Testing for Cascading

June 2019

What does cascading mean?

- **C**ascading (NERC Definition):
  - The uncontrolled successive loss of System Elements triggered by an incident at any location. Cascading results in widespread electric service interruption that cannot be restrained from sequentially spreading beyond an area predetermined by studies.
- **c**ascading
  - Successive, uncontrolled loss of System Elements
- Unacceptable cascading
  - Uncontrolled successive loss and unacceptable, may or may not be contained
- Acceptable cascading
  - Uncontrolled successive loss, but acceptable, must be contained

Why consider cascading?

- P6 (N-1-1) used to be considered an extreme event
- Not all parts of the transmission system have been built to withstand P6 for peak load
- Transmission systems have been operating successfully for decades without being planned for P6 peak load
- Building new infrastructure or RAS schemes to accommodate all P6 scenarios for peak load may not be economical, reliable, or feasible

Why consider cascading?

- For higher risk P6s, a system reinforcement may be appropriate
- “Higher risk” could be qualitatively defined by:
  - Risk of unbounded cascading
  - Number of elements that trip during cascade
  - Exposure (hours per year for gen/load levels)
  - MW amount that could be lost (load and gen)
  - Population density, load type
  - Foreign Utility impacted
  - Likelihood of contingency occurring
  - Duration of outage
  - Feasibility of system adjustment after first contingency
- Lower risk P6s may rely on non-consequential load loss
- Trade-off: this balances cost and reliability to maximize the value system

Acceptable *cascading*

- P2 through P7 category contingencies
  - Non-consequential load loss is allowed
- How do you evaluate non-consequential load loss if no RAS or SPS is in place?
  - Local voltage collapse
  - Thermal overload resulting in local protection operating
- How do you evaluate non-consequential load loss if power flow diverges?

BPA Cascading Methodology

For cascading or uncontrolled islanding, if any of the following thresholds is met for criteria outages, BPA will further investigate whether there is cascading or uncontrolled islanding:

1. Post-contingency loading on a facility exceeds the lesser of its known instantaneous overcurrent trip setting or 100% of the facility's highest seasonal ratings (continuous rating for transmission lines, emergency rating for transformers).
2. Transient stability performance does not meet the applicable WECC System Performance Reliability Criteria requirements for transient voltage performance.
3. No positive reactive power margin within a local area.

BPA Cascading Methodology

Cascading is tested for with steady state analysis in the following sequence:

1. Solve initial contingency
2. If any elements are loaded above 100% of their applicable emergency rating, open the element with the highest loading and re-solve power flow.
3. If power flow fails to solve, resolve the contingency by taking a “soft” outage by increasing the impedance of the line or transformer being taken out of service incrementally over several solution attempts until element can be opened completely with a full solution.
4. While taking a soft outage
   a) If a load bus voltage drops below 0.70 pu, trip the load.
   b) If a facility loads above 125% of its emergency rating or known trip setting, trip that facility.
5. Once the soft outage is successful (line or transformer is completely out of service), evaluate bus voltages and facility loadings. If any facility loading is above 100%, go to step 2 and repeat process. Otherwise, cascading is finished.
6. Once cascading test sequence is complete, note the total amount of load & generation disconnected as a result of the sequence

Possible Process Improvements

- Added PowerWorld feature for cascading test?
  - Continually remove overloaded or low voltage facilities from service and report amount and extent of load loss
- Scripting to accomplish “soft outages”
  - Partially automate “soft outage” process by incrementally increasing line impedance