Transmission High Voltage Conditions and Mitigations

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American Transmission Company

A multi-state, transmission-only electric utility

- NERC registered Transmission Owner, Transmission Operator and Transmission Planner
- Own and operate all or part of about 570 substations and about 9,900 miles of 69 kV to 345 kV lines
- Peak load of about 13,000 MW
- About 600 employees
Transmission High Voltage Conditions and Mitigations

Overview

• Emerging Causes of Transmission High Voltage Conditions
• Identification of High Voltage Conditions and Their Causes
• Measures to Reduce Transmission High Voltage Conditions
• Specific Examples
Causes of Emerging Transmission High Voltage Conditions

• More miles of transmission lines (ATC >710 miles since 2001)
• More leading power factor at distribution interconnections
• Less local generation dispatched at low system load levels
• More local generation is being retired than is being installed
Identify of High Voltage Conditions and Causes

- Collect specific historical system operating data
- Collect specific equipment information
- Analyze the historical operations data
- Model and analyze relevant planning horizon system conditions
Collect specific historical system operating data

Collect two or more years of hourly historical system operating data in the area under study. This data generally includes:

– Total system real power load
– Transmission voltages, reactive power flows, and voltage regulating device operations
– Generation interconnection reactive power levels
– Distribution interconnection reactive power levels
Collect specific equipment information

The specific equipment information generally includes:

- **Transmission**
  - Transformer no load tap settings
  - Transformer LTC controller settings
  - Reactive device voltage regulation settings

- **Generation**
  - Reactive power capability limits

- **Distribution**
  - Reactive power device operating modes
Analyze the historical operation data to identify high voltage and undesirable reactive power conditions. These conditions may include:

– Voltages beyond the normal or emergency system operating limits
– Excessive or offset reactive power flows
– Undesirable transformer tap changer operation
– Undesirable reactive device operation
Model relevant planning horizon system conditions

• Model the study area under relevant planning horizon system conditions with historically-adjusted operating behaviors as needed

• Run simulations and monitor the following system conditions
  – Transmission voltages, reactive power flows, and voltage regulating device operations
  – Generation interconnection voltages and power flows
  – Distribution interconnection voltages and loads
Analyze relevant planning horizon system conditions

Analyze relevant planning horizon system results to identify high voltage and undesirable reactive power conditions. These conditions may include:

- Voltages beyond the normal or emergency system operating limits
- Excessive or offset reactive power flows
- Undesirable transformer tap changer operation
- Undesirable reactive device operation
Measures to Reduce Transmission High Voltage Conditions

- Change transformer LTC voltage control settings
- Change capacitor bank operating modes or settings
- Change transformer no-load tap settings
- Add inductor (reactor) banks
Specific Examples

• Scenario #1 – More miles of transmission lines
• Scenario #2 – Local generation displaced by remote generation at low system load conditions
• Scenario #3 – More leading power factor at distribution interconnections
Scenario #1 – More miles of transmission lines

• In the past, there were fewer 345 kV and 138 kV lines and 345 kV generation. No load tap setting of 2.5% boost on 345/138 kV transformers provided acceptable 138 kV voltages.

• Then, the addition of more 345 kV and 138 kV lines and 345 kV generation caused 138 kV area voltages to sometimes be too high.

• High voltage mitigation included: lowered the no load tap settings of 345/138 kV transformers to the nominal (neutral) tap position.
Scenario #2 - Local generation displaced by remote generation at low load conditions

• Previously, local generation was sufficient to provide acceptable 138 kV voltage regulation.

• Then, when remote generation displaced local generation, 138 kV voltages would sometimes be too high during low system load conditions.

• Mitigation: lowered the no load tap setting of selected 345/138 kV transformers to the nominal (neutral) position and added transmission inductor (reactor) banks.
Scenario #3 - More leading power factor load at distribution interconnections

• In the past, no load tap settings of 2.5% boost on 138/69 kV transformers and sufficient transmission and distribution capacitors provided acceptable 69 kV voltage regulation.

• Then, 69 kV load interconnection power factors become more leading, which caused 138 kV and 69 kV voltages to sometimes be too high during low system load conditions.

• Mitigation: lowered no load tap settings by 2.5 %, changed distribution capacitor operating modes, and added transmission inductor (reactor) banks.
Questions?

Contact Michael Marz, mmarz@atcllc.com, for further information.