Numerical weather forecasts supporting the Renewable Energy Sector (RES) in Poland

Joanna Wieczorek[1], Bogdan Bochenek[1], Jakub Jurasz[2], **Adam Jaczewski**[1], Marta Gruszczynska[1], Mariusz Figurski[1], Andrzej Mazur[1], and Tomasz Strzyzewski[1]

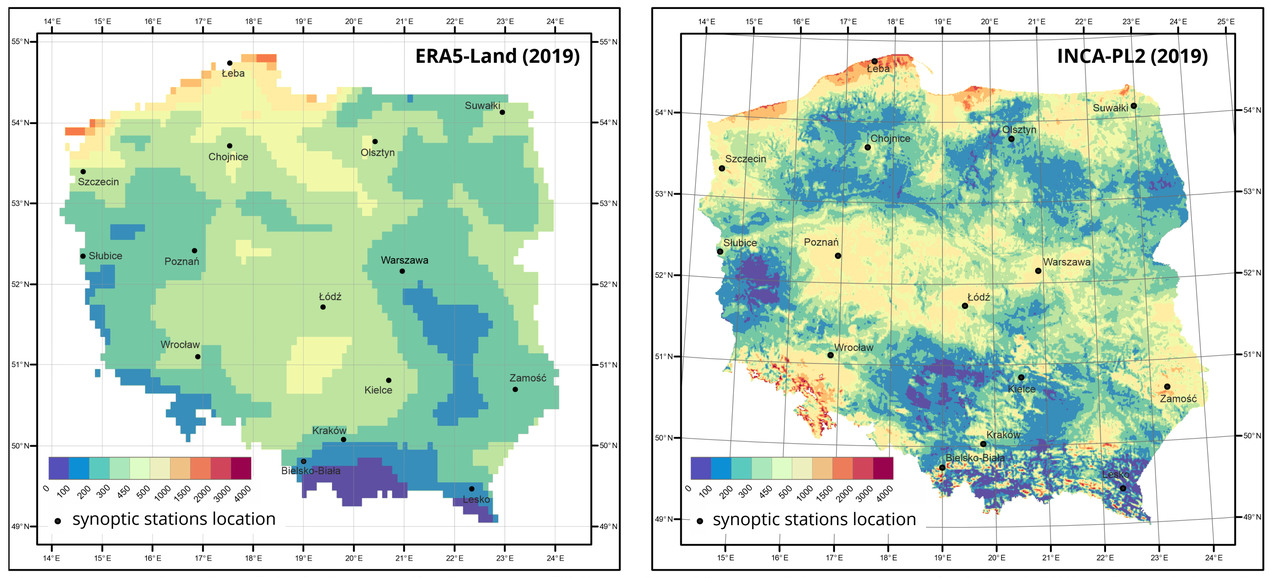
[1] Institute of Meteorology and Water Management - National Research Institute, Centre of Numerical Weather Prediction, Warszawa, Poland (adam.jaczewski@imgw.pl)
[2] Wroclaw University of Science and Technology, Wroclaw, Poland (jakub.jurasz@pwr.edu.pl)

Introduction

The climate and energy crises are closely linked, with an increasing need for cooling due to rising temperatures. This change notably impacts Central and Northern Europe, highlighting the urgency for a well-organized energy system that leverages renewable energy sources (RES), as outlined in the European Commission's 'fit for 55' package. Poland still lags in meeting its green energy targets despite a growth in renewable energy, particularly from prosumer installations. Challenges with energy connections and storage emphasise the importance of optimising self-consumption. Wind turbines and photovoltaic installations operate at their rated capacity for an average of 25% and 12% of the hours per year, respectively. However, the expected energy yields can be realistically assessed only by considering the variability of weather conditions. As well as their variation in neighbouring locations or on consecutive dates for the exact location.

Modern digital Atlas of Small-scall Wind Power for Poland (AMEW–PL)

To address the issue of high-risk investment in wind RES due to poor understanding of wind energy resources at low altitudes (10-20 meters above ground level), a digital Atlas of small wind energy for Poland is being developed. This open-access Atlas aims to assist investors by providing information on wind energy potential at heights of 10, 30, 50, 80, and 100 meters with a 1x1 km resolution. Initially, based on four years (2019-2022) of hourly data from the INCA-PL 2 model, the Atlas will evolve to include extended data. The necessity of this tool is underscored by the significant differences observed between the INCA-PL 2 model and ERA5-Land reanalysis, and the varied wind energy resources across Poland, which depend heavily on the specific wind turbine's power curve.



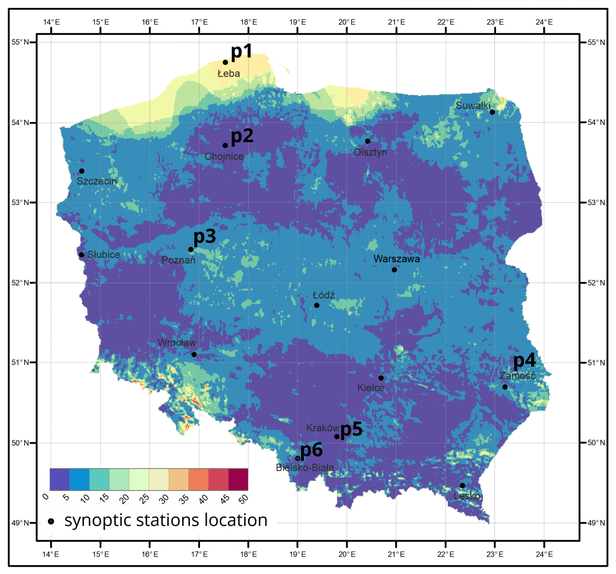
Average annual total useful wind energy (in the range of 3-25 m s^{-1}) at 10 m a. g. l. in open areas in Poland [kWh m^{-2} year^{-1}] based on ERA5-Land and INCA-PL2 reanalyses for 2019.

To be able to compare the efficiency of turbine operation, the generated power was replaced by the capacity utilisation rate (CF, capacity factor):

$$CF = \frac{\sum_{i=1}^{n} E_i}{P*n} * 100[\%]$$

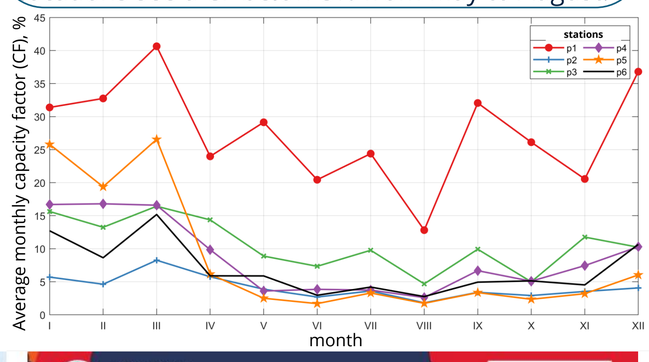
E_i – production of electricity from the generator at the i moment of [kW],
P – installed capacity of the generator [kW],
n – analysis period in hours [h]

Initially, the CF was calculated for 3.2, 6.0, and 8.2 kW. The figure on the right shows the annual CF value for the latter. The very high potential of small wind energy in northern Poland is noteworthy, as are the South Baltic Coasts and the most north-eastern part of Poland. At the same time, the Sudetes Foothills is a prosperous region in the south of the country. A CF characterises central Poland at a level similar to that of PV systems, i.e. 10-12.5%, with individual regions where this value is close to 15%. The southeast of Poland is characterised by relatively high CF values, reaching 20%.
In addition to the spatial variability, attention was paid to the temporal variability of the CF over time for 6 locations monthly, presented in the outermost figure on the right.



Annual average capacity factor (CF) for 8.2 kW wind turbine installed at 10 m a. g. l.

The seasonality analysis for 5 locations indicates peak CF values during the heating season (November–March) in Poland. The coastal location's CF is around 30%, nearly triple that of typical Polish PV installations, while other locations see a CF below 5% from May to August.



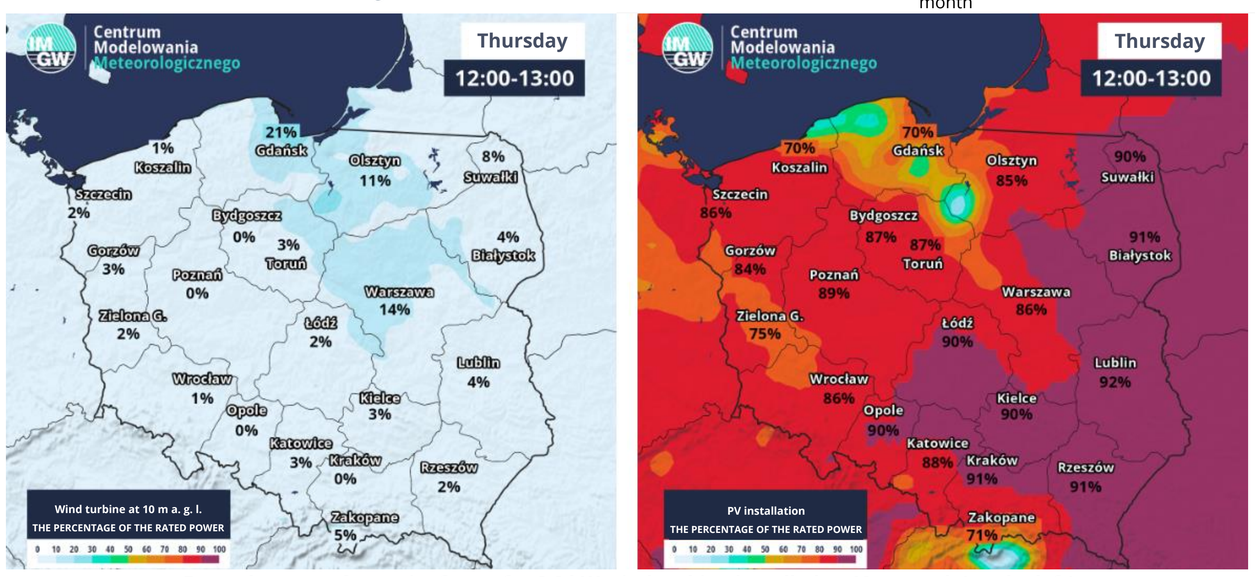
Forecast service for the Renewable Energy sector

Electricity generated from wind and solar varies daily and seasonally, influenced by weather, causing significant fluctuation in power output. This variability challenges the energy transition and RES prosumers in Poland. In October 2023, the - first in this part of Europe – public free-of-charge RES forecast service for micro-installations in Poland was launched. Constant and averaged solar irradiance values and wind speed are generated from the ECMWF HRES 0.1° model fields in hourly intervals.

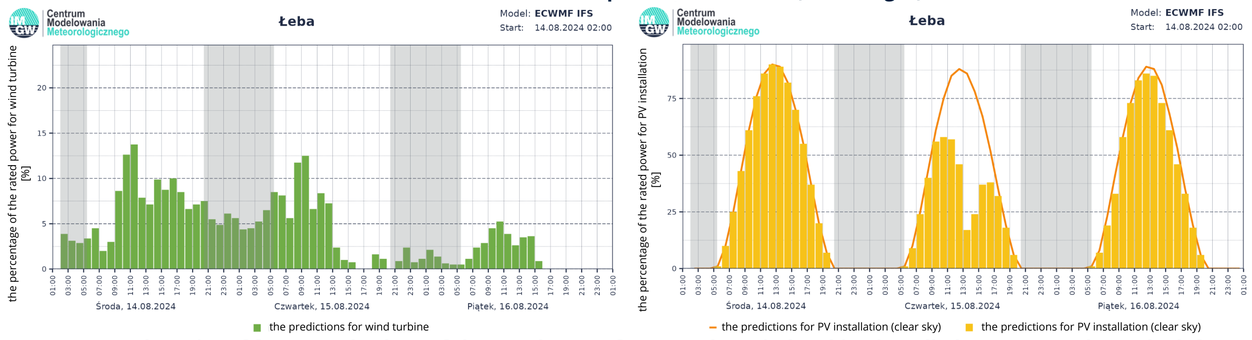
The forecast values were expressed as a percentage [%] of the rated power yield of a wind or photovoltaic installation according to the assumed installation parameters:

- **wind turbine** with a diameter of 1 m^2, with an installed rated power of 8.2 kW and a threshold value of useful wind speed of 3 m s^{-1}
- one **PV module** of southern exposure, 30° tilt, and power generated in standard conditions of 1 kW, where the maximum daily intensity of solar radiation in standard conditions was set at 1000 W m^{-2}. The operating temperature of the module in real conditions was assumed to be 50°C, and the overall efficiency of the system, taking into account losses on the inverter, wiring or contamination of the modules at the level of 80%

The forecast values are expressed as a percentage [%] of the rated power yield of the wind or photovoltaic installation according to the above-adopted installation parameters.



Example maps of capacity factor for 8.2 kW wind turbine installed at 10 m a. g. l. (on the left) and PV module of southern exposure, and 30° tilt (on the right).



An example series of forecasted values of the rated power for an 8.2 kW wind turbine installed at 10 m a. g. l. (on the left) and a PV module with southern exposure and 30° tilt (on the right).

Summary

The **AMEW-PL** offers comprehensive insights into wind energy potential with detailed spatial resolution to assess wind turbine performance at different heights. It allows users to access data in various formats, from average reports to time-specific analyses (hourly to annual), including meteorological and technical details, making it a crucial tool for preparing and evaluating investments.

Forecast service for the Renewable Energy sector assists in predicting electricity production from wind turbines and PV installations using weather models. This enables efficient planning and resource management for homeowners and businesses, optimising energy use, cutting costs, and supporting sustainability with dependable output estimates.

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AMEW-PL

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RES Service forecasts

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