Enhanced Multiple Element Contingency Screening and Cascading Analysis for NERC Compliance

Chengyue Guo
Chuck Lawrence

MIPSYCON
November 5th, 2014
ATC - Who we are

- Founded in 2001
- Multi-state transmission-only utility

- Over 9,500 miles of transmission line and 530 substations
- Voltages from 69 kV to 345 kV
Business Triggers

• Improve compliance support documentation
• Enhance ATC cascading methodology
• Simulate a larger number of multiple element contingencies
• Automate post-processing of simulation results
Total Load At Risk

- Consequential load loss (NERC term)
- Subsequent cascading load loss
- Expected load shed
• Used to classify “More Severe” contingencies

• Used to better define when NERC Cascading may occur (cascading versus Cascading)
ATC Enhanced Cascading Tripping Criteria

- Overhead conductor loading
  - 345kV (110%)
  - 115kV, 138kV, 161kV, 230kV (105%)
  - 69kV (100%)
- Transformer loading (30 min)
- Underground/Submarine cable loading (125%)
- Generator low voltage (0.9 pu)
- Load low voltage (0.8 pu)
Study Methodology

Steady-state screening analysis
- Screening analysis without mitigation (Stage 1)
- Screening analysis with mitigation (Stage 2)

Steady-state cascading analysis
- (Stage 3)
Screening Analysis – Stage 1

Identifies contingencies:

- Potential Voltage Instability
  -> Stage 3

- Exceeding system tripping criteria
  -> Stage 3

- Exceeding system normal limits
  -> Stage 2
Screening Analysis – Stage 2

Identifies contingencies:

- Exceeding emergency limits, but do not exceed tripping criteria
  - Two step mitigation analysis

- Exceeding normal limits, but do not exceed emergency limits
  - One step mitigation analysis
Feasible Mitigations

• Capacitor and inductor switching
• Transformer LTC adjustment
• Phase shifter adjustment
• Generator voltage schedule
• System reconfiguration
• Generation redispatch
• Load curtailment
Cascading Analysis – Stage 3

• Cascading Tier Analysis
  o Simulation stop criteria
    ◆ No more tripping
    ◆ Number of BES lines tripped threshold exceeded
    ◆ Total load at Risk threshold exceeded
    ◆ Unmitigated voltage instability

• Post Cascading Mitigation Analysis
  o Same as Stage 2 process
Working with V&R

• Screening and Cascading Analysis scripts
  o POM/OPM
  o Microsoft® VB.NET
  o Tailored to ATC’s process
  o Easy to use with different input options
  o Results tabulated in spreadsheets
  o Adaptable to various compliance studies
Typical Running Time

- **Screening Analysis - Stage 1**
  - ~250,000 contingencies
  - ~25 hours

- **Screening Analysis - Stage 2**
  - ~14,000 contingencies
  - ~10 hours

- **Cascading Analysis - Stage 3**
  - ~800 contingencies
  - ~2 hours
Future Improvements

Add consideration of:

• Circuit terminal equipment tripping criteria
• Generator high voltage tripping criteria
• Special Protection Schemes
• Loadability relay actions
• Element tripping sequence
• Breaker-to-breaker tripping
• Questions?