

NERC Lessons Learned / Incident Reviews

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Load-Pocket Shoulder Season Challenges

- Shoulder seasons are considered the fall and spring
- These months are used for planned Bulk Power System (BPS) maintenance and construction (Generation and Transmission)
- The BPS is in a cycle of growth and transition
 - There is new transmission development to support load growth
- Historically, BPS reserve margins have been sufficient
 - Reserve margins have shrunk in recent years
- Thermal generation has been replaced by Variable Energy Resources (VER) – introduced uncertainty for system operators

- Loads with a flat demand curve has grown significantly
- Seasons temperatures have varied more significantly than historic norms
 - Thunderstorms and tornadoes create unplanned (forced) outages
 - Load patterns are less seasonal and harder to forecast
- Multiple load-shed incidents have occurred in the shoulder months
 - These incidents have occurred in a smaller area within a Balancing Authority

- Entity A – Three load-shed incidents in the same load pocket
 - Rapid and significant load growth in area
 - Transmission projects are planned to increase the capacity into the area
 - Capacity margin in area contains substantial amount of VERs
 - Contributing Factors:
 - Unavailable generation
 - Load Forecast Error
 - Transmission Outages
 - Solar ramping off
 - Low wind output

- Entity B – Two load-shed incidents in the same load pocket
 - Real-Time Contingency Analysis (RTCA) indicated voltage instability requiring pre-contingency load shed actions
 - Contributing Factors:
 - 3,000 MWs of planned generation outages
 - Transmission line and DC tie outages – reduced import capability into the area
 - Higher than expected temperatures
 - Market analysis determined 347 MWs of natural gas generation internal to the pocket was not needed

- Entity C – load-shed incident of 600 MWs
 - Contributing Factors:
 - Combination of extensive planned and unplanned generation outages (9332 MWs / 74% of the generation internal to the pocket)
 - 500 kV forced transmission outage
 - Higher than expected temperatures
 - Loading was above 125% for the next worse contingency
 - Cascade scenario – created a temporary interconnection reliability limit (TIROL)

- All factors must be considered when granting equipment outage request
 - Planning to a higher level of operating margin
 - Include demand-side management in assessment
 - Consider more extreme scenarios when determining which outage requests to approve
 - PRC-023 loadability requirements for triggering cascade analysis
 - Reassess planned outages with updated system conditions
 - In market area – review processes to ensure the reliability studies (OPA) are using accurate generation dispatch

Preparing the Grid for Wind Energy Droughts and Down-Ramps

- Periods of low wind speed, known as wind energy droughts, can occur and reduces output of wind energy resources
- Regions with high wind penetration are vulnerable to these wind energy droughts for an extended periods of time
- Capacity factor for wind units is 33.2% vs Nuclear is 93%
- Wind speed down-ramping can occur faster than forecast
- MISO, ERCOT, and SPP had a combined installed wind capacity of 99,101 MWs as of 2023

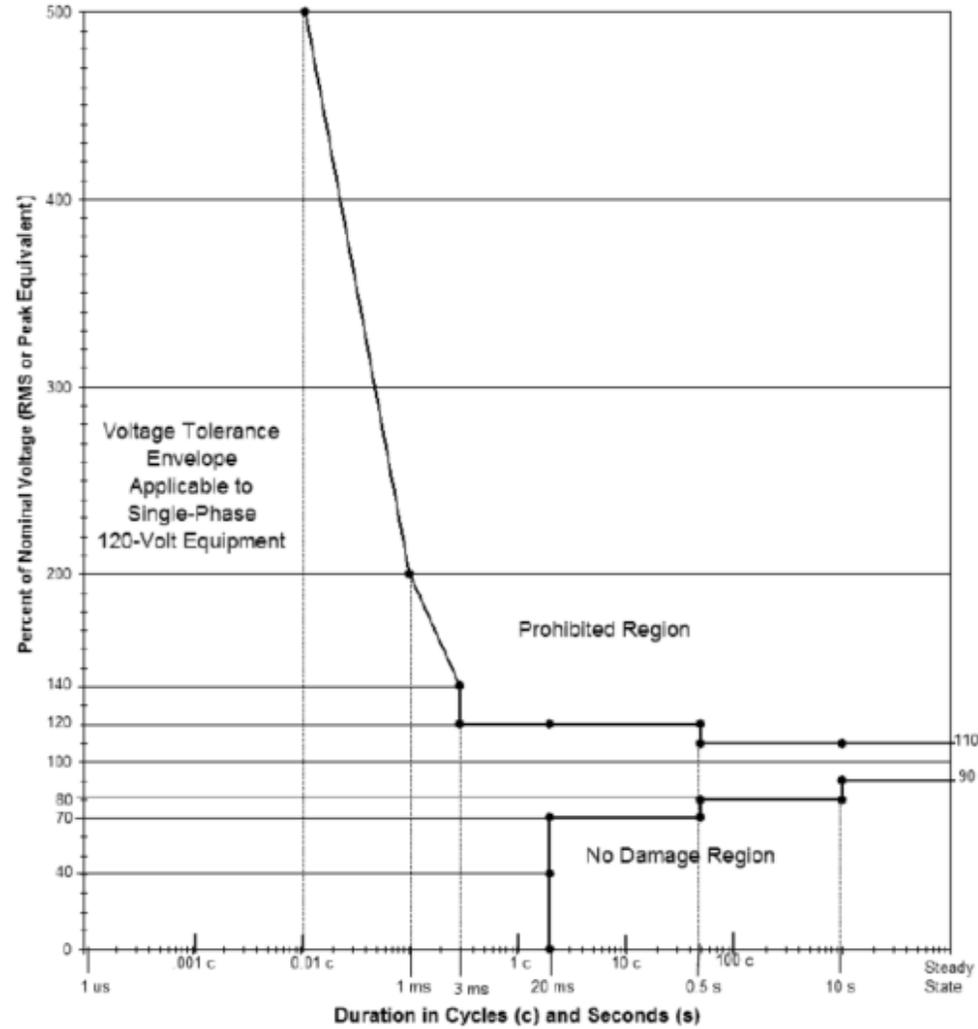
- In June 2023, ERCOT, MISO, and SPP experienced a period of low wind speed
 - This was forecasted ahead of time
 - They scheduled alternative resources
 - No energy emergency conditions or emergency procedures were required due to actions taken by entities
- Combines wind output dropped as low as 1,681 MWs

- To successfully manage these events requires:
 - Awareness, adequate planning, and appropriate operating procedures/processes
 - Categorize/communicate low-wind and down-ramp events
 - Accurate weather forecast
 - Detecting low wind speed weather patterns
 - Accurate variable resource forecasting
 - Perform backcast reviews
 - Unit commitment process relies on accurate resource capability
 - Consider a flexibility needs assessment
 - Use of multiple forecast providers and a meteorologist

Voltage-Sensitive Crypto Load Reductions

- Crypto-mining facility loads are unique and have sensitive ride-through characteristics
 - They rely on constant-power electronic supplies, cooling equipment, and single-phase devices that respond to normally cleared transmission faults
 - Experience load drops within milliseconds of a voltage sag
 - Facilities typically lack UPS systems or backup generation
 - Loads go through a multistage restoration process
- Essential to understand these behaviors for assessing grid impacts

- ERCOT has experienced 26 indirect load loss in response to normal cleared transmission line faults
 - Due to a lack of ride through of temporary voltage depressions
 - Impacts varied from 17% - 95% of pre-disturbance consumption
 - Voltage depressions of ~ 0.7 p.u. triggered miners to disconnect
- Crypto-miners deviates from the standard Information Technology Industry Council (ITIC) ride-through assumptions
- There are multiple technical observations based on the events
 - Protection schemes, transformer configuration, cooling system load, facility recovery



- Review neutral overcurrent protection
- Transformer winding configurations influence voltage sag severity
- Constant-power device behavior must be incorporated into event modeling
- Cooling-load ride-through coordination must be strengthened
- Restoration-time variability should be studied and tracked
- Interconnection requirements may need updates for evolving load types
- Enhancements are unlikely to address multi-phase fault conditions

- [NERC Event Analysis](#)
- [Incident Review: Load-Pocket Shoulder Season Challenges](#)
- [Incident Review: Preparing the Grid for Wind Energy Droughts and Down Ramps](#)
- [Incident Report: Voltage-Sensitive Crypto Load Reductions](#)

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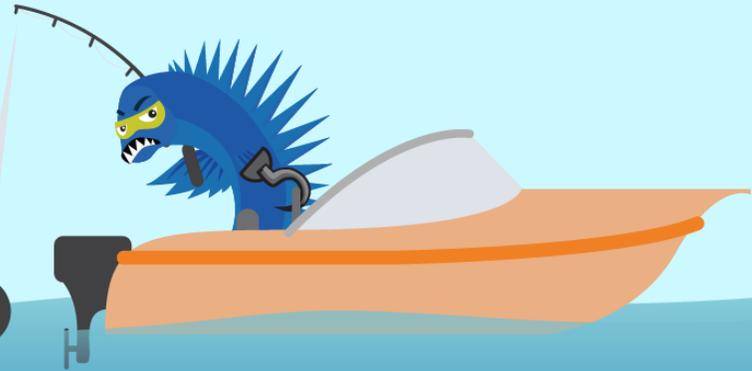
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