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More than power from wind: Empirical data from a wind farm providing power-frequency response and automatic generation control

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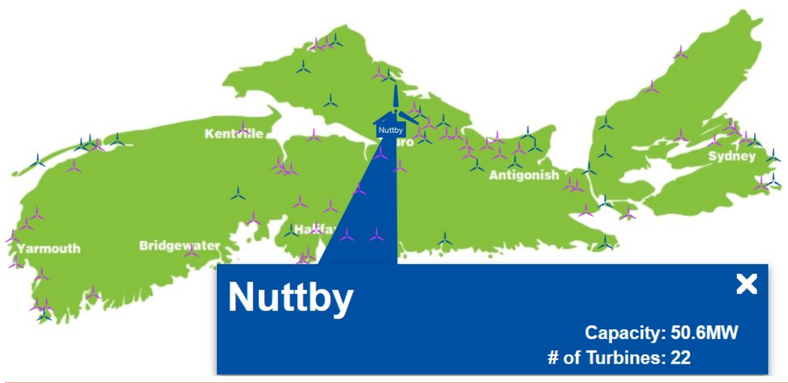
Abstract

More electrical energy from renewable sources means that more ancillary services and grid support services are provided by them. This work examines the ability of a commercial wind turbine to provide power-frequency control and AGC (automatic generation control). Power-frequency control opposes changes in grid frequency via active power and operates on time scales of 1 – 2 seconds. AGC is used by grid operators to maintain the demand-supply balance via small changes in generator active power output. This work was a collaboration between a system operator, a wind turbine OEM and an independent research institute. These results are useful to other grid operators as they represent the performance of commercially available wind turbines as opposed to a simulation.

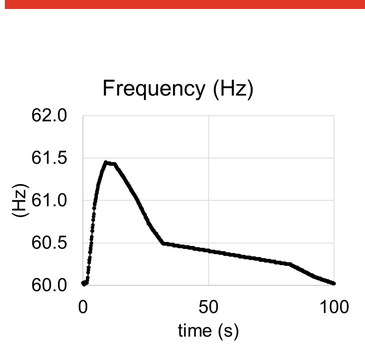


What	Power-frequency response, AGC
Where	Nuttby Mountain Wind Farm, Nova Scotia, Canada
Turbines in farm	22
Single turbine rating	2.3 MW Enercon E82 IEC Type IV
Utility of results	Useful to other system operators; not a simulation
Note	Response to frequency **increases** tested; Response to frequency **decrease** not tested due to requirement of continuous power curtailment

Objectives

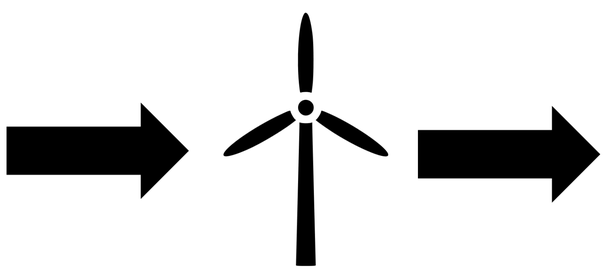
Test droop frequency response from a single grid-connected wind turbine. Test AGC for the entire wind farm. Examine the performance at various power levels.

Methods



Injected over-frequency signal (100 s)

Power-frequency response



Wind turbine control system detects f > 60.5 Hz

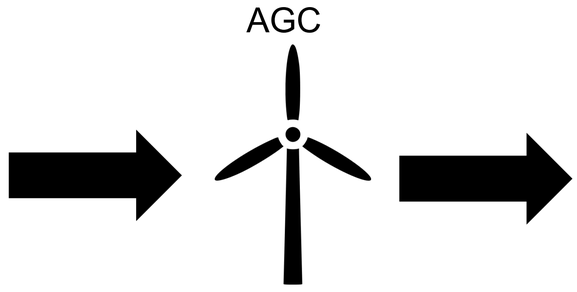
Power curtailment response;

Gather data;

Repeat at several power levels

AGC

System operator sends MW setpoint



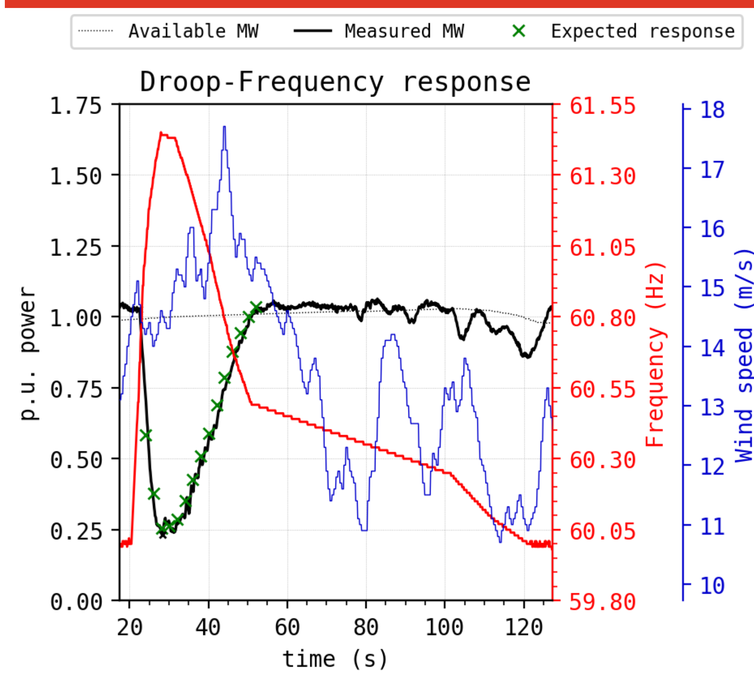
Wind turbine control system responds

Active power change

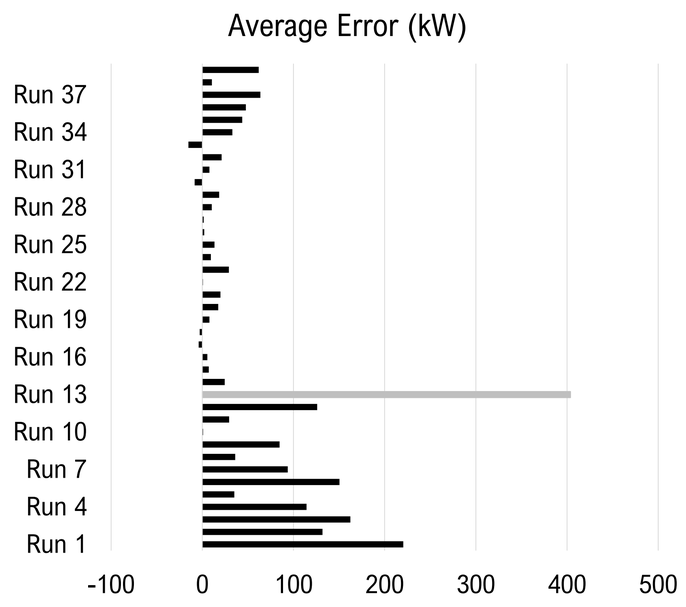
Gather data;

Repeat at several power levels

Results

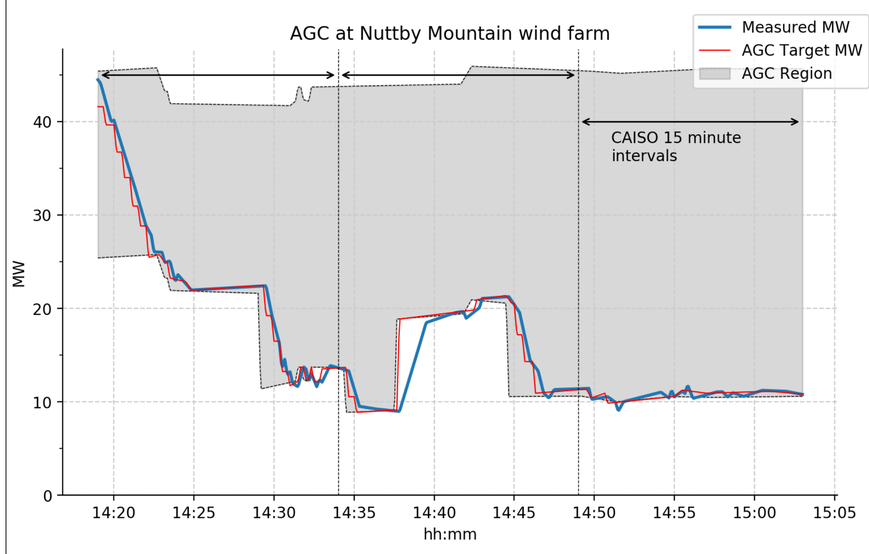


Injected frequency in red. Expected response is calculated based on frequency deviation from 60 Hz and initial power level. Data is normalized.



Mean error across all data is 50 kW or 2% of rated power.

Outliers are due to falling wind speeds during frequency event.



AGC data – 45 minutes

Conclusions

The results are in line with expectations, and this is useful data for other grid operators in evaluating whether such a response from wind farms can be used on to improve frequency stability. The value of this work is that we present empirical data as opposed to an analysis via simulation models. Empirical data as presented here is difficult to find. One can reasonably assume that behaviour on a different power grid will be similar to that reported here.

References

1. Enercon GmbH, "Grid Integration and Wind Farm Management," 08 2018. [Online]. Available: https://www.enercon.de/fileadmin/Redakteur/Medien-Portal/broschueren/pdf/EC_Netztechnologie_en_web.pdf. [Accessed 02 2021].
2. Power Advisory LLC for Offshore Energy Research Association (OERA), "Nova Scotia Ancillary Service Provision by Variable Output Renewable Energy Resources," 2020. [Online]. Available: https://oera.ca/sites/default/files/2020-09/Valuation%20Method%20for%20Electric%20Ancillary%20Services%20-%20Final%20Report_0.pdf.