New York State Reliability Council – Large Loads Working Group (LLWG)

Reliability Risks for Large Loads

1. System disturbance ride-through of Large Loads
    a. Interruption of large load demand during system disturbances can aggravate the disturbances, potentially leading to:
        - Angular instability
        - Voltage instability
        - Frequency instability
    b. The absence of a clearly defined voltage and frequency disturbance ride-through capability leads to highly variable responses among large loads.
    c. While loads are generally expected to remain connected through “reasonable” frequency and voltage disturbances, there is no formal definition of what constitutes reasonable, nor any enforceable criteria for performance at this time.

2. Potentially abrupt changes in active power demand of Large Loads
    a. Large loads have potential to cause gigawatt-scale changes in BPS real power flows within a few electrical cycles (50 milliseconds in a 60 Hz system).
    b. This can cause generating unit rotor angle transient (angular) stability risks.
    c. Resulting voltage phase angle jump can impose torsional stress on nearby turbo-generator units potentially causing loss of shaft life if torques exceed endurance limit.
    d. Large abrupt changes in Large Load demand (active and reactive) can result in overvoltage or undervoltage conditions.
    e. May require procurement of additional operating reserves and frequency regulation ancillary services for the Balancing Area

3. Fast ramping of Large Load power demand
    a. Current Reliability Standards lack specific guidance or constraints on how quickly large loads may ramp up or down.
    b. Excessively fast and large load ramps may exceed load following capability of existing resources causing balancing challenges.
    c. Operational challenges of respecting intra-area transfer limits.

4. Continuous active power variation (cyclic and stochastic) driven by Large Load process demand:
    a. Operations risk
    b. Stimulation of inter-area oscillations and generator rotor angle swings complicating system operations and potentially resulting in angular instability (“transient instability”). Large loads introduce rotor angle stability

risks primarily as a result of their potential to cause gigawatt-scale changes in BPS real power flows within a few electrical cycles (50 milliseconds in a 60 Hz system). Of the two forms of rotor angle stability (transient and small signal), these characteristics are more relevant in the context of transient rotor angle stability.

c. Stimulation of turbine-generator torsional oscillations potentially resulting in major unit damage with very long repair time and consequent loss of resource.
d. Voltage phase angle variations interfering with the control and protection of other facilities, including inverter-based resources, HVDC transmission systems, and FACTS devices.
e. Slower variations (periods of many minutes) can cause thermal cycling stress of system transformers cause thermal cycling stress and insulation degradation, potentially leading to loss of life.
f. Increased frequency regulation ancillary services need to be procured for the Balancing Area.

5. Dynamic (small signal) characteristics of Large Loads
    a. Electronically controlled loads (e.g., information processor power supplies, variable speed motor drives) have complex responses to variations in voltage magnitude, frequency, and phase angle. These loads can potentially exhibit a negative damping effect over certain modulation frequency ranges.
    b. Negative damping at frequencies coinciding with system generator rotor angle and interarea oscillation modes can reduce overall dynamic stability.
    c. In an extreme situation, negative Large Load damping might exceed the positive damping of the system, leading to dynamic (small signal) instability.
    d. Negative damping at frequencies coinciding with subsynchronous torsional oscillation modes of turbo-generator units can result in growing generating unit shaft torsional oscillations leading to loss of life or catastrophic unit failure (called Subsynchronous Torsional Interaction which has been an actual observed phenomenon in the case of HVDC converters).
    e. The dynamic performance of Large Loads needs more study.

6. Load shedding
    a. Manual load shed obligations
    b. Automatic under-frequency load-shedding program (UFLS) integration
    c. Failure to include large Loads in UFLS programs could lead to automatic UFLS to not successfully arrest frequency decline.
    d. The manual or UFLS shedding of the entirety of a very large load could lead to over-frequency or overvoltage.

7. System planning impacts
    a. Resource adequacy

b. Inability to accurately forecast Large Loads for planning purposes
c. System operators and planners need data and models about large loads to properly characterize the load's behavior and study potential risks to the BPS. To run steady-state and dynamic simulations, for example, the operator and planner need to know the expected interconnection timelines, peak demand, load behaviors, protection and control settings, and dynamic models (potentially including EMT models in addition to phasor-domain transient models) for the load.

8. Performance Verification & Monitoring
    a. High-speed disturbance data capture devices to monitor and assess the operational performance of Large Loads (e.g., Phasor Measurement Units (PMU)).
    b. High-resolution data monitoring and fault capture (e.g., advanced Digital Fault Recorders) is needed for Large Loads so that Large Load related disturbances can be recorded and analyzed.

9. Protection Issues
    a. Availability of power variation relays to enforce power variation limits
    b. Limited sources for torsional stress relays to protect critical generators.

10. Harmonics (note: a power quality issue, not a system security issue)
    a. Electronic devices such as adjustable speed drives, rectifiers, and switched-mode power supplies—commonly found in emerging large loads—produce harmonics and inter-harmonics that can contribute to unacceptable levels of voltage and current distortion in the BPS.
    b. The effective impedances at super-synchronous frequencies presented by Large Load facilities can amplify ambient distortion caused by other sources. The effective harmonic impedance is influenced by load devices, particularly actively controlled electronic loads, power factor correction capacitors, FACTS devices such as STATCOMs, and harmonic filters.