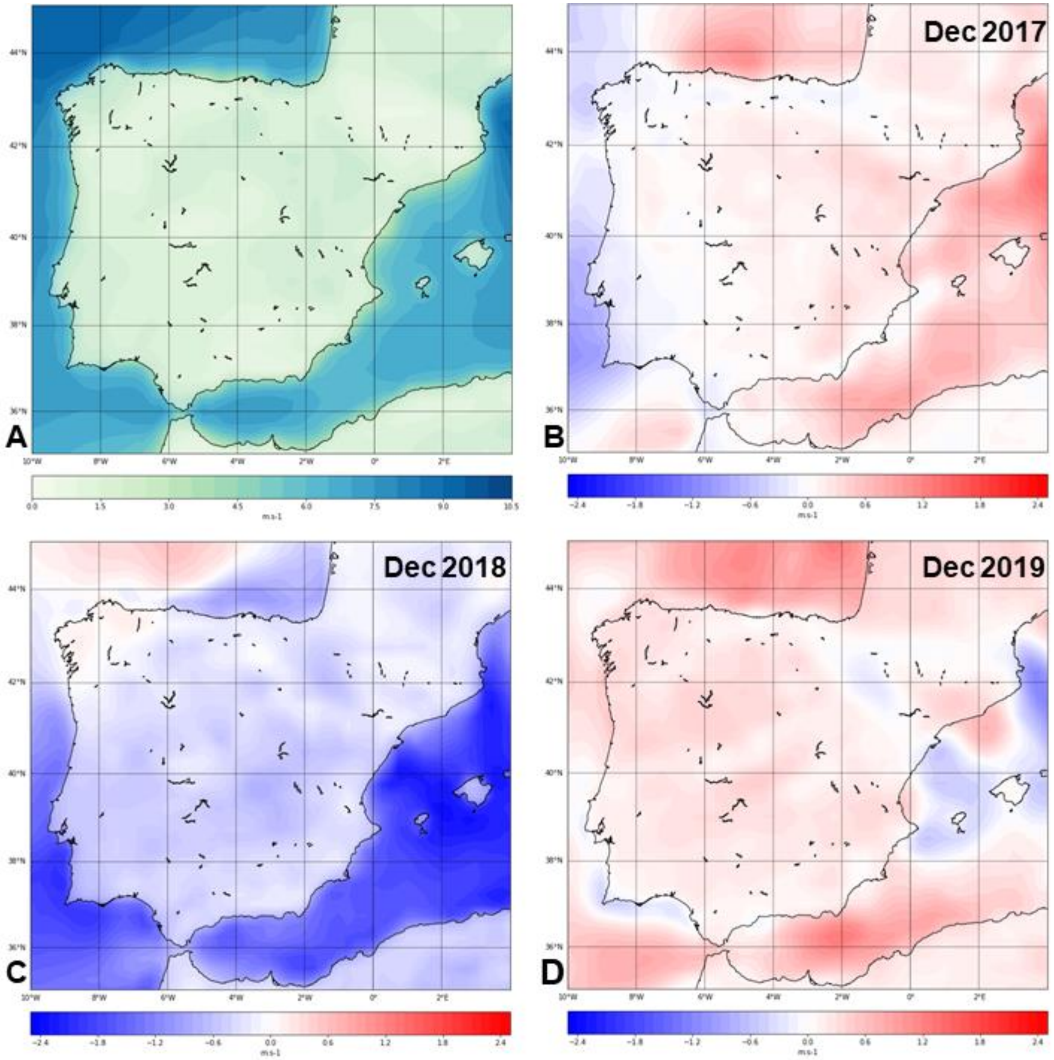


Figure 2. (A) Climatological average of ERA5 wind speed at 10m (m.s^{-1}), for the December months of 1981 to 2010; Anomalies of wind speed at 10m (m.s^{-1}) for December months of **(B)** 2017; **(C)** 2018; **(D)** 2019.

RESULTS AND DISCUSSION

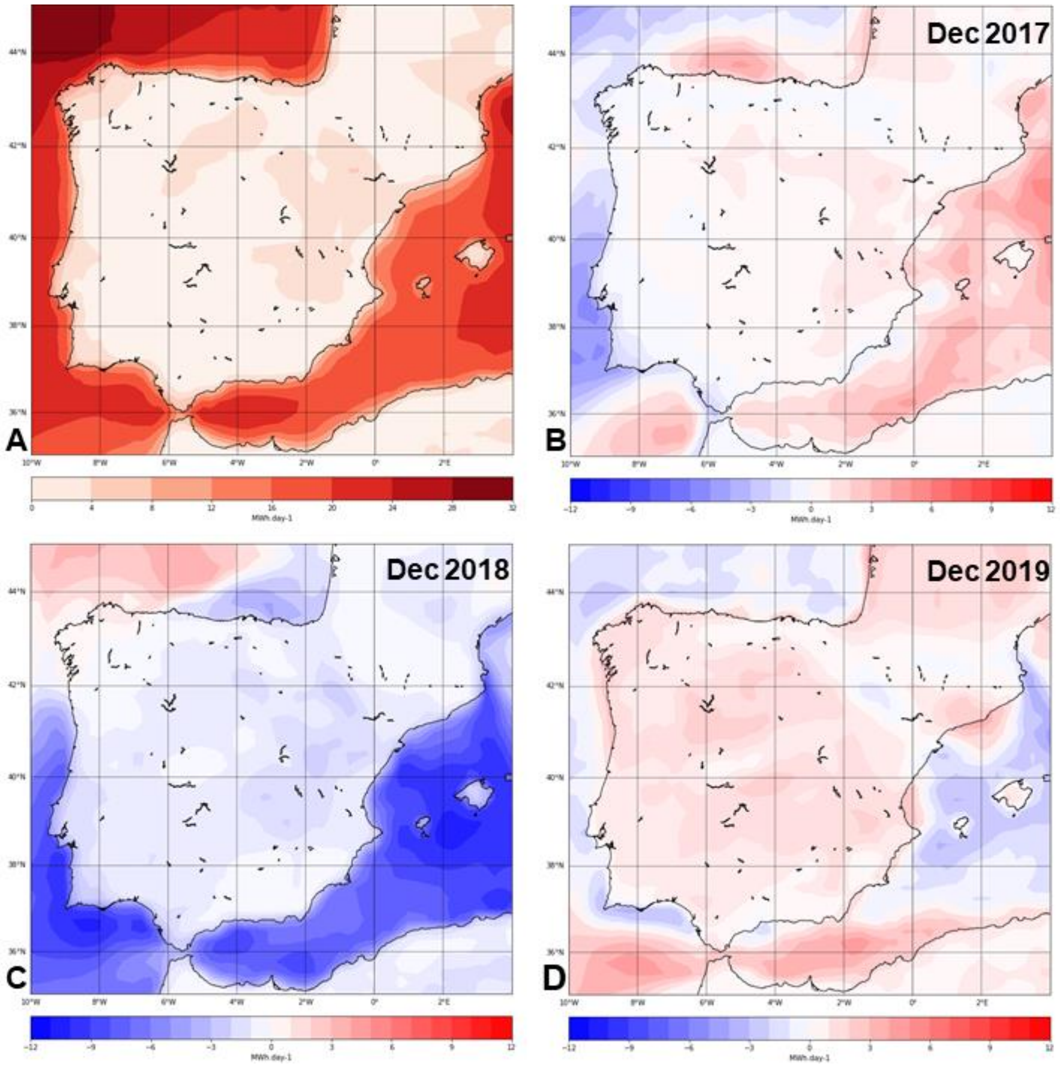


Figure 3. (A) Climatological average of Wind Energy Potential (WEP) (MWh.day^{-1}), for the December months of 1981 to 2010; Anomalies of WEP (MWh.day^{-1}) for December months of (B) 2017; **(C)** 2018; **(D)** 2019.

CONCLUSIONS

- The obtained theoretical values for the **wind energy potential (WEP)** are in line with the real values of electricity production from wind power in both countries, that is, **an increase in production in the months of December of the year 2017 and 2019**, and a **decrease in December 2018**.

- It was also confirmed that the **occurrence of high impact storms** with associated strong winds has **influence on the resource availability for energy production**, with the high values of the production of electricity registered in the days of the storms.

- However, the data used for this work **did not allow us to verify whether the passage of the storms caused** the **cut-off of the wind turbines**, due to the high values of the wind speed and strong gusts with different directions.

REFERENCES

1. El Khchine, Y., Sriti, M., & El Kadri Elyamani, N. E. (2019). Evaluation of wind energy potential and trends in Morocco. Heliyon, 5(6), e01830. https://doi.org/10.1016/j.heliyon.2019.e01830
2. Santos, F., Gómez-Gesteira, M., deCastro, M., Añel, J. A., Carvalho, D., Costoya, X., & Dias, J. M. (2018). On the accuracy of CORDEX RCMs to project future winds over the Iberian Peninsula and surrounding ocean. Applied Energy, 228(June), 289–300. https://doi.org/10.1016/j.apenergy.2018.06.086
3. RED Elétrica de España. Available online: https://www.ree.es/sites/default/files/11_PUBLICACIONES/Documentos/Renovables-2019.pdf (accessed on 07-09-2020).
4. Direção Geral de Energia e Geologia. Available online: https://www.dgeg.gov.pt/media/bbblbmb4/dgeg-arr-2020-07.pdf (accessed on 07-09-2020).
5. Associação de Energias Renováveis – APREN. Available online: https://www.apren.pt/contents/publicationsreportcarditems/boletim-energias-renovaveis-dezembro-2019-vf.pdf (accessed on 08-09-2020).
6. Instituto Português do Mar e da Atmosfera – IPMA (2020). Available online: https://www.ipma.pt/en/index.html
7. Agencia Estatal Meteorología-AEMet, (2020), Borrascas con gran impacto: Información divulgativa y de otras temporadas. Available online: http://www.aemet.es/es/conocermas/borrascas
8. Météo France (2020). Available online: http://www.meteofrance.com/accueil
9. Institut für Meteorologie. Met.fu-berlin (2020). Available online: http://www.met.fu-berlin.de/adopt-a-vortex/historie/
10. Met Office. Available online: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/interesting/2018/storm-deirdre---met-office.pdf (accessed on 09-09-2020).
11. Hersbach, H., Bell, W., Berrisford, P., Horányi, A., Sabater, J. M.,Nicolas, J., Radu, R., Schepers, D., Simmons, A., Soci, C., Dee, D (2019), "Global reanalysis: goodbye ERA-Interim, hello ERA5", ECMWF Newsletter, Vol 159, pp. 17–24, doi: 10.21957/vf291hehd7
12. Hoogwijk, M., de Vries, B., & Turkenburg, W. (2004). Assessment of the global and regional geographical, technical and economic potential of onshore wind energy. Energy Economics, 26(5), 889–919. https://doi.org/10.1016/j.eneco.2004.04.016
13. Masters, G. M. (2004). Renewable and Efficient Electric Power Systems. In Renewable and Efficient Electric Power Systems. https://doi.org/10.1002/0471668826
14. ENERCON – Energy for the World. Available online: https://www.all-energy.co.uk/__novadocuments/457177?v=636572338170430000 (accessed on 09-09-2020).
15. ENERCON – Energy for the World. Available online: https://www.enercon.de/en/products/ep-3/e-126-ep3/). (accessed on 09-09-2020).

FCT Fundação para a Ciência e a Tecnologia

Cofinanciado por:

PORTUGAL 2020

UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional

Acknowledgements

This work was carried out under the project "Weather Extremes in the Euro Atlantic Region: Assessment and Impacts — WEx-Atlantic" (PTDC/CTA-MET/29233/2017) and the Institute Dom Luiz (UIDB/50019/2020 - IDL) funded by the Foundation for Science and Technology, Portugal (FCT) and Portugal Horizon2020. Partial support was also obtained from Xunta de Galicia within the scope of Project ED431C 2017/64-GRC Consolidation and Structuring Program for Competitive Research Units (Competitive Reference Groups) and Consellería de Educación and Ordenación Universitaria, co-financed by the ERDF, under the Galician Operational Program 2014–2020.