Testing wind farm control

Developing unified simulation procedures for the evaluation of active-power reference tracking

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Technology for a better society

Motivation

- Wind farm control (WFC) = Coordinated operation of wind turbines
  - Wind power plant control (WPPC) is concerned with compliance to grid codes and power system services
  - Wind farm flow control (WFFC) considers aerodynamic interactions between wind turbines
- Most research on WFFC has focused on power maximisation

→ Power reference tracking is gaining importance

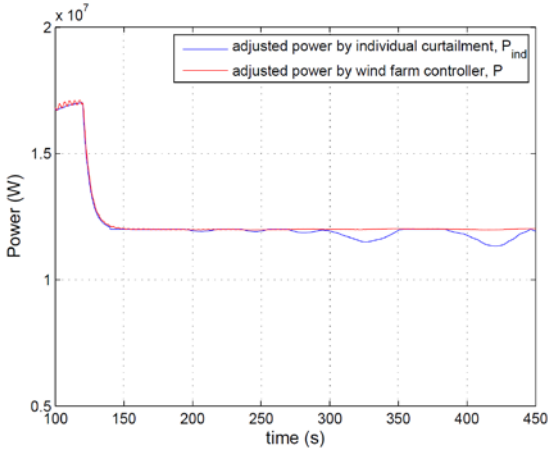
- Number of WFC simulation studies: e^x
- Number of methods to test WFC: $e^x - y$
- Comparability of WFC performance across studies: $\lim_{x \to \infty} = 0$

*Andersson et al. (2021). *"Wind farm control - Part I: A review on control system concepts and structures,"* IET Renewable Power Generation 2021. https://doi.org/10.1049/rpg2.12160

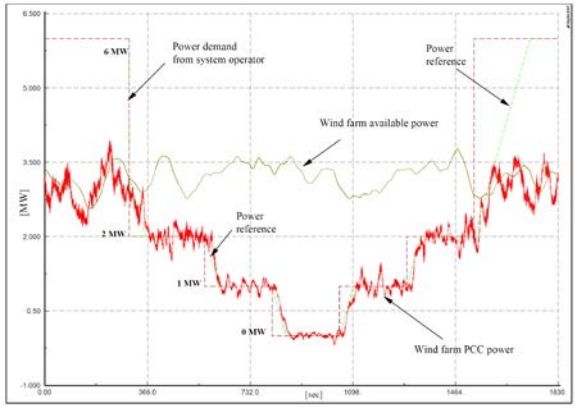
Power reference tracking

What is power reference tracking?

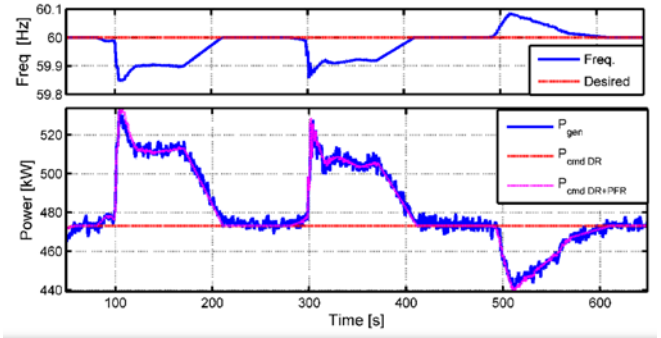
- Keeping constant power output in turbulent wind
- Following a power step or ramp command
- Deriving continuous power reference signal from frequency measurements



Hur, S.h., Leithead, W.E.: Adjustment of wind farm power output through flexible turbine operation using wind farm control. Wind Energy (2016)



Sørensen, P.E., et al.: Wind farm models and control strategies (2005)

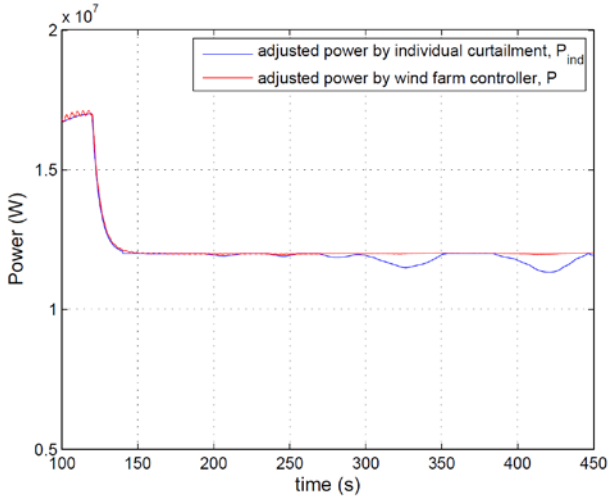


Aho, J., Pao, L., Fleming, P.: An active power control system for wind turbines capable of primary and secondary frequency control for supporting grid reliability. 51st AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition, Grapevine (2013)

Evaluation method differences

- Layout: single row, array, rectangular grid or random
- Wind inflow
  - Wind direction alignment
  - Wind speed (below, around, above rated)
  - Turbulence?
- Simulation duration varies by several minutes

- Performance indices
  - often only visual inspection of power-over-time plot
- Absence of base case

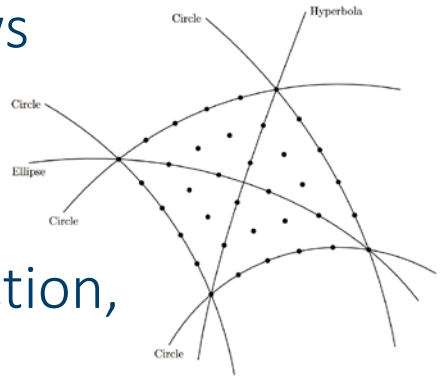


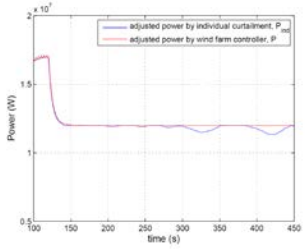
Outlook

Developing unified evaluation procedure of active-power reference tracking

Examples/Ideas:

- Layout: 6x6 wind turbine array with bent rows
- Power reference case set: constant, step, frequency disturbance event
- Wind inflow case set: wind speed, wind direction, turbulence intensity; all subject to change
- Reference scenario: control with equally distributed power set-points
- Performance indicators: NRMSE





Same procedure as every time, James …