



SYSTEM FREQUENCY RESPONSE CHANGES WITH INCREASED WIND PENETRATIONS

- Displacement of conventional plant by wind turbines
- Depletion of traditional ancillary services (inertia, primary operating reserve, secondary operating reserve, etc.)
- System dynamic characteristics changing
- Need to ensure secure operation following contingency events

ACTIVE CONTROLS FROM WIND TURBINES CAN HELP - SYNTHETIC INERTIAL FREQUENCY RESPONSE (SIR)

However, SIR from wind turbines is very different to conventional plant responses...

- Temporary power increase in response to system frequency deviation
- Wind turbine response capability varies with wind speed
- System-wide response depends on no. turbines online

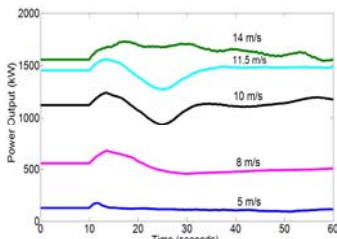


Fig.1. GE WindINERTIA™ field tests

THE PROBLEM: HOW MIGHT SYSTEM OPERATORS MANAGE SIR?

Prediction is very difficult, especially if it's about the future.

-Neils Bohr

- In the event of significant SIR technology penetration levels, this aggregate SIR may have significant impacts on the system frequency response following a contingency event.
- System operators must therefore be capable of predicting how much SIR is available.

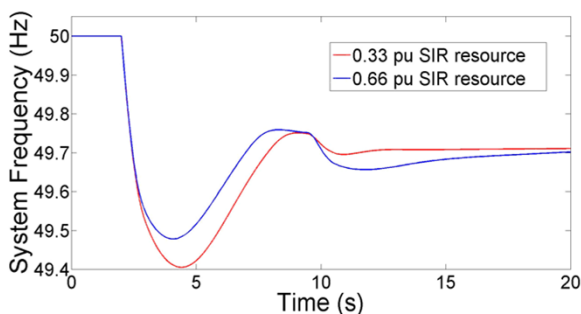
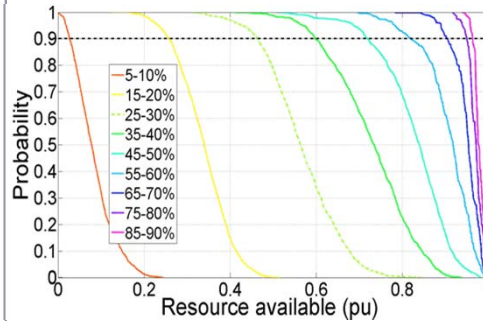
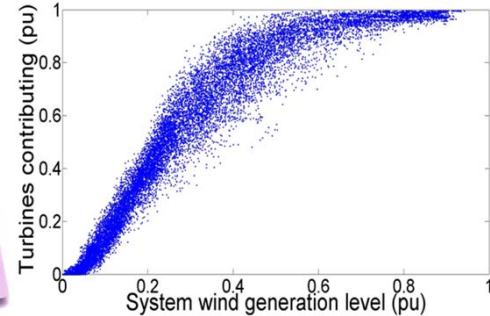


Fig. 2 System frequency response with varying levels of synthetic inertia available

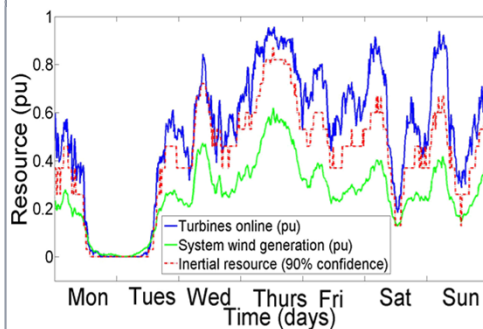
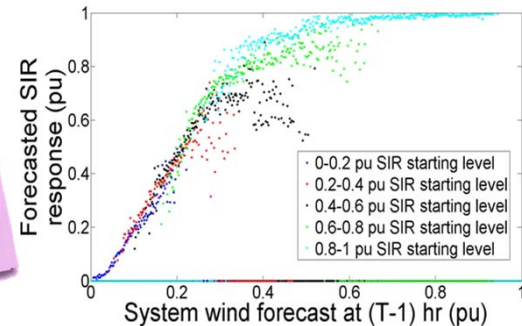
PREDICTING THE SYSTEM-WIDE SIR RESOURCE

- Number of turbines capable of providing SIR may vary for given wind generation level
- Number of contributing generators no longer deterministic



- Historical data illustrates likely SIR levels for varying system wind generation
- Greatest variability at medium system wind generation levels

- Conditional probability informed by current SIR level as well as wind forecast



- System-wide SIR resource can be predicted for given confidence levels

FUTURE WORK:

- Resource estimation on larger systems
- Frequency response coordination (considering responses from demand, electric vehicles and wind generation)

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