

GE
Energy

GE's "Grid Friendly" Wind Plant Technology

EXECUTIVE EXCHANGE ON THE
USE & INTEGRATION OF
RENEWABLE ENERGY IN THE
POWER SECTOR

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GE Energy
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GE imagination at work

GE Proprietary & Confidential



Model: 1.5 sle



Technical Data (General)

Rated Capacity: 1.5 MW

Cut in Wind Speed: 3.5 m/s (7.83 mph)

Cut out Wind Speed: 25 m/s (62.63 mph)

Rated Wind Speed: 14 m/s (31.32 mph)

Hub Diameter: 77 m (252.62 ft)

Hub Height: 80 m (262.47 ft)

Certification: IEC TC IIb Ve50 = 52 m/s

Climate Conditions: Standard Weather

Operation: -15 C to +40 C (-5 F to 104 F)

Survival: -20 C to +50 C (-4 F to 122 F)

Noise Level: 104 db (A) average

Model: 2.5 XL



Product Characteristics

Wind Regime	DIBt WZ II, IEC TC IIIa, IEC TC II-b
Rotor Diameter	100m
Rated Power	2.5MW
Hub height	100m
Average wind speed	8.5 m/s
Survival wind speed	59.5m/s
Cut in wind speed	3.0m/s
Cut out wind speed	25m/s
Operating temperature	-15C to +40C
Noise level	≤ 105 dB(A)

Plant performance solutions

Grid friendly capabilities

WindFREE
Reactive Power

Reactive Power
even with no wind

WindRIDE-THRU

Uninterrupted turbine
operation through grid
disturbances

WindINERTIA

Inertial response for
large, short duration
frequency deviations

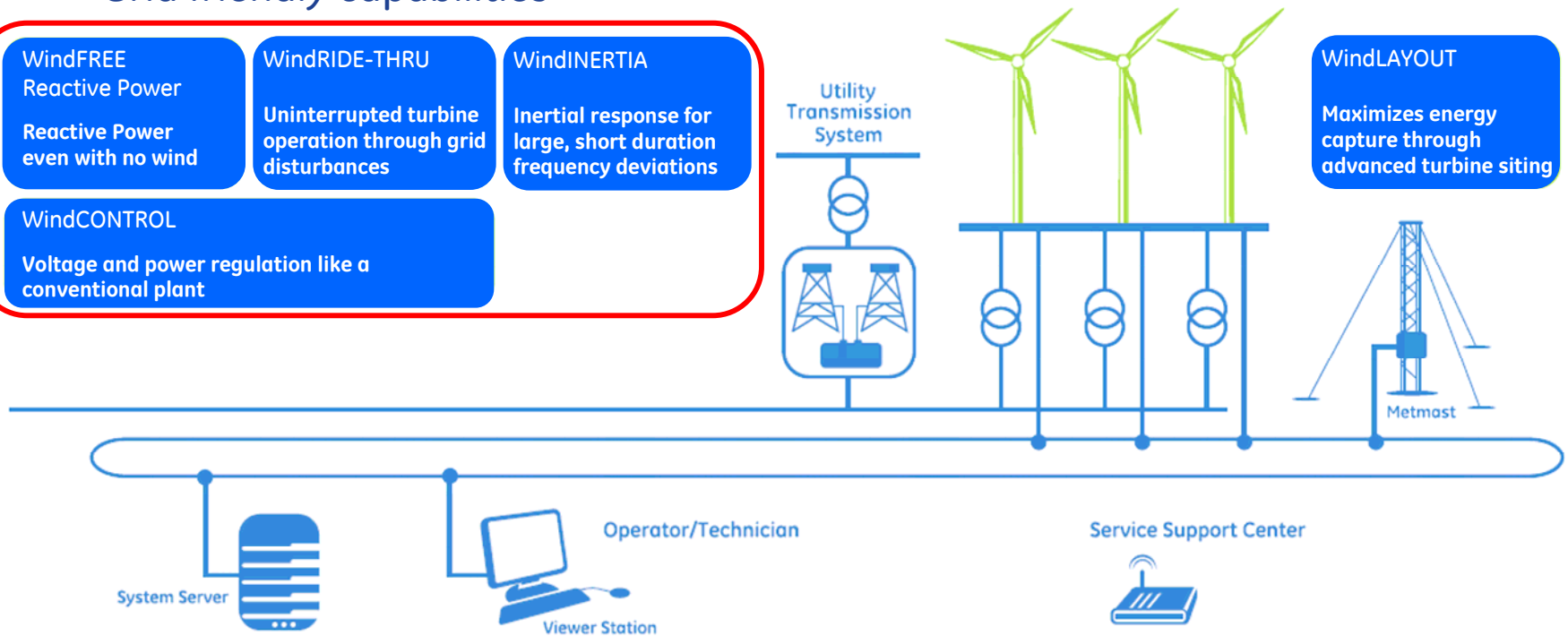
WindCONTROL

Voltage and power regulation like a
conventional plant

AEP improvement

WindLAYOUT

Maximizes energy
capture through
advanced turbine siting



WindSCADA

Sophisticated tools to operate, maintain and manage the entire wind plant

O&M tools

As Wind Power Plants increase in size and contribution ...

Utility systems require that wind power plants:

- > Provide Controlled and Predictable Power Response From Variations in Wind, Turbine and Grid Frequency
- > Must remain connected to the grid following disturbances – in short, they must remain stable

Good locations for wind plants often entail connection to relatively weak transmission systems

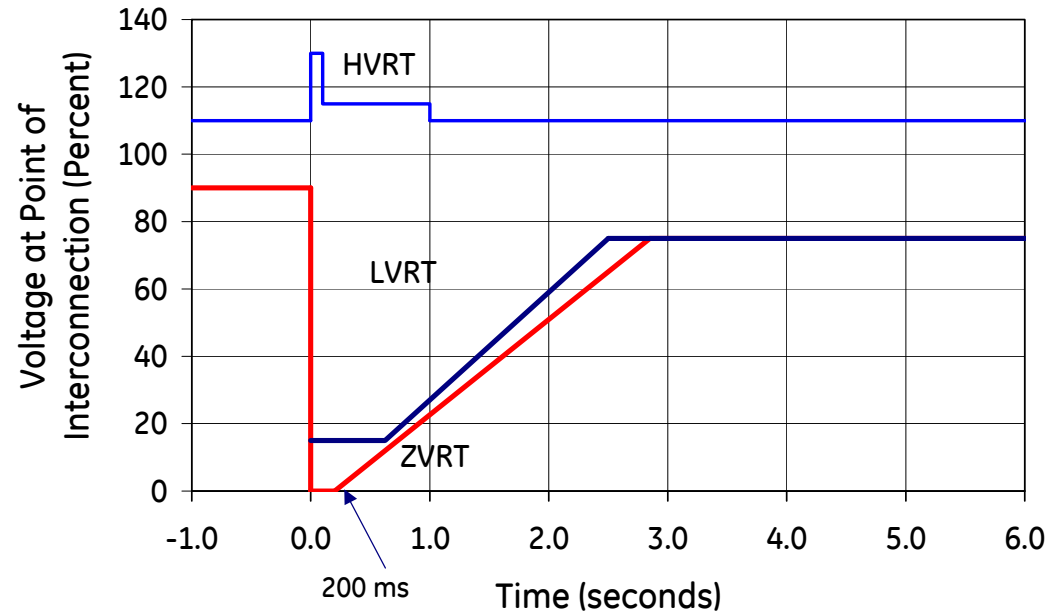
Wind plants must perform like a conventional power plant



Ride-Thru Capabilities

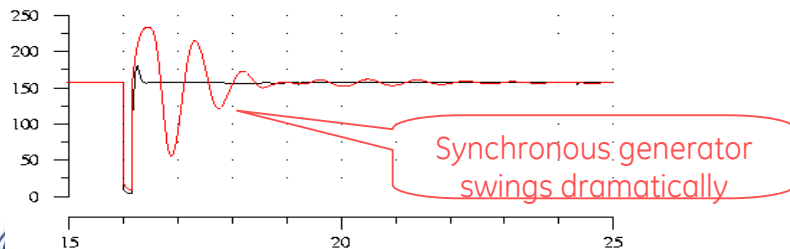
GE's Standard WindRIDE-THRU Offerings

- Remains on-line and feeds reactive power through system disturbances
- Meets present and emerging grid requirement with Low/Zero Voltage Ride Through (LVRT/ZVRT) capability
- Meets transmission reliability standards similar to thermal generators

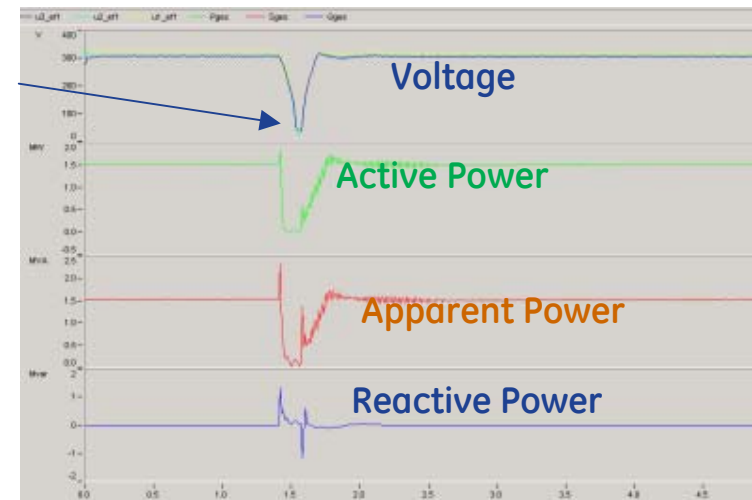


Fault Recovery

- Voltage recovery better than conventional generator



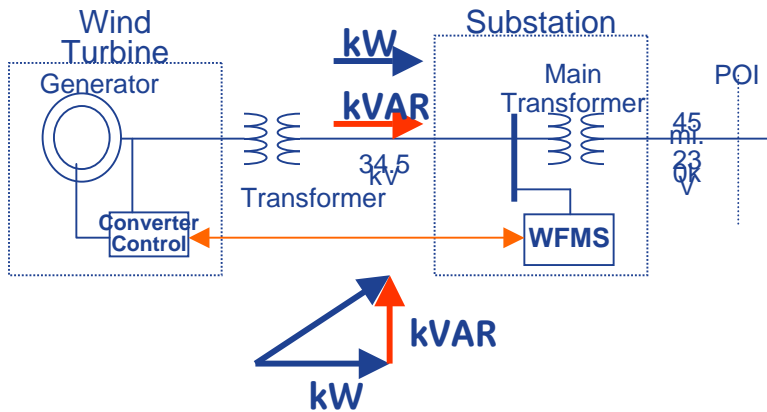
Zero Voltage Event



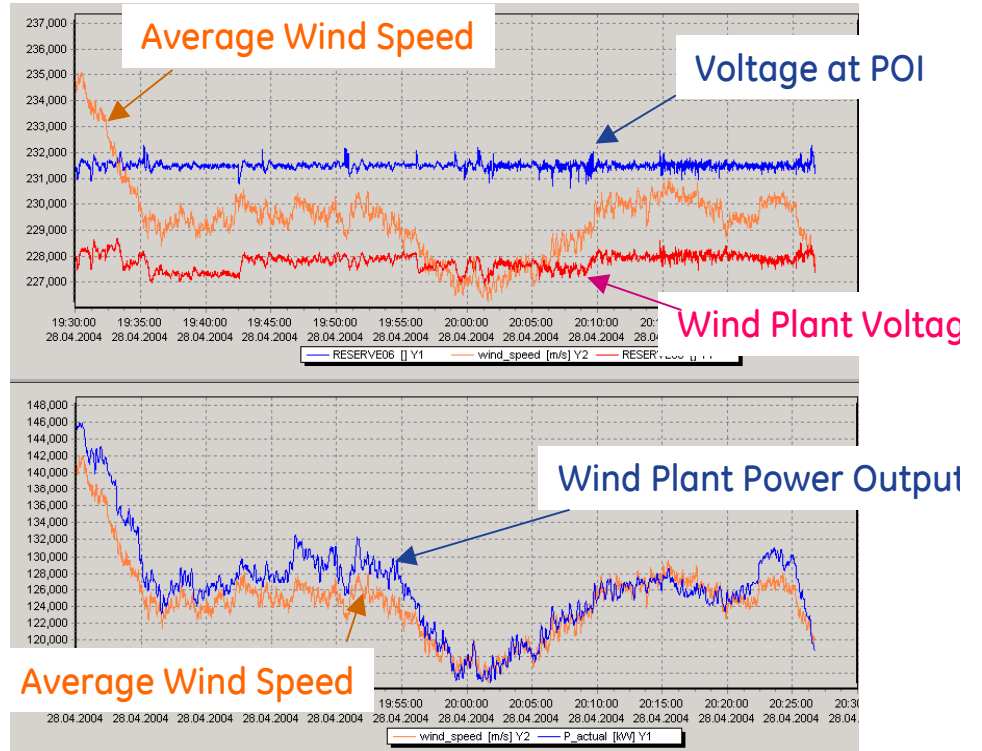
April 3, 2008

Voltage Regulation

- Regulates Grid Voltage at Point of Interconnection
- Minimizes Grid Voltage Fluctuations Even Under Varying Wind Conditions



Actual measurements from a 162MW wind plant



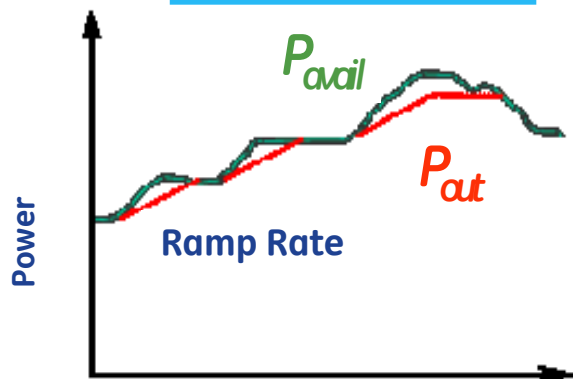
**Voltage Regulation
Like A Conventional Power Plant**

Active Power Controls

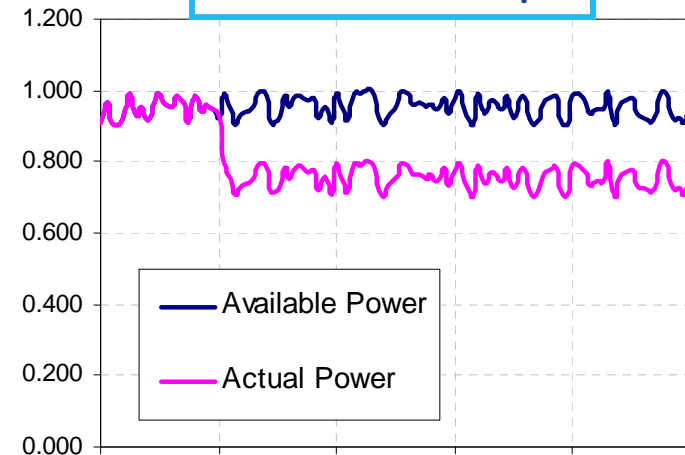
Typical Grid Requirements

- Ramp rates
- Power curtailment
- Power droop w/ frequency

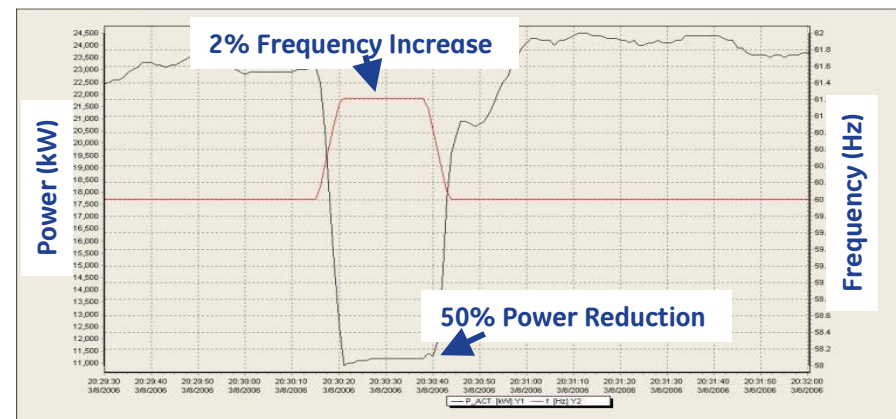
Power Ramp Rates



Curtailment Example



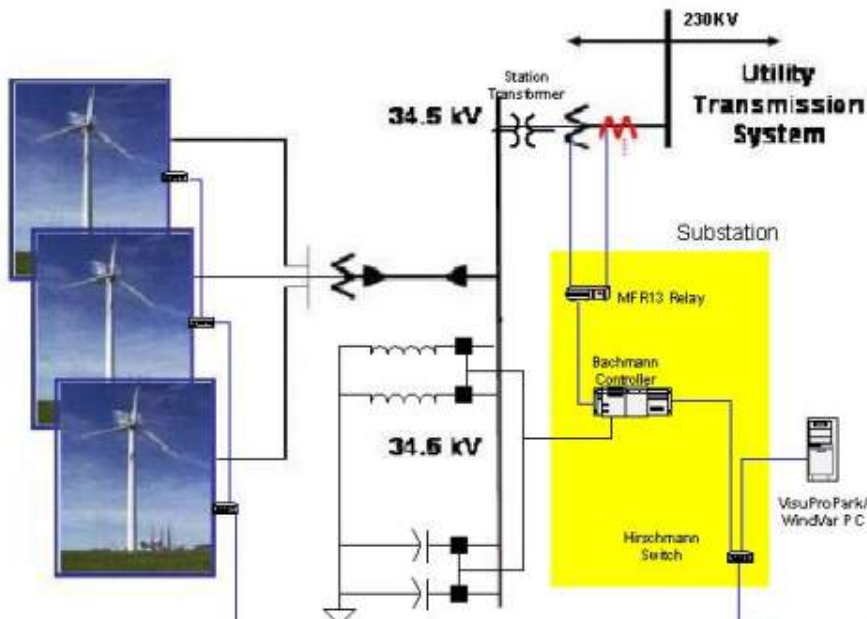
Power Droop Test



WindCONTROL

Hardware Overview

- Substation Mounted Cabinet
 - PT&CT Interface to Substation
- SCADA HMI
 - Operates on Wind Plant LAN



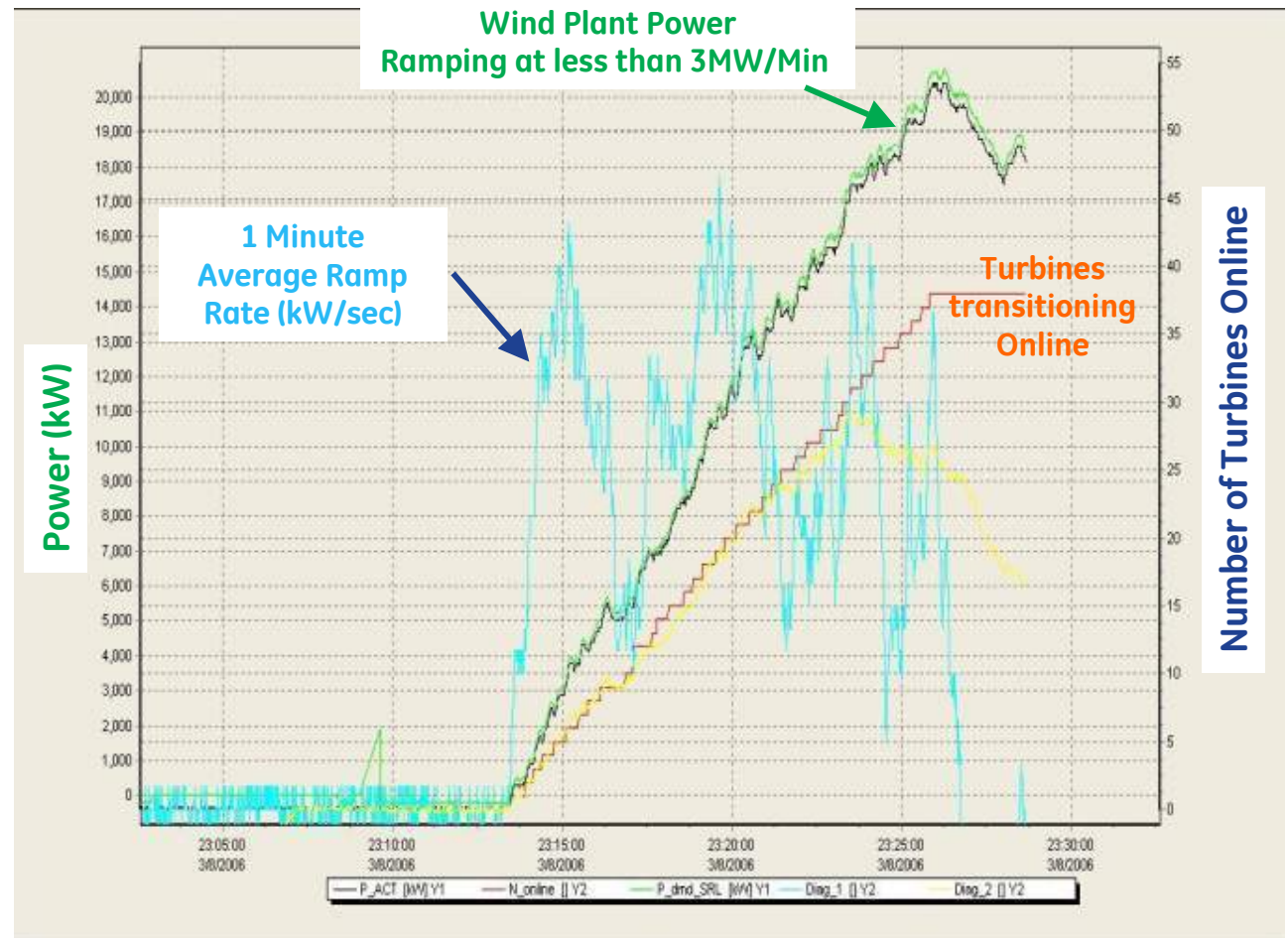
Plant Level Controller Orchestrates Operation of Individual Turbines

Wind Plant Startup

Settings:

Turbines Sequenced
On at 20 second
Intervals

Ramp Rate Limit
3MW/Min



Wind Plant Output Controlled During Startup Conditions



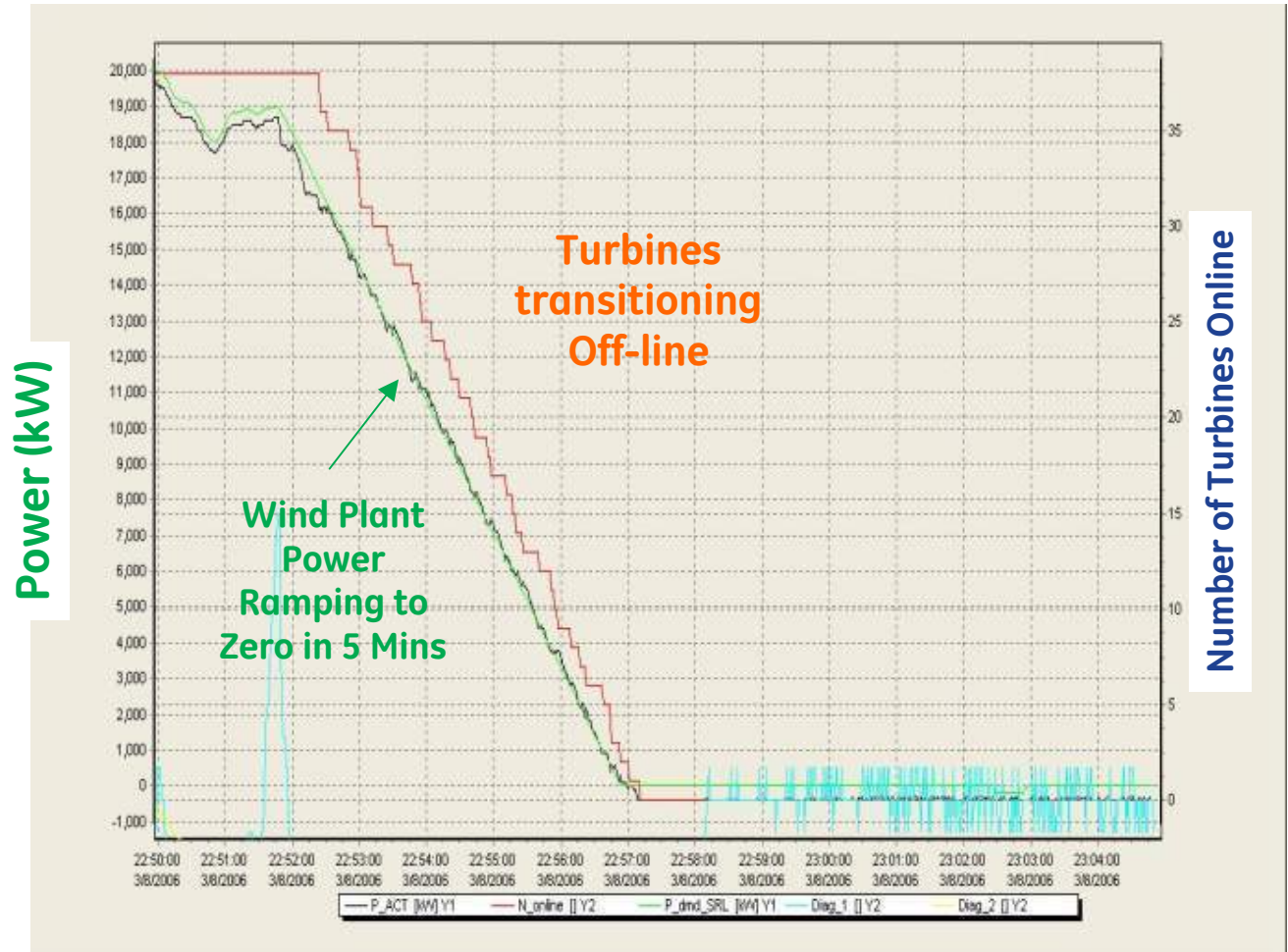
GE imagination at work

EWEC Grid Friendly Presentation 10
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Wind Plant Shutdown

Settings:

Shutdown Interval Set to 5 Minutes



Wind Plant Output Controlled During Shutdown Conditions



GE imagination at work

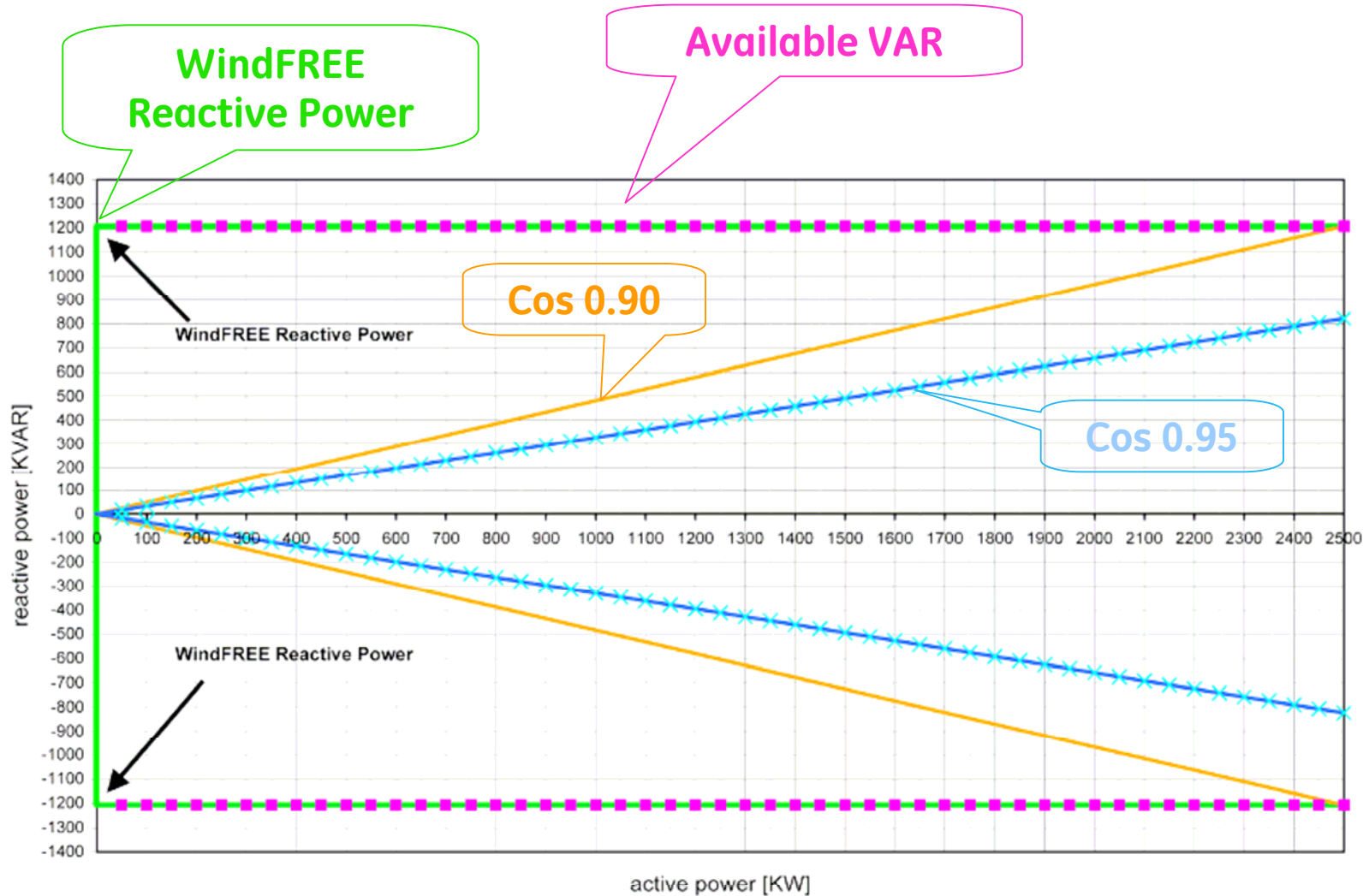
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WindFREE Reactive Power

- Wind Turbine converter can deliver reactive power (kVAR) without wind (kW)
- Benefits weak grids and systems with high wind penetration
- Voltage support continues without active power generation...even following trips

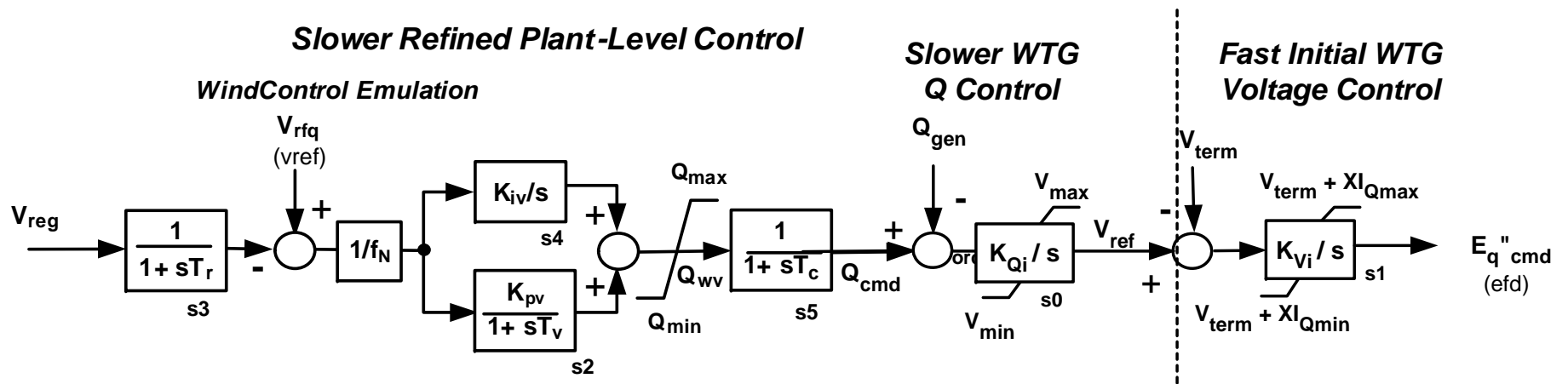
Reactive Power - *even without wind*

2.5 WTG Reactive Power Capability



Wind Plant-Wind Turbine Stability Modeling

- Good models of wind plants gain importance as wind penetration levels impact system performance

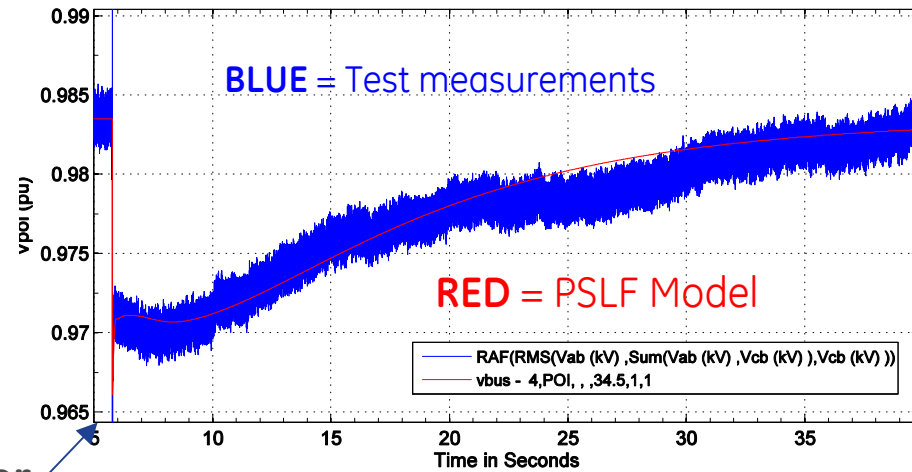


Positive Sequence Load Flow Model For GE Plant Systems

- Development of stability models is on-going and evolving with equipment capability and validation efforts
 - ZVRT and Voltage Response models closely replicate plant performance

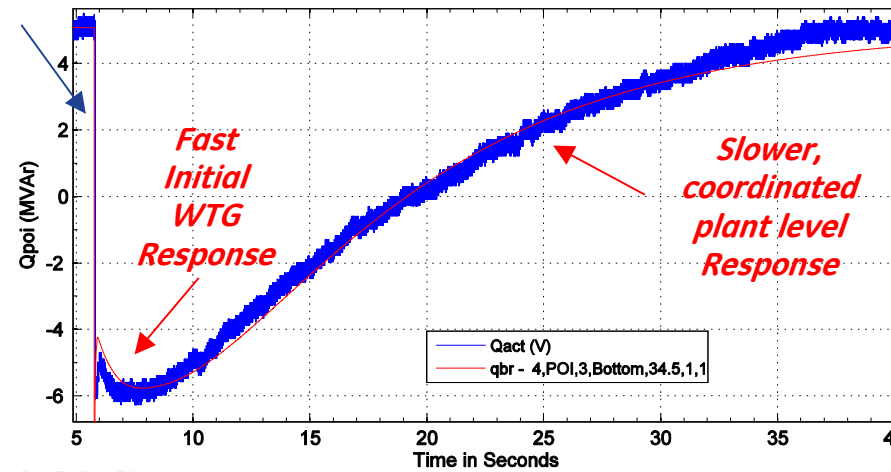
Field Measurements vs Model for a Wind Plant

POI voltage response



Capacitor switched offline

POI reactive power response



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Multi-modal response is grid friendly

“Grid Friendly” Wind Power Plant...

- Addresses Reliability Concerns of Grid Operators
- Improves Grid Operability and Security
- Increases Capability of Grids to Successfully Achieve High Levels of Wind Penetration



Thank you!



imagination at work

