NERC SPI DERWG Studies Sub-Group
S4 Update on Reliability Guideline for UFLS/UVLS Programs with Increasing DER

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Studies sub-group S4 Strike Team Lead
NERC SPI DERWG Meeting, WECC, Salt Lake City, UT
July 24-25 2019
<table>
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<th>Participating Organizations: March 2019 – June 2019</th>
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S4A (Q4 2019) Reliability Guideline: Recommended Approaches for Developing UFLS Programs with Increasing DER Penetration

Guidance on how to study UFLS programs and ensure their effectiveness with increasing penetration of DER represented.

**Premise:** *If a higher percentage of load is served by DER, island-level frequency will be impacted. UFLS program design should follow from those impacts.*
S4A (Q4 2019) Reliability Guideline: Recommended Approaches for Developing UFLS Programs with Increasing DER Penetration

Guidance on how to study UFLS programs and ensure their effectiveness with increasing penetration of DER represented.

• Background
• Impacts of DER on Island-Level Frequency
• Impacts of DER on UFLS Program Design
• Recommendations
Background: UFLS Programs

“UFLS programs are inherently heterogeneous as programs are developed to balance electrical islands with different characteristics of generation and load.”

“PRC-006-3 and its variances afford PCs flexibility to develop UFLS programs suited to their respective electrical islands.”

<table>
<thead>
<tr>
<th>Frequency Set Point (Hz)</th>
<th>ERCOT¹</th>
<th>ISO New England²</th>
<th>PJM³</th>
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<tr>
<td></td>
<td>All DSPs</td>
<td>Peak ≥ 100</td>
<td>50 ≤ Peak &lt; 100</td>
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<tr>
<td>59.5</td>
<td>6.5-7.5%</td>
<td>14-25%</td>
<td>28-50%</td>
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<tr>
<td>59.3</td>
<td>5%</td>
<td>6.5-7.5%</td>
<td>28-50%</td>
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<tr>
<td>59.1</td>
<td>6.5-7.5%</td>
<td>14-25%</td>
<td>28-50%</td>
</tr>
<tr>
<td>59.0</td>
<td>6.5-7.5%</td>
<td>28-50%</td>
<td>10%</td>
</tr>
<tr>
<td>58.9</td>
<td>10%</td>
<td>6.5-7.5%</td>
<td>10%</td>
</tr>
<tr>
<td>58.7</td>
<td>10%</td>
<td>6.5-7.5%</td>
<td>10%</td>
</tr>
<tr>
<td>58.5</td>
<td>10%</td>
<td>2-3%</td>
<td>10%</td>
</tr>
<tr>
<td>59.5 (10s)</td>
<td>2-3%</td>
<td>25%</td>
<td>29.5-31.5%</td>
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**Table 1: Load Shedding Requirements in ERCOT, ISO New England, and PJM**

1. See ERCOT Nodal Operating Guidelines Section 2.6.1(1) for further information.
2. See PRC-006-NPCC-1 for further information. Please note that Peak values are in MW.
Background: FERC Order No. 763 (2012)
Automatic Underfrequency Load Shedding and Load Shedding Plans Reliability Standards

- PRC-006 “does not limit the resources that can be modeled in the UFLS assessments” and “does not require all of the generation that is not directly connected to the bulk electric system to be included in the modeling”

- “Not requiring applicable entities to model sufficient amounts of qualifying generation indirectly connected to the bulk electric system [that may serve load designed to be shed in a UFLS program] could result in applicable entities not knowing how those resources react during underfrequency situations, which could cause excessive load shedding in an emergency and further contribute to system instability.”
  - Sufficient amounts? 20 MVA (DER) and 75 MVA (DER Aggregation).
Background: NERC’s “High Levels of DER” Standard is Consistent with Order No. 763

2011 Special Report: Potential Bulk System Reliability Impacts of Distributed Resources

At high levels of DER, the effectiveness of existing underfrequency and under voltage load shed schemes may need to be reviewed...

2017 Distributed Energy Resources Connection Modeling and Reliability Considerations

DER are not coordinated with UFLS programs nor are they used to calculate the most severe single contingency and contingency reserve requirements. High levels of DER with inverters can also result in a decline in short circuit current, which can make it more difficult for protection devices to detect and clear system faults. Hence, the implications of DER as part of system protection must be taken into consideration while planning the BPS and distribution systems...
Impact of DER on Island-Level Frequency: Rate of Change of Frequency

2017 Black System – South Australia – 28 September 2016 (AEMO)

BPS-Connected Inverter-Based Resources Example: Displacement $\rightarrow$ Higher RoCoF

The RoCoF following separation of the South Australian system was 6.25 Hz per second, “too great for the UFLS scheme to operate effectively”.

...NERC ERSTF (2015) also highlighted the importance of Synchronous Inertial Response and Rate of Change of Frequency (RoCoF).
Impact of DER on Island-Level Frequency: Available Load Shed

ISO New England’s Islanding Study – Impact of DER

Installed PV Capacity as of December 2018 – ISO New England by Size Class

Example of BTM PV Impact on Summer Peak Day – August 29, 2018

PV Growth: Reported Historical vs. Forecast
Impact of DER on Electrical Island-Level Frequency: Available Load Shed

ISO New England’s Islanding Study – Impact of DER

Dynamic Load Model with R-DER and U-DER Represented
Impact of DER on Electrical Island-Level Frequency: Available Load Shed

ISO New England’s Islanding Study – Impact of DER

ISO New England Island Frequency Performance – 60 Seconds
Impact of DER on Electrical Island-Level Frequency: Available Load Shed

*ISO New England’s Islanding Study – Impact of DER*

*This simulation does not meet NPCC Dir-12 requirement as the frequency is below 50.5 Hz for more than 30 seconds*

ISO New England Island Frequency Performance Relative to NPCC Directory #12
Impact of DER of UFLS Program Design:

Frequency Set Points
Ensuring that RoCoF is not too high for the UFLS scheme to operate effectively may require mechanisms to ensure sufficient frequency response...

Load Selection
Although UFLS entities typically implement UFLS programs by selecting specific feeders for UFLS, there is no requirement under PRC-006-3 that requires tripping entire feeders...

Adaptive UFLS Design
- Stage 1 and stage 2 should sum to 15% of the system net load
  - maximum allowed load shedding for N-1 unit trips.
- Stage 1 through stage 4 should sum to 40% of the system net load which is the maximum allowed load shedding for N-1-1 unit contingencies
- Adjust the stages of UFLS to reflect a percentage of net system load on each stage.
  - $\Delta f/\Delta t = 15\%$, 0.5 Hz/sec, 9 cycle relay plus breaker time (not currently active)
  - Stage 1 – 5%, 59.1 Hz, 8 cycle relay plus breaker time
  - Stage 2 – 10%, 58.8 Hz, 8 cycle relay plus breaker time
  - Stage 3 – 10%, 58.5 Hz, 8 cycle relay plus breaker time
  - Stage 4 – 15%, 58.2 Hz, 8 cycle relay plus breaker time
  - Stage 5 – 10%, 57.9 Hz, 8 cycle relay plus breaker time
  - Stage 6 – 20%, 57.6 Hz, 8 cycle relay plus breaker time
- Retain most recent UFLS settings in the event of SCADA/EMS communication failure until communications are restored.

Case Study: Hawaii Electric Light
Recommendation: Model Island-level Gross Load > Island-level Net Load

\[
\text{imbalance} = \left(\frac{\text{"net" load} - \text{actual generation output}}{\text{"net" load}}\right),
\]
of up to 25 percent within the identified island(s)

\[
\text{imbalance} = \left(\frac{\text{"gross" load} - \text{actual generation output}}{\text{"gross" load}}\right),
\]
of up to 25 percent within the identified island(s)
Recommendation: Model “Sufficient Amounts” of DER within UFLS Entity Footprints

- 2,200 MW of Residential-scale DER displacing synchronous generation has a material impact on island-level frequency...
Recommendation: New Technologies May Improve Island Performance...

- E.g. 1,500 MW of battery storage (6 MW at 250 buses) would improve island performance...
S4B (Q4 2019) Reliability Guideline: Recommended Approaches for Developing UVLS Programs with Increasing DER Penetration

Guidance on how to study UVLS programs and ensure their effectiveness with increasing penetration of DER represented.

Premise: If a higher percentage of load is served by DER, local area-level voltage will be impacted. UVLS program design should follow from those impacts.

- Background
- Impacts of DER on Local Area-Level Voltage
- Impacts of DER on UVLS Program Design
- Recommendations

Interested?

Contact:
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Peng Weng
Questions and Answers