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# Application and verification of ECMWF seasonal forecast for wind energy

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A good understanding of long-term annual energy production (AEP) is crucial when assessing the business case of investing in green energy like wind power. The art of wind-resource assessment has emerged into a scientific discipline on its own, which has advanced at high pace over the last decade. This has resulted in continuous improvement of the AEP accuracy and, therefore, increase in business case certainty.

Harvesting the full potential output of a wind farm or a portfolio of wind farms depends heavily on optimizing operation and management strategy. The necessary information for short-term planning (up to 14 days) is provided by standard weather and power forecasting services, and the long-term plans are based on climatology. However, the wind-power industry is lacking quality information on intermediate scales of the expected variability in seasonal and intra-annual variations and their geographical distribution. The seasonal power forecast presented here is designed to bridge this gap.

The seasonal power production forecast is based on the ECMWF seasonal weather forecast and the Vestas' high-resolution, mesoscale weather library. The seasonal weather forecast is enriched through a layer of statistical post-processing added to relate large-scale wind speed anomalies to mesoscale climatology. The resulting predicted energy production anomalies, thus, include mesoscale effects not captured by the global forecasting systems.

The turbine power output is non-linearly related to the wind speed, which has important implications for the wind power forecast. In theory, the wind power is proportional to the cube of wind speed. However, due to the nature of turbine design, this exponent is close to 3 only at low wind speeds, becomes smaller as the wind speed increases, and above 11-13 m/s the power output remains constant, called the rated power. The non-linear relationship between wind speed and the power output generally increases sensitivity of the forecasted power to the wind speed anomalies. On the other hand, in some cases and areas where turbines operate close to, or above the rated power, the sensitivity of power forecast is reduced. Thus, the seasonal power forecasting system requires good knowledge of the changes in frequency of events with sufficient wind speeds to have acceptable skill.

The scientific background for the Vestas seasonal power forecasting system is described and the relationship between predicted monthly wind speed anomalies and observed wind energy production are investigated for a number of operating wind farms in different climate zones. Current challenges will be discussed and some future research and development areas identified.