EVALUATING THE PERFORMANCE OF A WIND GENERATOR IN PROVIDING ANCILLARY GRID SERVICES

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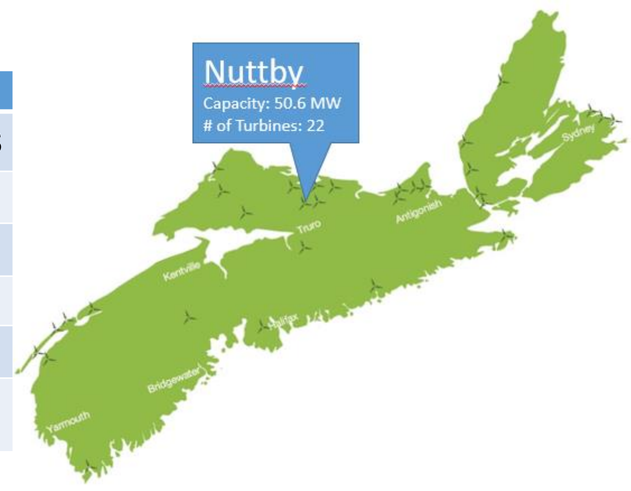
Background

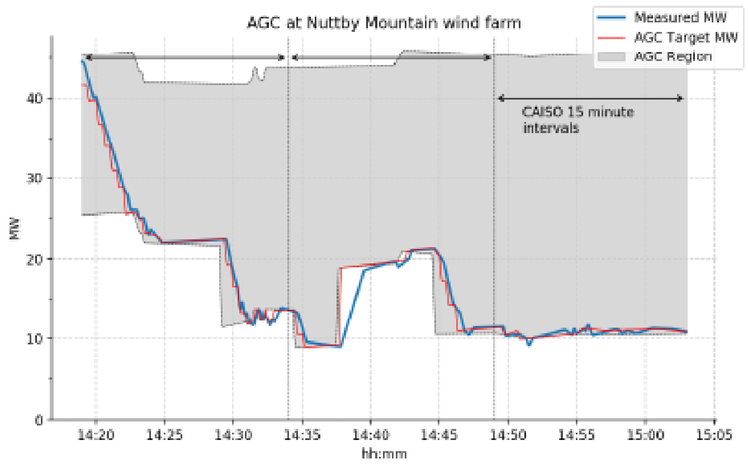
As the grid shift towards wind energy generation, the full potential of wind turbine generators (WTGs) must be explored. More than simply a source for power, WTGs can support grid stability. This work tests three of the ancillary grid services that WTGs can offer: power-frequency response, automatic generation control (AGC) and fast-frequency response. Empirical data is gathered from the Nuttby Mountain wind farm in Nova Scotia, Canada.

Nuttby Mountain Wind Farm	
Farm Location	Cobequid Mountain, NS
Farm Capacity	50.6 MW
Turbines on Site	22
Turbine Model	Enercon E-82
Turbine Capacity	2.3 MW
Farm Operator	Nova Scotia Power Inc. (NSPI)



Automatic Generation Control

AGC is a secondary frequency regulation in which a dispatch controller commands generators to correct short-term imbalances in an identified regulation region.



Nuttby Mountain was added to NSPI's AGC dispatch controller for a 45-minute test run. AGC performance was calculated using CAISO and MISO methods.

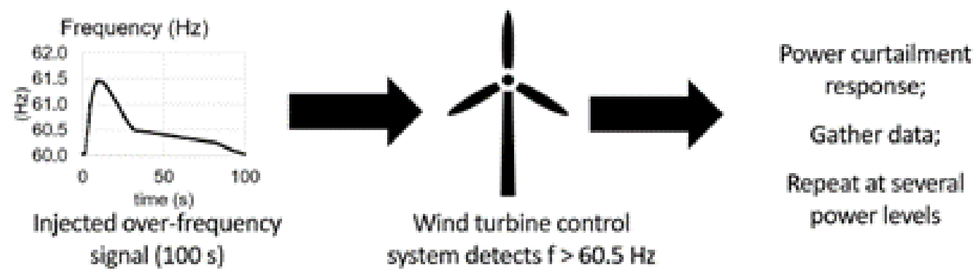
Results

Scoring Method	Time Interval	Performance Score (%)
CAISO	Interval 1 (15 min)	97.8
CAISO	Interval 2 (15 min)	97.1
CAISO	Interval 3 (15 min)	99.9
MISO	Overall (45 min)	87.9

NSPI reported a performance factor of 1.09 for this AGC demonstration which compares well with performance factors of 0.3 - 0.6 for NSPI's steam and hydro units.

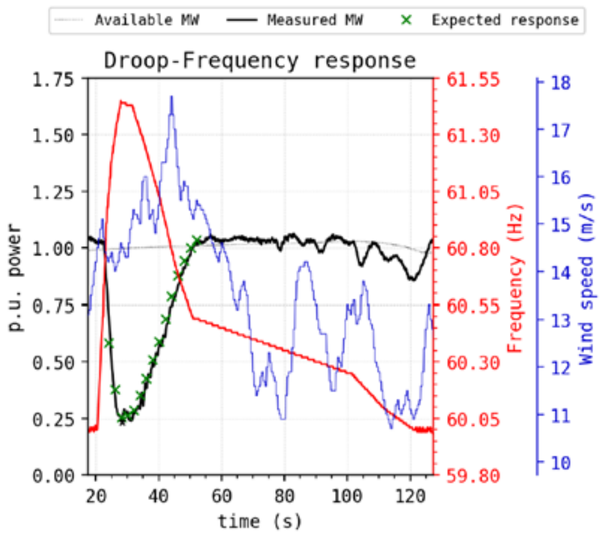
Power Frequency Response

Like droop frequency in synchronous machines, inverter-based WTGs can counter changes in grid frequency by adjusting the active power setpoint.



An artificial frequency signal was injected into the control system of one turbine for 39 test runs. A response in proportion to the frequency deviation is expected.

Results



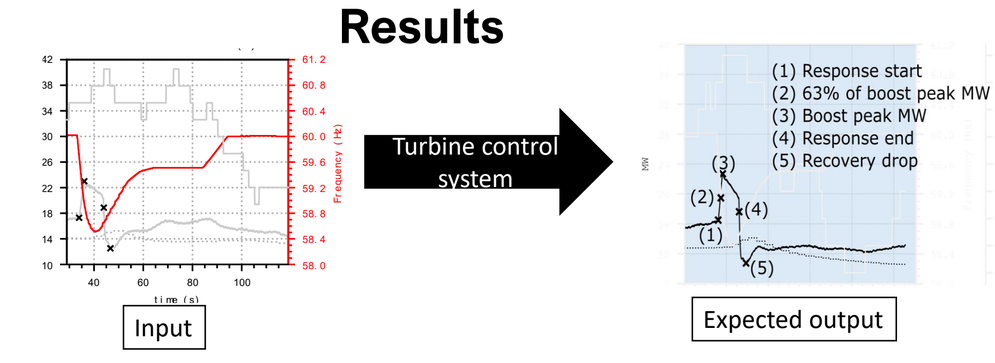
The turbine generators respond as expected, curtailing power (black) in response to the injected frequency (red).

Fast Frequency Response

While synchronous generators have stored inertia that slows the rate of change of grid frequency and increases stability, the power electronic converters found in many wind turbines do not. Fast-frequency response uses some of the rotational energy of the turbine's blades to mimic inertial damping.

By using a series of injected frequency signals, the fast frequency response was tested on the Nuttby Mountain wind farm. Thirty-eight runs at various power levels were tested.

Results



	Expected	Observed
Boost magnitude	10% P_{rated} or 5 MW	6 MW
Boost duration	10 s	<10 s
Rise time to 63% of peak boost	1 s	1.2 s
Maximum value of recovery drop	50% P_{rated} or 25 MW	<25 MW

Conclusions

The Nuttby Mountain demonstration presents empirical data showing that a wind farm can provide three ancillary services: automatic generation control, power frequency response, and fast frequency response. The power-frequency error was within 2% of the turbine's rated power, the AGC performance score exceeded that of equivalent thermal units, and the fast frequency response closely followed the expected profile. This demonstration shows that the use of a wind farm as a regulating resource is feasible.

References

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