



# Making Wind Work ...On the Plant Side

Reigh Walling  
GE Energy



GE imagination at work

**DISTRIBUTECH**  
CONFERENCE & EXHIBITION



# Perceived System Issues of Wind Generation

- Intermittency
- Var demand, voltage regulation
- Variability, abrupt changes in output
- Participation in frequency regulation
- Trip-outs due to grid events



# Voltage Response

Modern wind generation can support system voltage

*Capability depends on technology and supplemental devices*



# Wind Turbine Generator Technologies

## Induction generators

- Fixed and variable rotor resistance

## Doubly-fed asynchronous generators

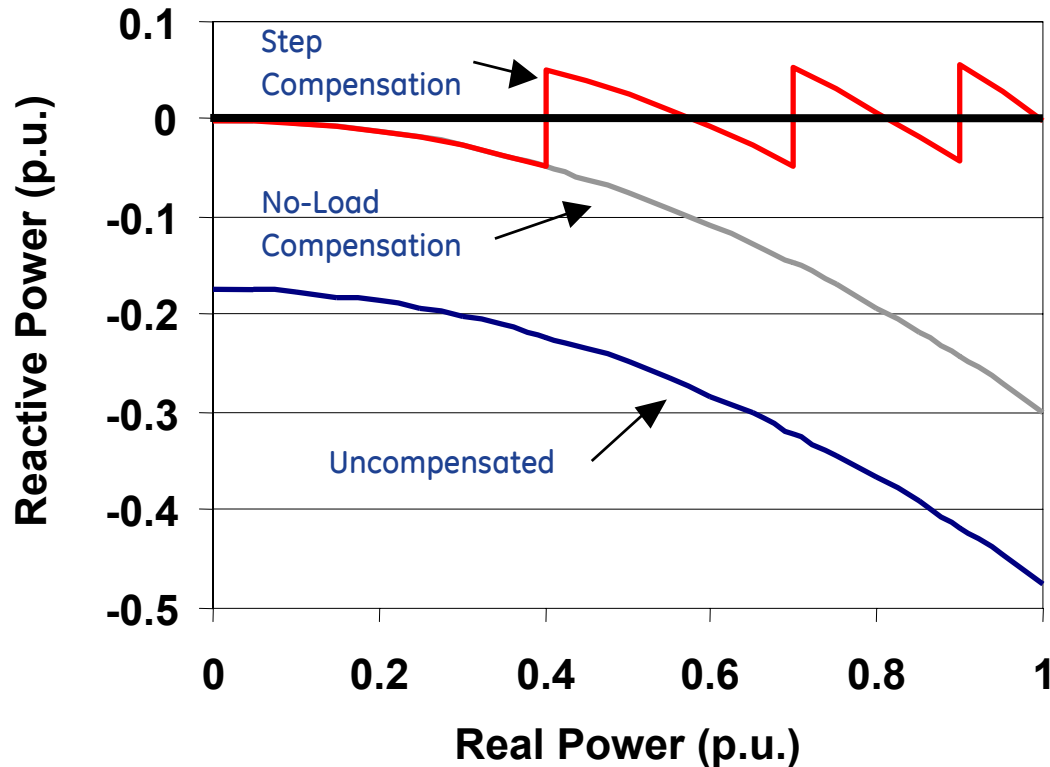
- Sometimes called doubly-fed “induction” generators (DFIG)
- Wide speed variation
- Provide controlled excitation

## Full-conversion

- AC-DC-AC conversion link decouples generator from system wind turbines

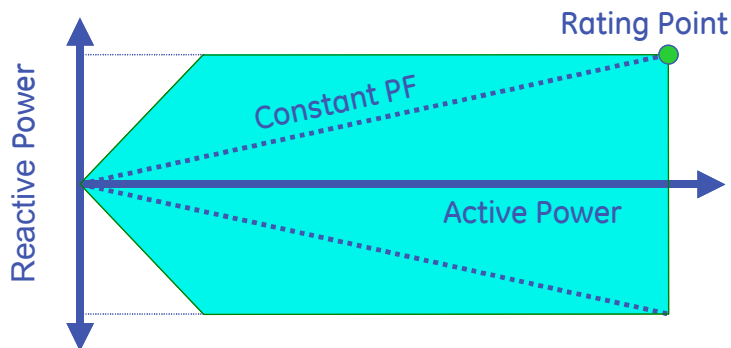
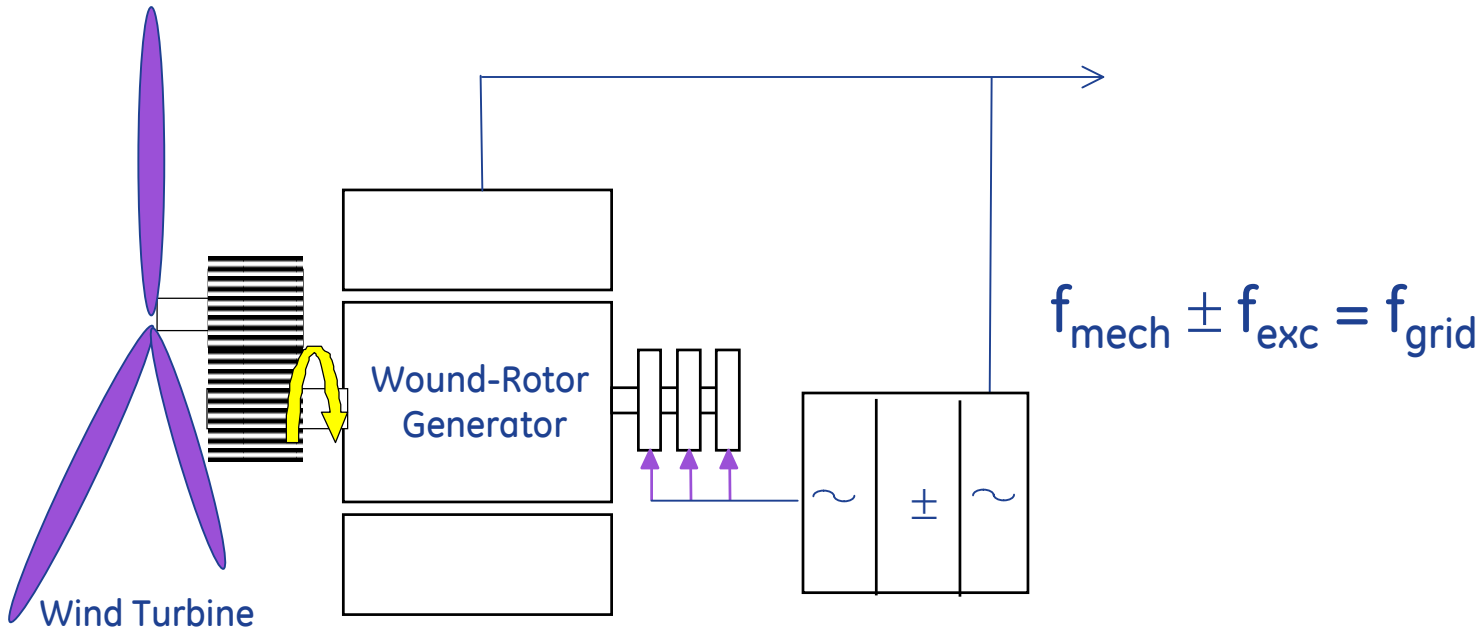


# Typical Induction Generator Reactive Power Performance



Smooth reactive power and voltage regulation requires a supplemental device (SVC, STATCOM, D-VAR)

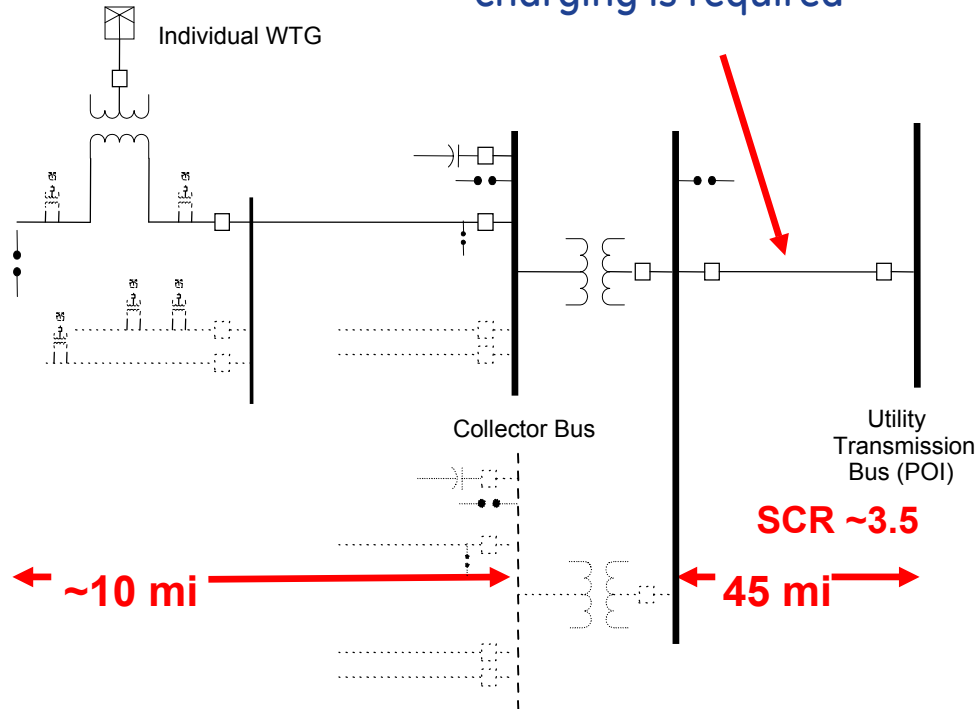
# Doubly-Fed Asynchronous Generators



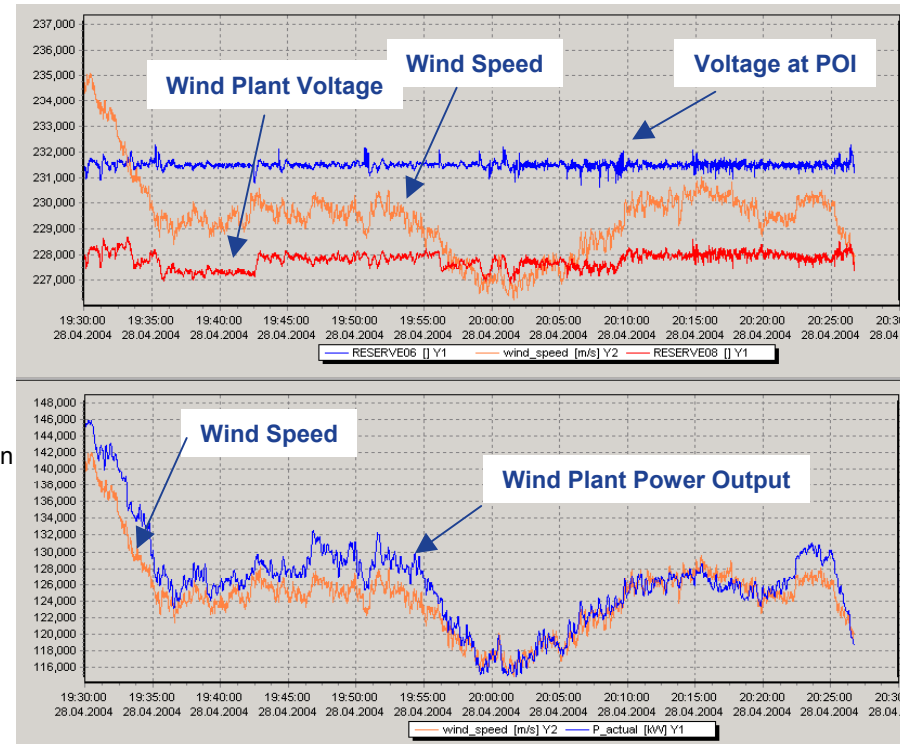
- Supply or absorb VARs, as desired
- High-speed controllability
- Supplemental devices are not needed

# Voltage Regulation

Compensation including charging is required

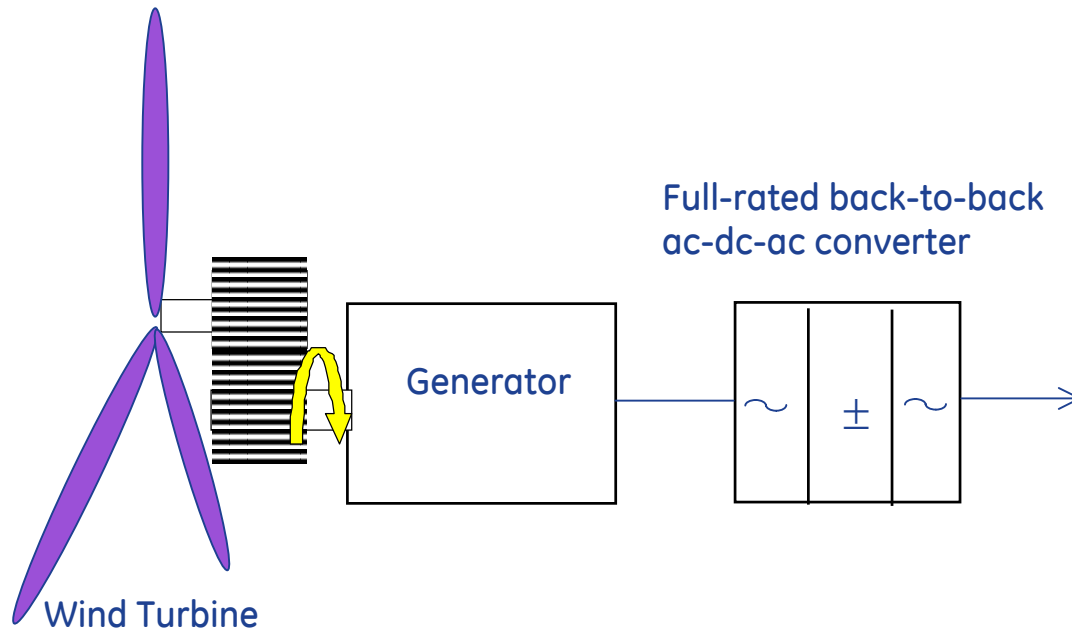


Actual measurements from a GE 162MW wind power plant.



Wind power plant control minimizes grid voltage fluctuations with varying wind conditions

# Full Conversion – Wind Turbine Generator to System Coupling

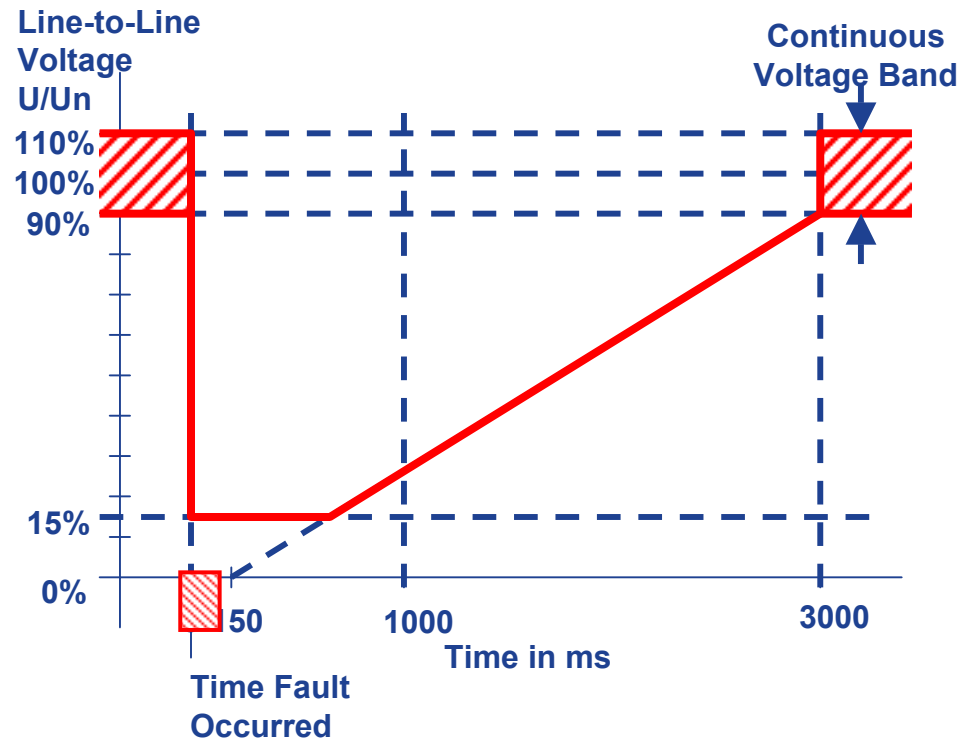


Can be made to have a wide reactive range, voltage response similar to STATCOM

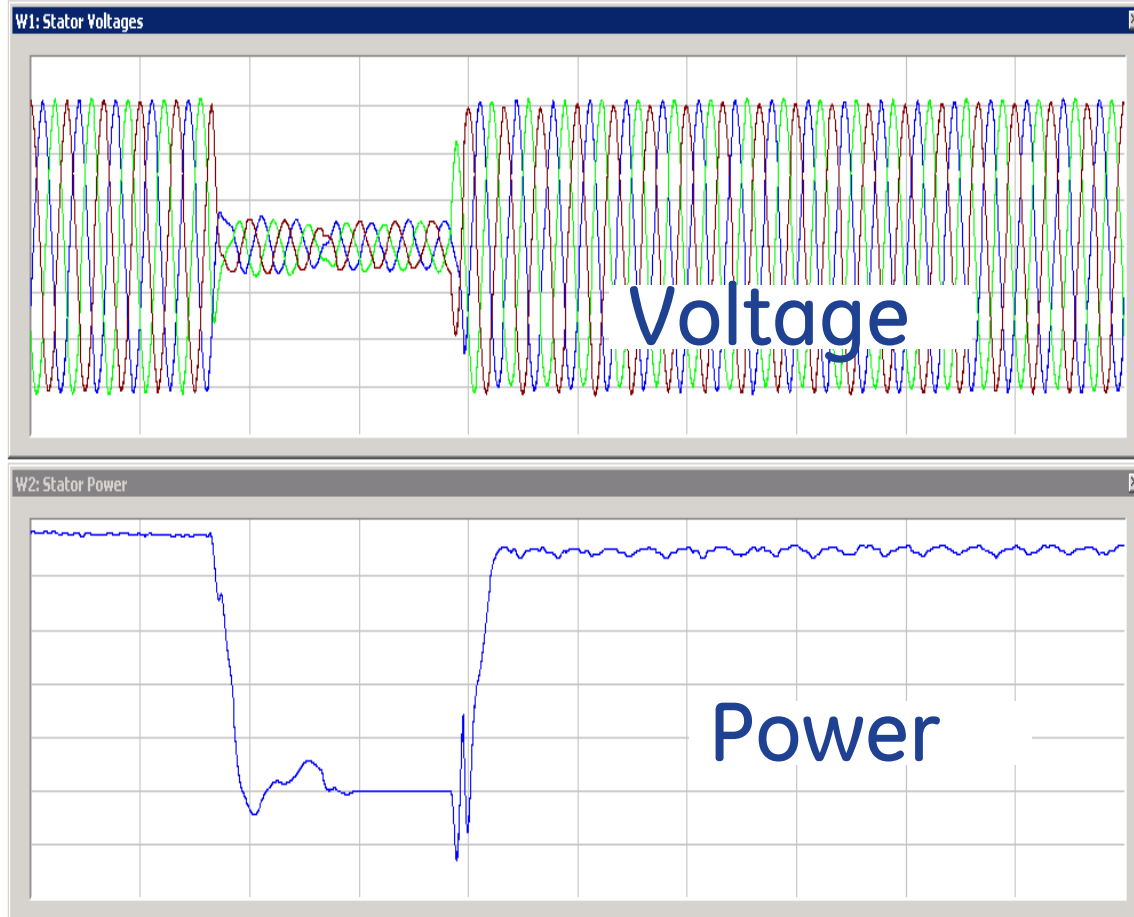
# Fault Tolerance: LVRT Capability

## Rapidly Evolving Grid Codes for Low Voltage Ride-Through

- Success of wind is driving sweeping changes
- New ride through capabilities are engineered to meet global needs
- Designed for 15% retained voltage 3-phase faults (E-ON) and Zero voltage for 150ms (new FERC requirements)



# LVRT Factory Test



# Power Response

Advanced plant controls power response to variations in wind and system frequency

**Power Ramp Rate** – Limits the rate of change from variations in wind speed

**Startup and Shutdown** – Control the insertion and removal of large power blocks

**Frequency Droop** – React to changes in system frequency

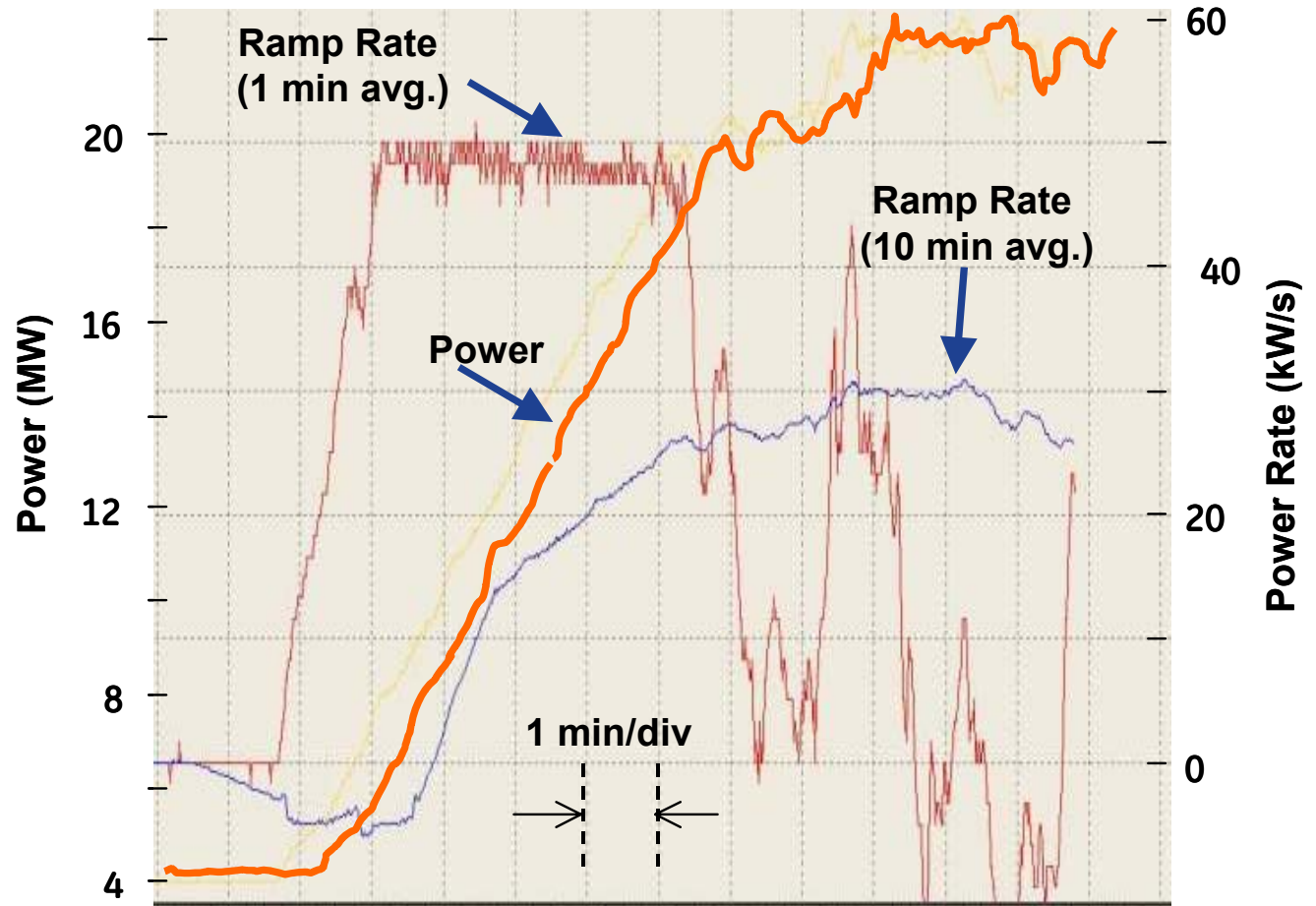


# Ramp Rate Limits

Settings:

5%/min limit  
1 minute average

Curtailed to 4MW  
and released



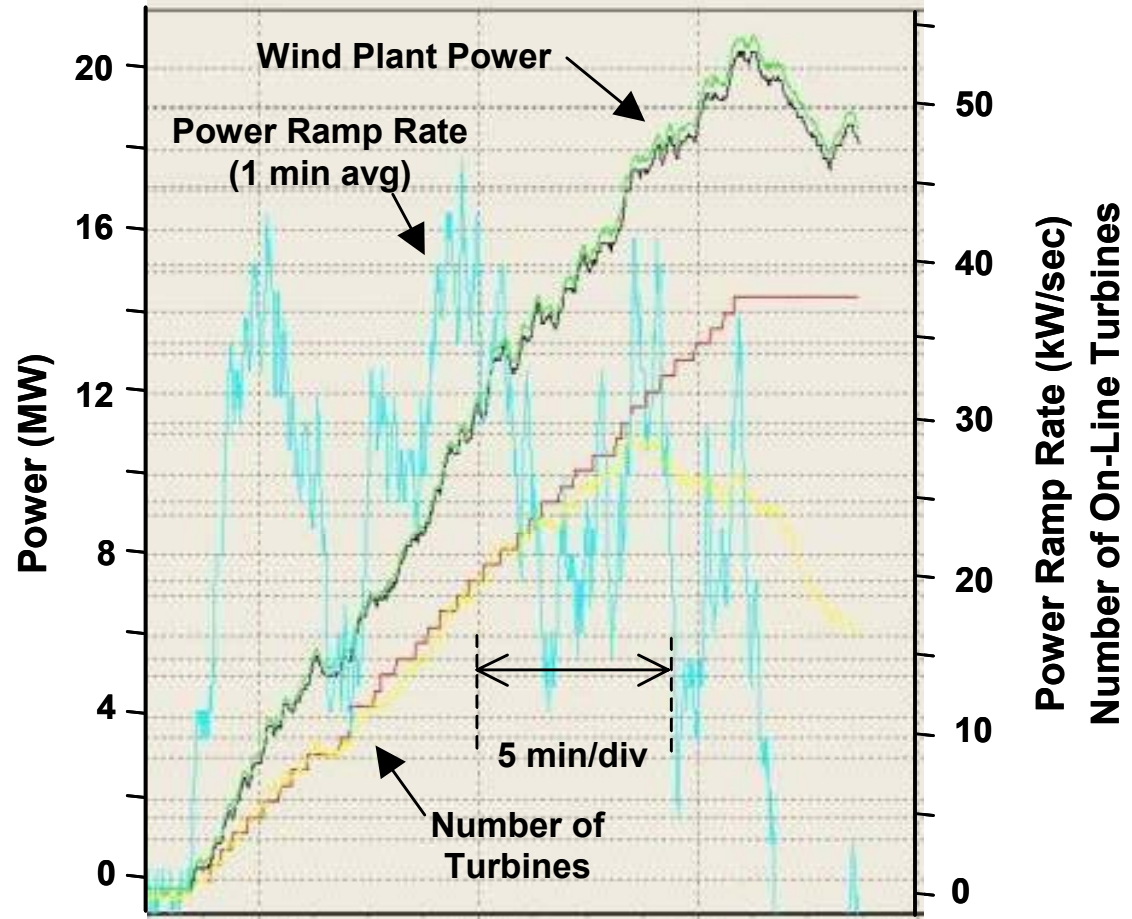
Ramp rate controlled to 50kW/sec (3MW/Min)

# Wind Power Plant Startup

## Settings:

Turbines sequenced on  
at 20 second intervals

Ramp rate limit  
3MW/Min

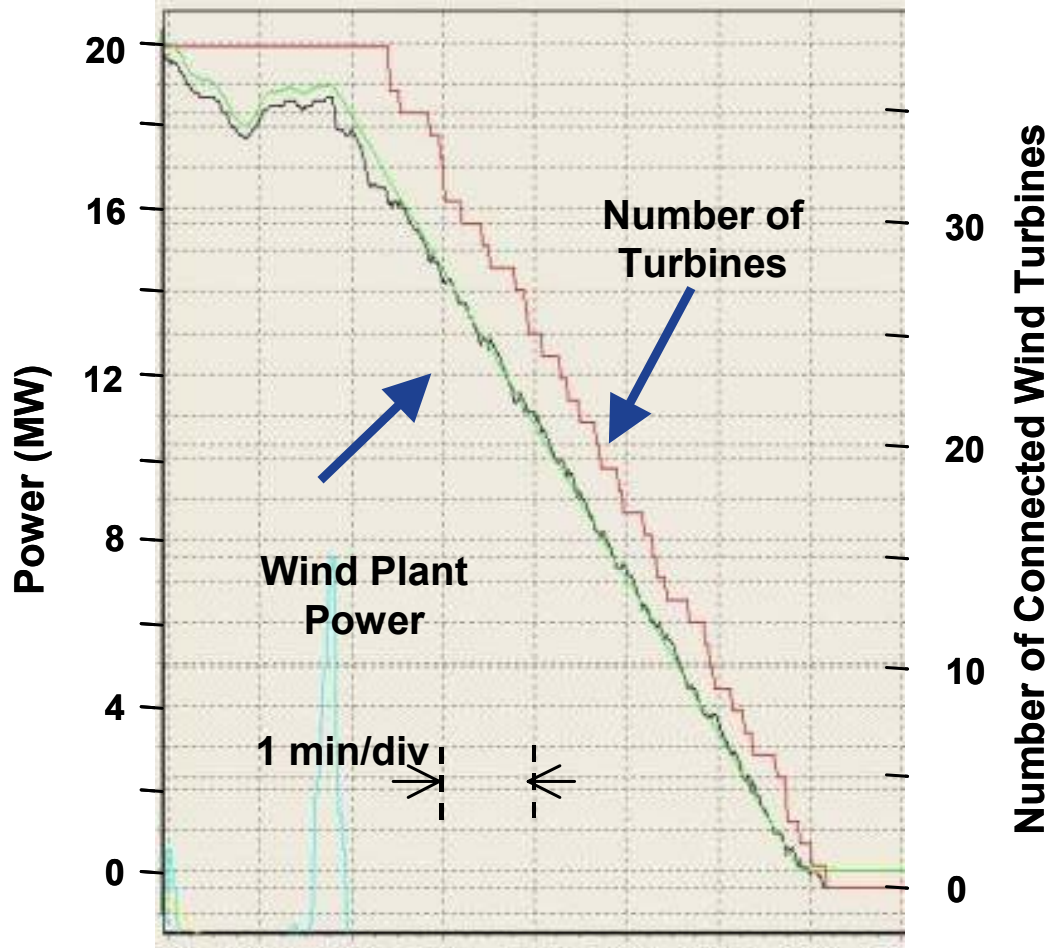


Wind plant output controlled during startup conditions

# Wind Power Plant Shutdown

Settings:

Shutdown interval set to 5 minutes



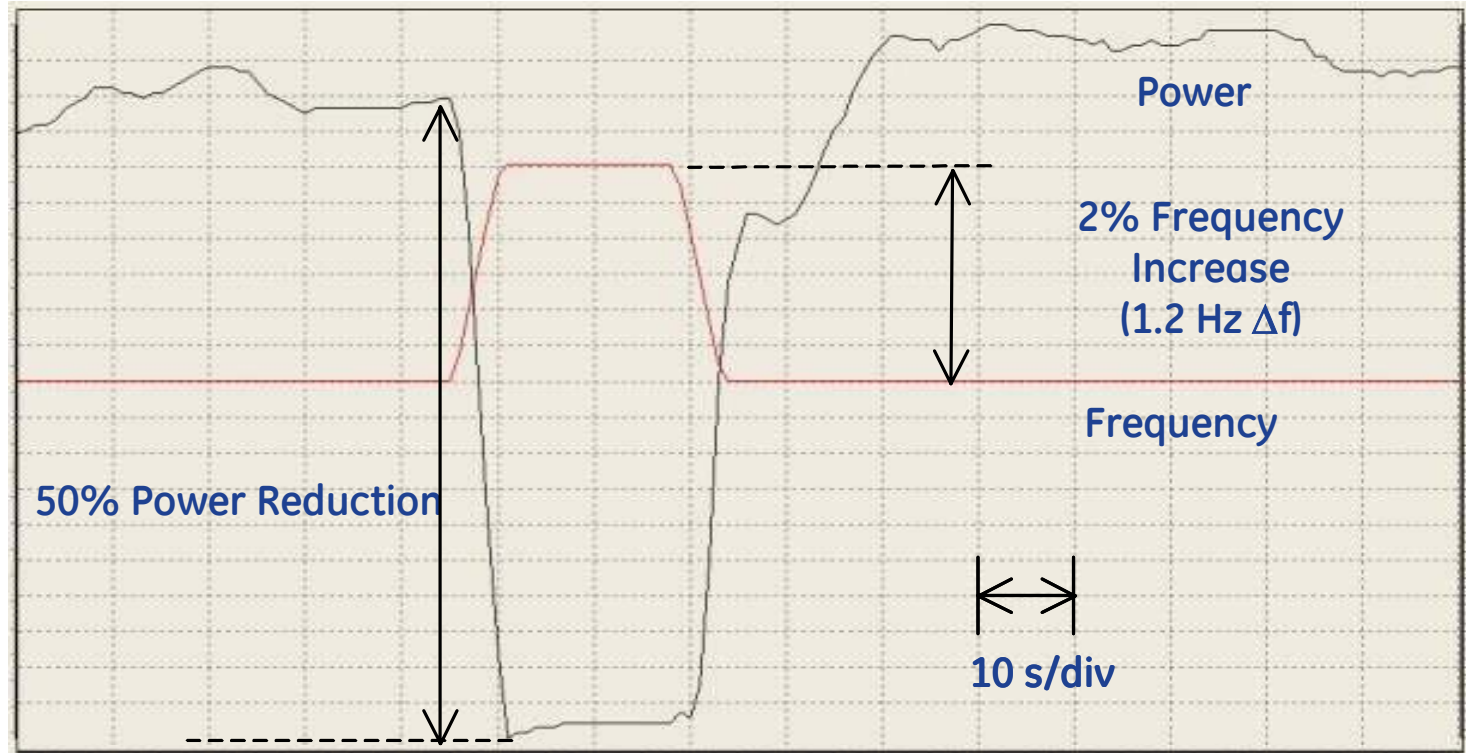
Wind plant output controlled during shutdown conditions

# Over-Frequency Droop Response

Settings:

4% Droop

2% Frequency  
step  
@0.25Hz/sec



50% reduction in plant watts with 2% over-frequency

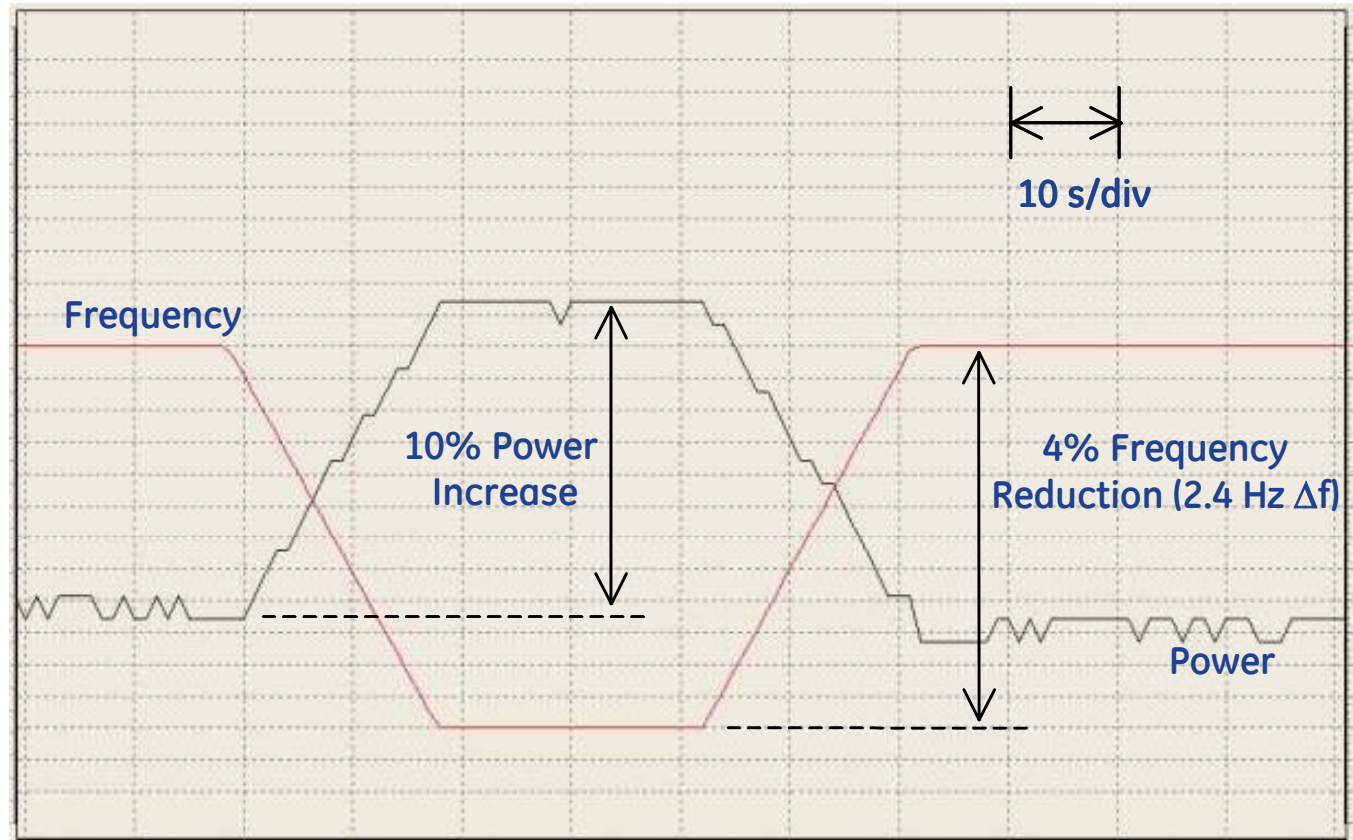
# Under-Frequency Droop Response

Settings:

90% wind capacity

4% droop

4% frequency step  
@0.125Hz/sec



10% Increase in plant watts with 4% under-frequency

# Conclusion

## System-Friendly Wind Technologies...

- Address reliability concerns of system operators
- Improve system operability and security
- Increase capability of systems to successfully achieve high levels of wind penetration

