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A dynamical approach to characterize the wind power conversion process

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Based on a stochastic model for the power conversion process, we propose a so-called dynamical method for the estimation of wind power performance curves. We motivate this dynamical approach particularly with regard to an appropriate description of the short-time dynamics of the process. We discuss the consideration of fluctuations in wind speed and corresponding power output, and delimit our approach from other methods like the international standard due to IEC 61400-12-1. The main idea of the dynamical method is to separate the dynamics of a wind turbine, given by high-frequency power output and corresponding wind speed data, into a deterministic and a stochastic part. This splitting allows to distinguish the actual behaviour of the wind turbine, i.e. relaxation and control effects, from external influences such as the turbulence of the wind. In particular, to recontruct the power conversion dynamics of the wind turbine, we apply a dynamical systems approach, assuming that the variable P(t), the time series of the power output, follows a diffusion process and can be described by a Langevin equation. After reconstructing the entire response dynamics given by the deterministic part of this process, we obtain the power curve by a fixed-point analysis. On this level, we compare our method with other approaches and show that the stationary states of the power conversion process is defined by a fixed point of a dynamical system more adequately than by a maximum or mean value as in the IEC standard.