



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



Total Load At Risk

- 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
 - 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
 - Same as Stage 2 process



Working with V&R

- Screening and Cascading Analysis scripts
 - POM/OPM
 - Microsoft® VB.NET
 - Tailored to ATC's process
 - Easy to use with different input options
 - Results tabulated in spreadsheets
 - 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?