Review for WES-2022-27

General assessment

Technology

This paper presents a novel Fault Impact Reduction Control (FIRC) module. Key advances are the potential prevention of an impending fault by a derating strategy, and the communication of useful turbine information (warning mode, warning time, predicted time until derating step, predicted derated power) to the grid operator. Furthermore, the FIRC can be deployed as an add-on to existing operational controllers and fault detection logics. The FIRC can be very helpful in rendering wind turbines more cooperative and operator-friendly.

Contribution

The main contributions of this paper are from my point of view:

- Very comprehensive overview of fault detection, isolation and control. Thank you very much for that!
- Development of a solid base concept for FIRC, which could stimulate various future research (for instance, communication of probabilities of actual stop within the next 1s/10s/100s to the grid operator).
- The task and solution seem to be very relevant for and very close to industrial application.
- Very thorough and clear explanation of the FIRC logic.
- Solid and successful demonstration of the FIRC behavior under various fault cases, and of the FIRC effects in national grid or microgrid scenarios.

Reservation

In the abstract you state “controls to ameliorate such faults are *uncommon* in research and industry”. Unfortunately, I cannot judge to what extend pre-fault warnings and preventive derating could already be state-of-the-art in the wind industry.

Proposed minor corrections

The following set of proposed minor corrections may improve the already very solid paper:

- Abstract, line 1: Does “in distribution applications” mean that the turbines are connected to the distribution grid, or that they are distributed around a wider area, i.e. are not part of a wind farm?
- Abstract, line 12: A limitation to “easy to integrate with the existing controller” may be, that an existing commercial operational controller would be required to have a derate functionality and an input port for derating commands.
- Section 1, line 22: The term probably should be “shutdowns” instead of “shutdown”.
- Section 1.2, line 58: The “Pourmohammed” reference contains one surplus bracket.
- Section 1.2, line 85: It could be specified that the stated goals are only two amongst many others (e.g. also alleviation of tower loads).
- Section 2, line 138: Maybe you can specify which “mechanical systems” are utilized in an open loop stop.
- Section 2.1, Derate warning mode: I understood that the unit “pu” in the power context is always with reference to rated power. If so, I am not sure about the fixed upper saturation limit of 31/32pu. Shouldn't the upper limit be dynamically set to one power step below the

lowest power where a derate warning has been triggered since the last FIRC reset by the grid operator? Example: A derate warning is triggered at P_derate = 1pu, but is also present when P_derate =31/32pu. The FIRC steps down to P_derate = 0.5pu and the derate warning vanishes. Consequently, the FIRC would gradually step up until 31/32pu, where the derate warning is triggered again. Consequently, the procedure of stepping down and back up to 31/32pu would be repeated, right? Thus, wouldn't P_derate periodically oscillate between 31/32pu and 30/32pu, and periodically activate the derate alarm? The above proposed dynamic rule would set an upper saturation of 30/32pu = 31/32pu (lowest power with derate warning) – 1/32pu (smallest step size), preventing this oscillation.

- Section 2.1, Stop warning mode: Could it be reasonable to also inform the grid operator about the expected normal/open-loop/emergency stop power trajectory? Depending on the ramp slope, the grid operator could select the best spinning reserve generator.
- Section 2.1, lines 168 f.: The jump to Fig. 5 and 7 in the results section feels a bit distractive and does not seem to be necessary.
- Section 2.3, Table 2: Which acceleration quantity (location, direction) is represented by "x acceleration"?
- Section 4.1, Fig. 5: Why does the actual power seem to have an always-positive steady-state offset to the commanded derate power? Consequently, also the power predictions would be misleading for the grid operator.
- Section 4.1, Fig. 6: Why is the actual power negative at t=50s?
- Section 4.1.3, line 274: Does "model controller instability" refer to instability of the FIRC or of the operational controller?
- Section 4.2.2: I have the impression that the figure files (but not the captions) have been interchanged for Fig. 9 and Fig. 10.
- Section 4.2.2: In the scenario with FIRC, the turbine exactly faults at that moment when the diesel generator has completed its start-up. However, it would be fair to state that this fault event time represents a lucky optimal coincidence, and could have happened either during diesel start-up or hours after diesel start-up.
- Section 4.2.2.: Thinking further, in some scenarios of short time frames between warning and fault and with an expensive battery, it may be advisable to emergency-start the diesel after the FIRC stop warning, right?
- Section 5: For me it would be interesting to extend the outlook by potential benefits of FIRC-equipped turbines in a wind farm control setting. For instance, the derate prediction also represents a prediction of changes in the wakes, which could be utilized to proactively optimize operation of the other turbines in the farm.