NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Lesson Learned

Managing Underfrequency Load Shed Obligations and Service to Critical Loads during an Energy Emergency

Primary Interest Groups
Transmission Operators (TOP)
Transmission Owners (TO)
Distribution Providers (DP)
Balancing Authorities (BA)
Reliability Coordinators (RC)
Planning Coordinators (PC)

Problem Statement
Due to the amount of load shed during the February 2021 cold weather event[1], entities found it difficult to rotate customer outages while maintaining service to critical loads and underfrequency load shed (UFLS) feeders. Simultaneously, the percent of system load connected to UFLS feeders substantially exceeded the required percentage levels which created a risk of frequency overshoot and instability in the event of UFLS activation.

Details
Planning Coordinators develop UFLS programs to arrest declining frequency, to assist recovery of frequency following underfrequency events, and to preserve system stability. Underfrequency programs typically require each UFLS entity to shed a predetermined percent of load at specific frequency setpoints. In the event of an underfrequency event, each TOP is required to provide load relief by shedding the required percentage of connected load with automatic underfrequency relays. The percentage of connected load obligation is typically based on "normal" system conditions as a starting point. UFLS entity compliance with the UFLS program is typically verified through periodic surveys of the loads that are armed with UFLS compared to the total system load at the time of the survey.

TOPs typically exclude load connected to UFLS relays from manual load shed plans whenever possible. Additionally, EOP-011-1 R1.2.5 requires that TOPs minimize the overlap between operator-controlled manual load shedding and automatic load shedding. This requirement is intended to ensure that system operators maintain adequate load in their UFLS programs to preserve bulk power system reliability in the event that manual load shed was insufficient to arrest the decline in frequency and relay action was required to further protect the system from a black out. Excluding all load connected to underfrequency relays reduces the amount of load available for manual load shed.

Additionally, system operators must exclude circuits that serve certain critical loads from being used for manual load shed. These critical loads may be public safety facilities, hospitals, military facilities, natural gas facilities, etc. Service should be maintained to these customers due to the direct impacts to public health

[1] See FERC - NERC - Regional Entity Staff Report: The February 2021 Cold Weather Outages in Texas and the South Central United States.

and safety or security of the bulk power system during load shed events. This further reduces the number of circuits available for load shedding and rotating outages during load shed.

As the magnitude of load shed directives approaches the total load available to be shed (which consists of non-UFLS circuits and non-critical load circuits), the system operators' ability to rotate outages will diminish, extending outage times during rotation and eventually preventing rotation.

After exhausting the normal processes of public appeals, demand response, and voltage reduction during Winter Storm Uri; increasing levels of unplanned generating unit outages and de-rates; and increasing electricity demands, the RC had to instruct large amounts of firm load shed to keep the power grid stable. As a direct result of generating unit losses, system operators were forced to order an unprecedented 20,000 MW of firm load shed and to maintain firm load shed for nearly three days. For the reasons described above, the magnitude and duration of the manual load shed limited system operators' ability to effectively rotate outages during portions of the event, causing some customers to remain out of service for many hours or days. Some system operators ultimately ran out of non-UFLS and non-critical load circuits and were forced to use a portion of their UFLS circuits to meet manual load shed directives.

During the event, this was deemed an acceptable means to meet the manual load shed directives because the combination of high system loading and the reduced demand due to the prior manual load shed directives resulted in a significant margin of UFLS load above the required levels for TOPs. Several TOPs noted that their UFLS-connected load represented up to 60% of its remaining load during the period of February 15–16 (see Figure 1).

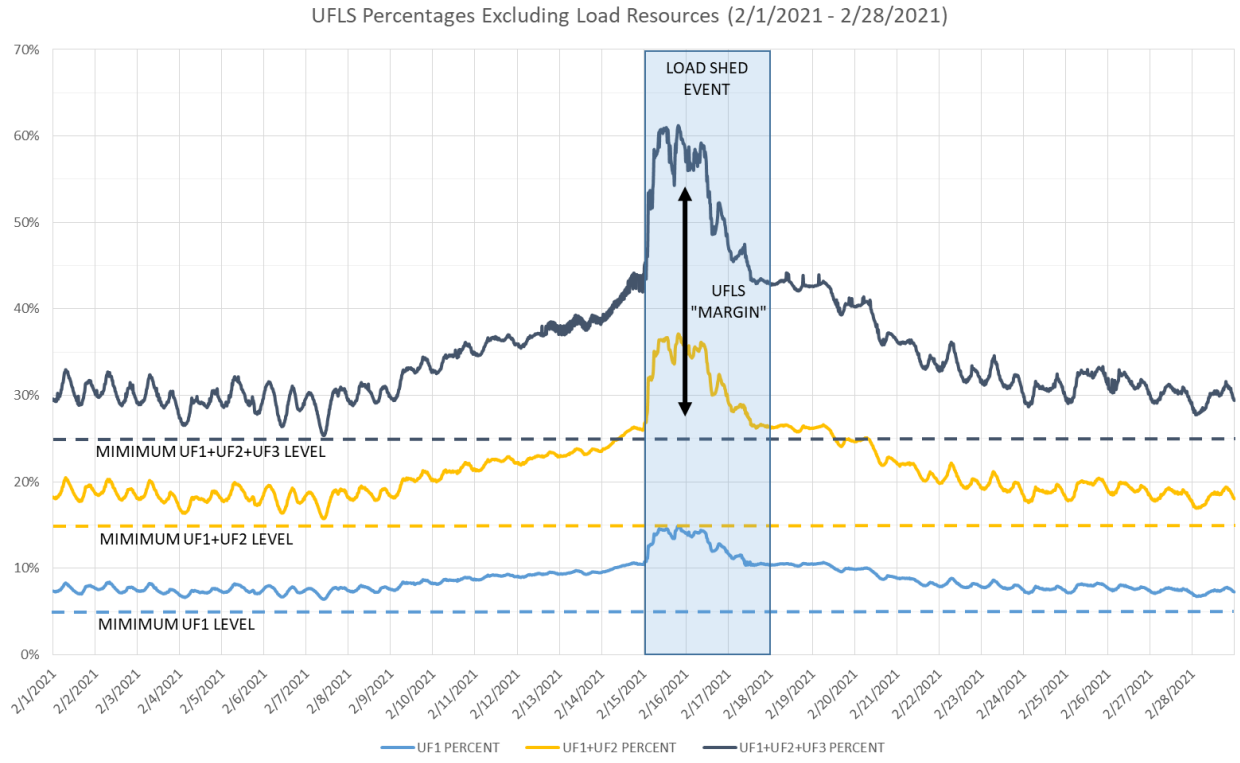

Figure 1: February cold event UFLS connected load percentages (Feb 15-16 in blue shade area)

This percentage was substantially higher than the minimum UFLS requirement of 25%. The excess represents an opportunity to increase the amount of load available to respond to load shed directives and to reduce outage durations for load that is in rotation. Additionally, the excess UFLS represents a risk to the system in the sense that UFLS load substantially exceeds levels envisioned in the UFLS program established by the PC. An actual UFLS operation while the system is in this state could lead to an overshoot in frequency and further system instability.

Corrective Actions

In several instances during the event, individual TOPs received RC approval to utilize UFLS circuits to meet their manual load shed obligations.

In the Electric Reliability Council of Texas, protocol and operating guide revisions have been implemented that specifically allow entities to shed UFLS load as long as they continue to meet their UFLS obligations.

Lessons Learned

In cases where a TOP has sufficient monitoring capability during an extreme load shed event to calculate the difference between the UFLS load required to meet its UFLS obligations and the actual load on its UFLS circuits, the TOP may have the option to use some of the UFLS "margin" to include in load shed and rotating outages while still meeting its UFLS obligations. Having this operational flexibility would increase the amount of load available for rotation, spread the burden of outages to a larger pool of load, and reduce customer outage times. Taking this approach of including UFLS circuits during load shed lowers the risk of an overshoot in frequency if UFLS operates when actual UFLS loads substantially exceed the required obligations.

- When UFLS-connected load is well above the minimum required per the UFLS program, system operators (with RC and BA permission) should have the flexibility to utilize some of the UFLS "margin" from circuits normally reserved for UFLS to manually shed load and rotate outages in extreme load shed scenarios. RCs and PCs should review their UFLS program rules for this potential.
- Critical loads should not all receive the same level of priority, and the characteristics of a load shed event (depth/duration/season) will impact the treatment of certain critical loads. Some critical loads are able to withstand outages of several hours without having negative impacts and should therefore only be exempted from load shed in situations where load shed is expected to be of substantial duration/depth. Additionally, it is important to recognize that criticality designations must be considered in the context of the situation. If conditions continue to deteriorate and other load shed options are exhausted, then some critical loads may need to be shed in the interest of preserving the system. It is critical to have the flexibility to include or exclude certain facilities based on the load shed scenario.

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