NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

Load Modeling & FIDVR

FIDVR & Dynamic Load Modeling Workshop
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RELIABILITY | ACCOUNTABILITY




Introduction

- **End-Use Load is Evolving –** Electronically coupled loads, distributed generation, etc.
- **Continually Changing –** End-use load continually changes
  - Day, time, season, geography, weather, economics, etc.
- **Difficult to Model –** Even with load composition known, difficult to relate to load model parameters – *Rules of Association*
- **Minimal Data –** Distribution data hard to collect; often minimal collaboration between transmission and distribution entities
- **Best Practices –** Sharing best practices and experiences is critical
- **Benchmarking –** Historical events can be benchmarked against today's models
- **Prediction –** Does not make them useful for predicting future events

What's in Your House?

- Inverters are everywhere
- Variable frequency motor drives
- CFL & LED lighting
- Plug-in electric vehicles
- Motors

Distributed Generation

- Solar energy penetration is growing rapidly; likely to continue into future
  - Declining cost of materials
  - More economical

- May not be "BES", but this has an impact on reliability and performance
- This is likely not in your planning model; it needs to be!
- ***Collaboration key to develop best practices***

Battery Storage

- Battery storage systems are also increasingly becoming popular
  - Declining cost of materials
  - More economical

- "If I can cheaply put rooftop panels on my house, store my energy, and use it through the night, why wouldn't I?"
- Grid will likely still play a critical role
- What are its electrical characteristics?
- How is this being modeled?
- ***Collaboration key to develop best practices***

Nature of the Issue

- End-use load (response) changing rapidly – need collaboration between utility industry, manufacturing community, and end-use standards; ensure devices are grid friendly
  - Energy Efficient Loads are often not "Grid Friendly"
- Voltage sensitive loads often trip
  - Normally cleared faults – 1-ϕ motor stalling can occur for normally cleared 3-phase faults, Sensitivity to point on wave voltages, voltage rate of change, voltage magnitude and duration, etc.
  - Slowly-cleared faults – power quality requirements
- Behind the meter generation (distributed resources) becoming increasing popular – solar, micro-turbines, etc.
  - Some of those resources have voltage and frequency ride-through sensitivities
  - How should these be modeled??

Nature of the Issue

Loss of voltage-sensitive loads are NOT classified as Consequential Load Loss (NERC Glossary*)

Consequential Load Loss

All Load that is no longer served by the Transmission system as a result of Transmission Facilities being removed from service by a Protection System operation designed to isolate the fault.

Non-Consequential Load Loss

Non-Interruptible Load loss that does <u>not</u> include: (1) Consequential Load Loss, (2) the response of voltage sensitive Load, or (3) Load that is disconnected from the System by end-user equipment.

- Models not perfect – need improvements to address complexities
- Transient voltage response study criteria is vague

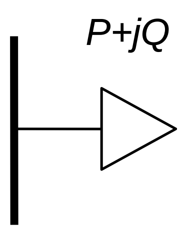
**http://www.nerc.com/files/glossary_of_terms.pdf*

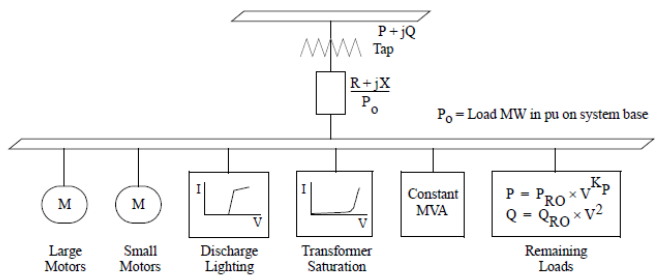
Voltage Sensitivities Highlighted

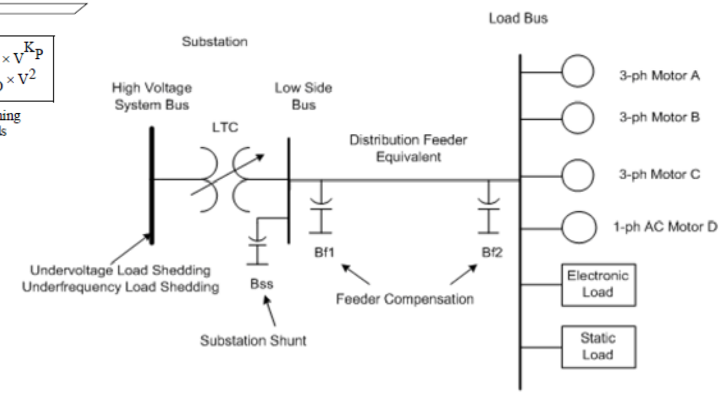
- Toronto, Ontario – 2007
  - 230 kV cap bank failure – slow clearing 3-Ø fault
  - 1,700 MW of voltage-sensitive load lost in the Greater Toronto Area
- Salt Lake Valley – 2009
  - low voltage spike initiated ~920 MW non-consequential load lost
  - 138 kV SLG fault of 4 cycles, evolving into a three-phase fault for 6 more cycles; 10 cycles total fault duration
  - Load – several server farms – voltage-sensitive loads transfer to backup power sources
- Washington, DC Area – 2015
  - Protracted 230 kV fault created prolonged low-voltage
  - ~445 MW load lost
    - Some voltage sensitive load transferred to backup supplies
    - Some tripped by end-user connection protection action

TPL-001-4 - Transition in Load Models

- TPL-001-4 requires use of “a Load model which represents the expected dynamic behavior of Loads … considering the behavior of induction motor Loads.”







FROM…

$$\boldsymbol{P}=\boldsymbol{P}_0[p_1\boldsymbol{V}^2+p_2\boldsymbol{V}+p_3]$$
$$\boldsymbol{Q}=\boldsymbol{Q}_0[q_1\boldsymbol{V}^2+q_2\boldsymbol{V}+q_3]$$

TO…

- *3-phase Motors – Fans, Pumps, Compressors*
- *1-phase Induction Motors*
- *Power Electronic Load*
- *Static (Polynomial) Load*
- *Distribution Equivalent*

Transient Voltage Recovery

- TPL-001-4 requires PCs and TPs have a *transient voltage response criteria* in place
  - Clarification is needed – Is this transient voltage dip criteria or a transient voltage recovery criteria?
- How does transient voltage response criteria directly relate to reliability?
  - *Used as a metric for ensuring reliability*
  - *Future work to focus on developing a criteria that directly relates to continuity of the bulk power system for large voltage excursions.*
  - *Need improved models (on load and generation side) to accomplish this*

Goals for Reliability

- **High Probability, Low Risk –** Faults such as SLG, simple generator trips, etc., should be evaluated against a criteria in which continuity of serving load is priority
  - Load bus transient voltage response criteria
- **Low Probability, High Risk –** Faults such as 3-phase or stuck breaker should have a criteria in which continuity of the bulk power system is priority
  - PRC-024 ride through requirements
- **Resolution of Consequential vs. Non-Consequential Load Loss –** Clarify how to classify voltage-sensitive and frequency-sensitive loads in reliability analysis

Moving Forward – Next Steps

- Share best practices for dynamic load modeling and FIDVR events
- Share best practices for non-traditional resource modeling
- Collaborate with software vendors to further develop and improve available dynamic models in software
- Continue engaging manufacturing community to raise awareness of grid needs – promote grid-friendly devices
- Engage in IEEE equipment standards – awareness of aggregate impact of multiple small devices
- Collect as much load data as possible (classification, end use , feeder information, etc.)
- Develop a process for creating load models – ***zonal or regional load models are NOT sufficient***
- Sensitivity, sensitivity, and more sensitivity studies

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Questions and Answers