Large Wind Plant Collector Design

IEEE PES T&D 2008

Monitoring, Control, and Automation of Large Wind Plants

Mark Cardinal

April 23, 2008

imagination at work

Plant Requirements

Function as a single coordinated power plant

- SCADA
  - Turbine Operation
  - Turbine/Plant Monitoring
  - Communications LAN
- Control Functions
  - Plant Power Regulation
  - Plant VAR Regulation
- Electrical Interfaces
  - Fixed VAR Banks
  - Utility control references
  - PT's and CT's

imagination at work

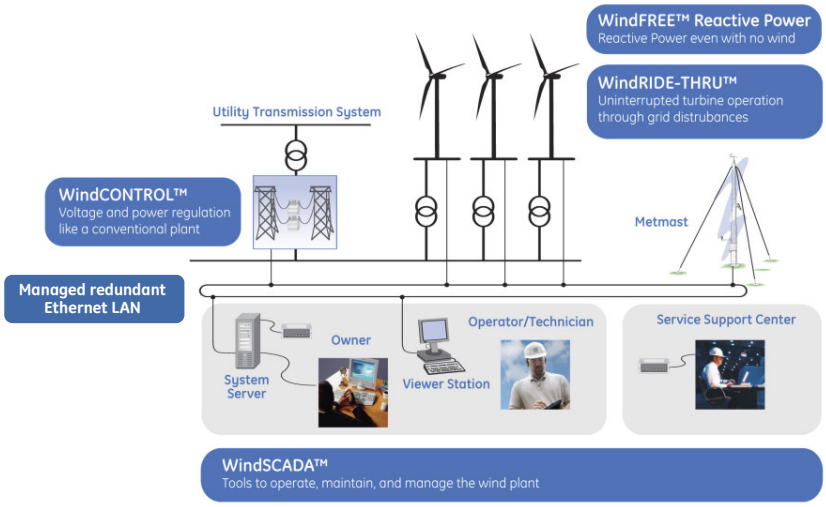
Plant SCADA

Integrated operation, monitoring and control system

- User HMI
- Communications LAN
- Real time Watt/VAR regulation
- Unit sequencing
- Historical and real time monitoring
- Reporting

imagination at work

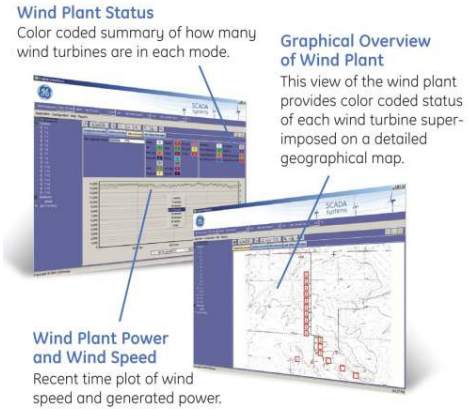
Power Plant SCADA and Control Architecture GE WindSCADA & WindCONTROL



imagination at work

Wind Plant SCADA System

- Real-time operational control of each turbine & complete Wind Plant
- Historical data base with reporting system including Production and Wind reports
- Secure User-Access, intuitive Operation & Maintenance tool



imagination at work

Control Functions

Power control

-Curtailment
- Power-Frequency droop
- Ramp Rate
- Coordinated plant startup & shutdown

VAR control

- Voltage (optional droop & line drop)
- Power Factor

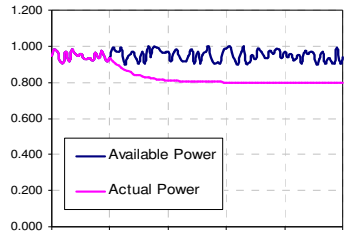
imagination at work

Power Controls

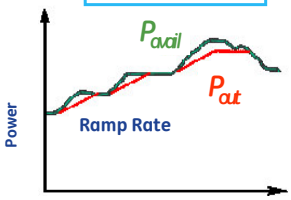
Typical Grid Requirements

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

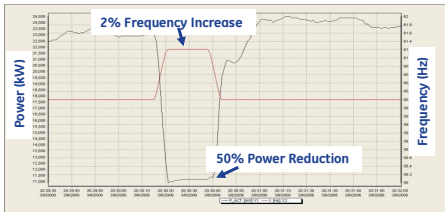
Curtailment Example



Power Ramp Rates

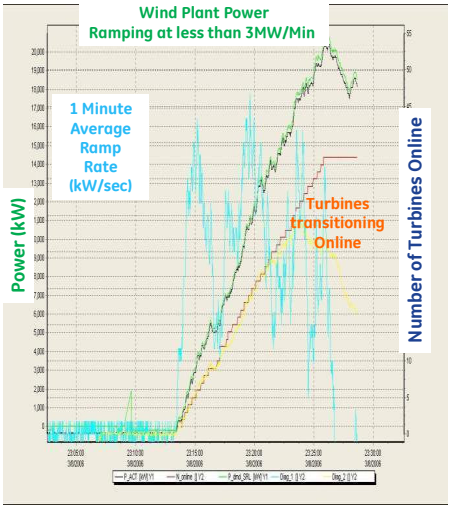


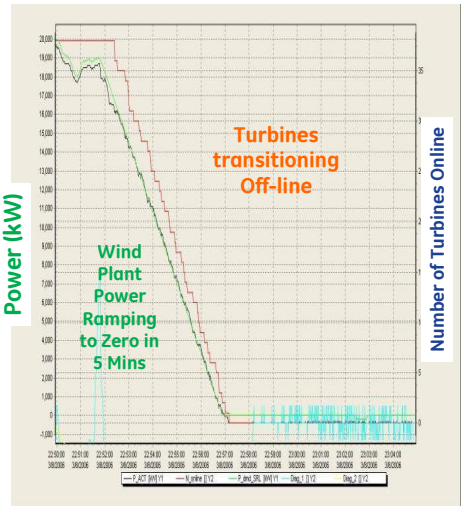
Power Frequency Droop



imagination at work

Startup and Shutdown Control -Controls the Insertion and Removal of Large Power Blocks

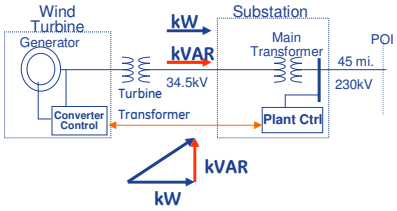




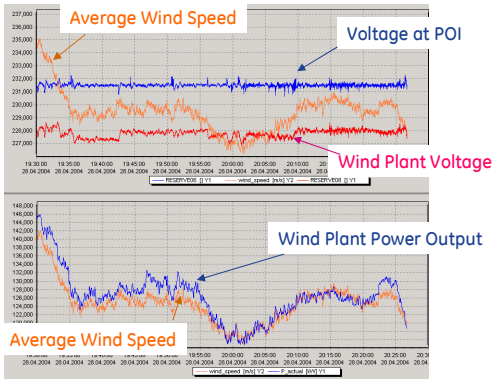
imagination at work

Voltage/Pf Regulation

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



Actual measurements from a 162MW wind plant with line drop compensation



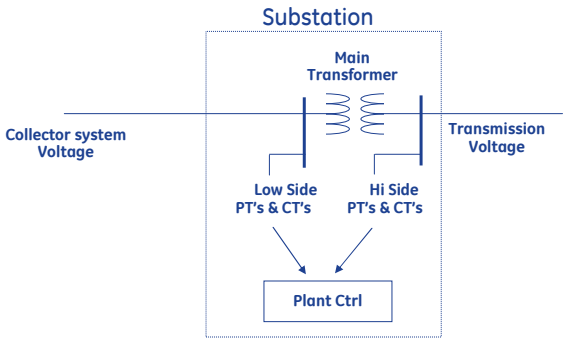
imagination at work

Wind Plant control application criteria

- Metering or Protection Grade CT
- PT & CT location
- Other control requirements
  Intra area coordination

imagination at work

Plant Measurement Location Tradeoffs



Low Side Measurement

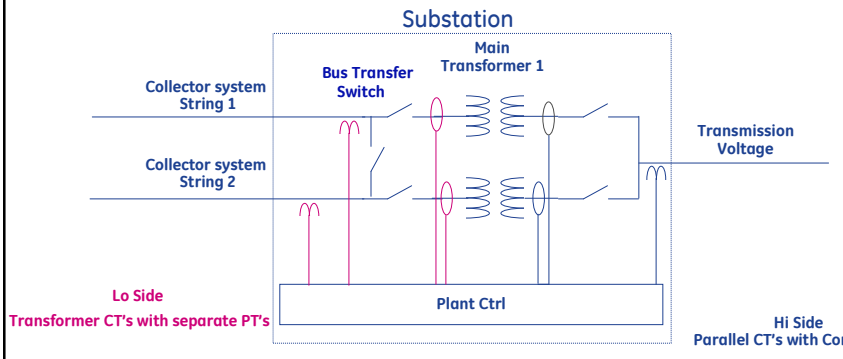
Regulates collector system voltage
Conflict with OLTC operation
XFMR droop & impedance buffering
Neglects XFMR power losses

Hi Side Measurement

Regulates transmission voltage
Coordinates with OLTC operation
May require synthesized droop
Includes XFMR power losses

imagination at work

Dual or Redundant Main Step Up Transformer Instrumentation Wiring



Lo Side
Transformer CT's with separate PT's

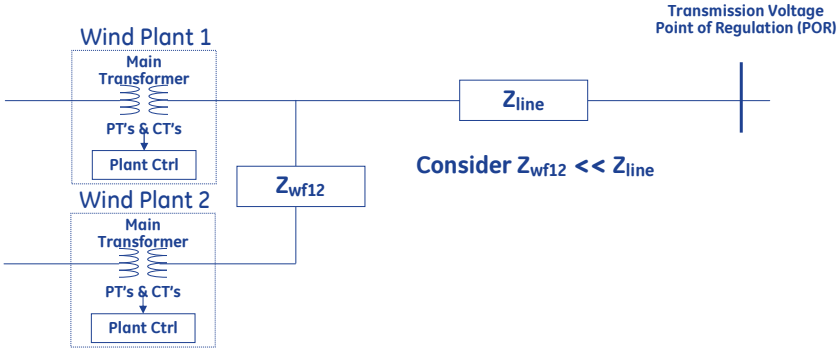
Hi Side
Parallel CT's with Common PT

Transfer switch closed –
2 separate control circuits
Transfer switch open -
Common control circuit

Single control circuit 1 or 2 transformers

imagination at work

Wind Plant Local Area Control Applications



Voltage regulation with tightly coupled wind plants

Line Drop Compensation for POR is problematic
Most often requires each wind plant to operate in voltage droop
Power Factor control or 3rd party master control potential solution

imagination at work

Summary & Conclusion

Wind Plant Controls

- **Are available that allow wind plants to function as single power plant**
- **Integrated SCADA system architecture**
- **Control requirements are important when applying plant controls to wind plant electrical design**

imagination at work