Collector System Design
Considerations for Wind Farms

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Overview

• Challenges in wind farm collector systems
• Design considerations for collector systems
• Summary

The presentation will discuss the most prevalent collector system design for land based wind farms with underground collector systems.
Challenges in Wind Farm Collector Systems

- Location and terrain of wind farm site
- Installation methodology and constructability
- Ice throw from wind turbines
- Length of collector system cable circuits
- Cable testing and fault locating of collector circuits
Design Considerations for Collector Systems

- Most common voltage levels for collector systems
  - 15 kV
  - 25 kV
  - 35 kV (most typical) / 46 kV (Canada)
- 35 kV is the most common system voltage utilized for wind farm collector systems because of the long circuit lengths and loading requirements
- UK voltages typically 11 kV and 33 kV
Cable Design

- Cable insulation levels
- Cable type and sizes
- Cable ampacities
  - Load factor
  - Number of circuits
  - Cable installation geometry and method
  - Thermal resistivity and temperature
  - Cable shield voltages and bonding method
Circuit Configuration and Soil Thermal Resistivity Impact on Ampacity

Ampacity vs RHO for Single and Parallel Circuits

1 Circuit, 3 Cables, Trefoil, 90 °C, 1/3 Neutral, 35 kV, 40” Direct Buried, Spaced 12” Between Circuits
Cable Sheath Bonding and Grounding

- Three basic methods of sheath bonding
  - single-point bonding
  - solid bonding
  - cross bonding
- NESC Sec. 9 Rule 92C
  - “4 grounds per mile”
  - includes grounds at transformers, splices, etc.
- Parallel grounding conductor
Surge Protection Considerations for Collector Systems

- Surge protection typically installed at last pad-mounted transformer on each feeder string of collector circuit
- Considerations in application of surge arresters
  - location of arresters, type of mounting
  - system grounding
  - circuit length
  - transient analysis (EMTP) may be required
System Protection Considerations for Collector Systems

- Considerations for protection of collector systems
  - long circuit lengths may not allow for easy detection of ground faults
  - system grounding (grounded vs. ungrounded)
  - selective coordination of collector system circuits
  - selective coordination with upstream pad-mounted transformers at WTG
  - temporary overvoltages caused by ground faults
  - loss of phase during fault with single phase tripping and reclosing on transmission system or downed conductor
  - WTG may feed faults for several cycles
Collection Switchgear

- Underground distribution switchgear
- Metal-enclosed switchgear
- Circuit breakers
Reactive Power Compensation

- Reactive power compensation systems for meeting interconnect requirements (FERC 661-A) for power factor and LVRT:
  - power-electronically switched capacitors
  - distributed static compensators
  - mechanically-switched capacitors
Other Considerations

- Ferroresonance
  - can occur in collector system circuits with ungrounded wye or delta primary transformer connections because of:
    - single pole switching or reclosing
    - single phasing during faulted conditions
  - preventing ferroresonance on collector systems
    - provide grounding transformers
      - size of grounding transformers > 5% of feeder load
Other Considerations

• Fault locating
  – long circuit lengths can make locating and isolation of faults difficult
    • provide sectionalizing points for circuits that do not exceed capabilities of fault locating equipment
    • include sectionalizing points for isolation and restoration
• Use directional fault indicators at WTG transformers to provide for fault detection and isolation
Other Considerations

• SCADA systems
  – typically installed as a part of the collector system
  – design considerations
    • circuit length
    • number of turbines on a circuit
    • communications protocol
    • fiber type
      – single-mode fiber
      – multi-mode fiber
Analytical Studies for Collector Systems

- Analytical studies typically performed during the design phase:
  - cable ampacity
  - system losses
  - voltage drop/regulation
  - short-circuit and coordination
  - transients and insulation coordination (EMTP)
  - harmonics
Summary

• Key considerations in collector system design
  – system voltage
  – insulation levels
  – cable ampacity parameters
    • load factor, installation method, bonding method, thermal considerations
  – other factors
    • surge protection, system protection, ferroresonance, SCADA
  – collection switchgear and compensation requirements
IEEE PES Support for Wind Farm Collector System Design

- Recommended practices/standards
- Equipment application guidelines
- Development and validation of equipment models
- Training