Wind Power Plant SCADA and Controls

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Presentation Overview

Modern Wind Power Plants (WPPs) contain a variety of intelligent electronic devices (IEDs), Supervisory Control and Data Acquisition (SCADA) and communication systems.

This paper discusses the issues related to a typical WPP's SCADA and Control.

Presentation Topics

- Wind Turbine Controls
- Wind Plant SCADA
  - OEM SCADA Solutions
  - Third-Party SCADA Solutions
- Wind Plant Control
- Security and Reliability Compliance

Wind Turbine Controls

- For safe, reliable and automated control individual turbines use microprocessor controllers with closed loop algorithms to regulate the following internal controllers:
  - Pitch
  - Yaw
  - Generator
  - Supervisory
- Safety system independent of the main controller for fail safe (hardwired) for emergency shut-down

Wind Turbine Controls

- Stall regulated – Uses characteristics of the blade to limit the rotor speed and aerodynamic power.
- Pitched regulated – Changes blade pitch to limit rotor speed and aerodynamics.
  - Collective pitch moves all blades together (same time, same angle)
  - Independent pitch uses separate non-linked systems for each blade (same angle)
  - Individual pitch can vary each blade separately to a different angle

Wind Turbine Controls

- Yaw Controller – rotates the turbine into or out of the wind using drive motors
  - Essential to mitigate fatigue loads
  - Maintain optimal energy production
  - Unwinds power and control cabling between nacelle and base
- Generator Controller – regulates torque to maximize power output and maintain rotor speed below rated
  - Actively dampen drive train torsional vibrations by applying small ripple torque close to drive train natural frequency and phase angle

Wind Turbine Controls

- Supervisory Controller – necessary to operate turbine autonomously from one operational state to another
  - Start-up
  - Power production
  - Shut-down
  - Stopped (fault case)
- Operation of auxiliary equipment
  - Cooling of gearbox, generator, power converter fans and pumps
  - Heaters for cold weather applications
  - Lubrication pumps

Plant SCADA

- Real time visibility of plant operation
- Ability to control plant centrally or remotely

- Two Options:
  - Original Equipment Manufacturer (OEM)
  - 3rd party common for fleets with multiple OEMs

Plant SCADA: OEM

- Variable functionality based on manufacturer
- Potential advantages:
  - Tightly integrated with turbine control system
  - Advanced turbine details and diagnostics
  - Advanced troubleshooting and data analysis
  - Verification of contractual obligations
    (production, availability, power curve guarantees, etc.)
  - Reduces number of service inspections

Plant SCADA: OEM

- Relies on site communication network as backbone
- Uses standard industry protocols such as Modbus for data exchange
- Network configurations include bus, star, and ring
- Fiber optic common for interconnection between plant assets for speed and bandwidth
- Design considerations include:
  - Distance: multimode vs single mode
  - Cost: Single mode cable less, but transmitter more
  - Mixed Mode: single mode for homeruns, multimode inter-turbine. Increases inventory and construction complexity.

Plant SCADA: Third-Party

- Commonly used for
  - Manufacturers without OEM systems
  - Supplement to OEM system
  - Managing WPPs with different OEMs
  - Enterprise level view of multiple WPPs
- Potential advantages include:
  - Consolidated view of all assets
  - Common monitoring interface
  - Standardized reporting
  - Single interface for communication with system operators
  - Flexibility for incorporating substation SCADA

Plant Control

- To enable WPP to behave like a conventional power plant and meet specific grid requirements, advanced controls are common at the Point of Interconnection (POI)
- Typically integrated to Plant SCADA to coordinate turbine operation and provide stable response to grid requirements

Plant Control

- Voltage and Power Factor Regulation
  - Capacitor/Reactor Banks provide coarse, static reactive support. Typically located on medium voltage bus
  - Dynamic Var devices provide fine, rapid reactive control
  - Turbine and external device control can be centralized and coordinated to achieve desired behavior at POI
- Ramp Rate Control
  - Often required by system operator and referred to as power ramp rate (PRR)
  - Enforced in MW per minute, commonly 10 minutes or less
  - Direct remote control from system operator or local control

Plant Control

- Frequency Droop
  - Varying power output as a function of grid frequency to stabilize grid frequency variation
- Power Curtailment
  - System operator may require direct remote control of plant power output to deal with grid stability and transmission constraints
  - Simple turbine shut-down, global (aggregate) setpoint, or balanced rotational algorithm
- Auxiliary
  - Battery banks, turbine SCADA alarms, substation equipment alarms, etc.

Security and Reliability Compliance

- Beyond prudent engineering, WPPs often must comply with contractual obligations under an interconnection agreement (IA) and other requirements necessary for grid security and reliability
- Failure to comply can result in Default
- Provisions vary regionally and are dependent on project specific parameters such as size, POI, and impact to the grid

Security and Reliability Compliance

- Remedial Action Scheme (RAS)
  - AKA Special Protection Scheme (SPS)
  - Automatic protection system to detect abnormal conditions and responds to maintain stability/reliability
  - Triggers can include:
    - Grid voltage, power flow, and/or frequency deviations
    - Cascaded tripping
  - Common Actions
    - Transfer trip of WPP
    - Load shedding
    - Tap changer blocking
    - Automatic shunt of capacitor/reactor switching

Security and Reliability Compliance

- Protection System Relaying
  - Protection scheme must be interoperable with existing system
  - Necessary to protect equipment internal and external to WPP
  - Governed by IA
- Data Telemetry
  - Managing increasing wind power penetration will require real-time communication with interconnection entities
  - To manage schedule, generation, and power flow interconnecting entities may require data to forecast availability, such as, real-time meteorological data to optimize wind power forecasts
  - Communications for grid operations are subject to NERC Critical Infrastructure Protection (CIP) requirements

Security and Reliability Compliance

- NERC Reliability Standards
  - FERC Order 706 requires compliance enforced at regional levels for CIP and other reliability standards.
  - WPP SCADA, control, and communication systems must comply with cyber security provisions of CIP and other protection and control provisions.
- IEC Reliability Standards
  - 61400-25 is an extension of IEC-61850 utility automation standard providing a uniform information exchange environment and governing WPP SCADA, control, and communications with grid control centers in Europe
  - 61400-25 defines data objects and maps to protocols such as DNP3, XML, and OPC

Conclusion

- SCADA, IEDs, control, and communication systems are integral for optimization of WPP performance, financial return, and meeting contractual obligations and requirements.

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