IGP TAP Transmission Subgroup

Feedback on UFLS Study Plans

3/8/2022

This feedback to HECO is based on HECO's slides and presentations on 2/25/2022 related to their initial plans for a UFLS study.

As with all TAP feedback, please consider this input as a set of recommendations for consideration – the final choices are yours of course. Some of these topics are complex; the brief feedback included here just points in a direction we think might be helpful.

Several items in this document are intended to help inform additional discussion on this topic.

TAP members attending 2/25: Andy Hoke (NREL, Chair), Debbie Lew (ESIG), Matt Richwine (Telos/HNEI), Deepak Ramasubramanian (EPRI), Vishal Patel (SCE), Michael Ingram (NREL, first meeting). Not able to attend: Aidan Tuohy (EPRI), Terry Surles (HNEI), Dana Cabbell (SCE),

HECO presenters: Li Yu, Ken Arakawa, Brian Lee, Leland Cockcroft, Lisa Dangelmaier

Consultants to HECO: Andrew Isaacs, Lukas Unruh

TAP feedback and comments are divided into three categories:

1. Informational – no action needed.
2. Suggest addressing during this current UFLS study.
3. Consider feedback for future studies or other portions of the IGP process (after this study).

TAP comments during meeting and HECO responses

In general, the TAP members agreed that quantifying the broad costs and benefits of UFLS is difficult because events are rare. Some work does exist quantifying the cost of outages.

The TAP agrees the UFLS situation in Hawaii is different from the mainland situation (i.e., maybe one UFLS event per decade on the mainland). ULFS is much more common in Hawaii, especially on the smaller islands. Customer expectations of reliability also differ from the mainland. Islands in general have faster ROCOFs and deeper frequency deviations than mainland grids. Each of the islands in Hawaii has different needs.

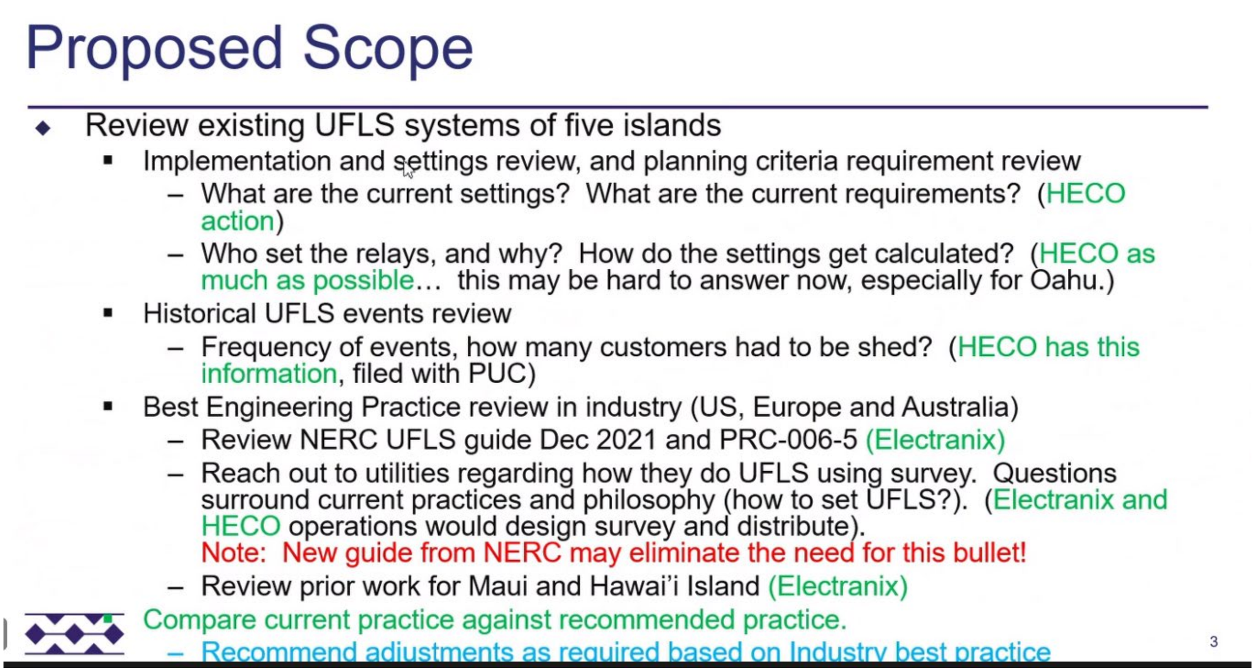
- TAP question: How common is UFLS in Hawaii?
- HECO response: 1-2x per year on Oahu. 6-12x per year on Maui and Hawaii. It takes about 10 minutes to restore power to a tripped circuit.
- TAP question: Is this acceptable to customers?
- HECO response: People are accustomed to it. We have studied (on Maui and Hawaii islands) what it would take in terms of reserves to reduce UFLS use. The cost of additional reserves was very high at the time. That may have changed. The contingency reserve batteries that HECO has applied for would likely reduce the use of UFLS if approved.

The TAP agrees with HECO that as part of routine interconnection studies for all large plants, it should be determined whether the POI is behind a UFLS breaker. This should be done for all plants, including those that are currently in all stages of the interconnection process, if it has not been done already; if the plant is behind a UFLS breaker, a mitigation should be proposed.

The adaptive UFLS scheme used on Hawaii island appears to be a good way of mitigating the effect of DERs on ULFS. The TAP recommends analyzing whether the adaptive UFLS scheme used on Hawaii island can be applied to the other islands. This analysis should include technical and economic considerations.

Reducing UFLS usage typically comes at some operational and/or capital cost. Part of the UFLS study could include surveying customers to understand the relative priorities of cost versus reliability of electricity.

The proposed scope in the slide below appears reasonable as part of the UFLS study. The TAP agrees with the proposal to review NERC UFLS-related documents[1]. No need to repeat any work that has already been done, of course:



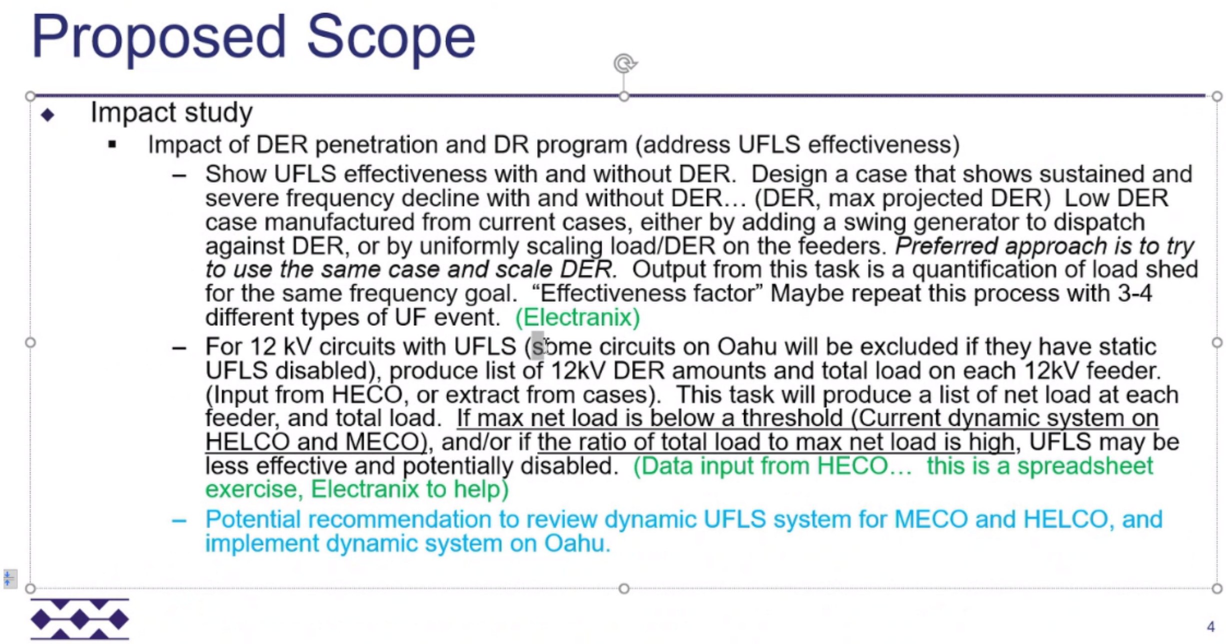
When analyzing past UFLS events, note the system conditions, why UFLS occurred, which resources responded, etc.

The first bullet on the slide below may not be needed if existing studies already examined this and are still relevant (or it may only be needed for some islands). In addition, the TAP recommends a broader

[1] https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Recommended_Approaches_for_UFLS_Program_Design_with_Increasing_Penetrations_of_DERs.pdf

study scope in line with the various red recommendations in this document, to the extent possible in the time allowed.

PSCAD simulations can be one aspect of this study but are not necessarily the focus of the study.



The TAP and HECO briefly discussed the use of ROCOF as a UFLS trigger. This is acknowledged to be very technically challenging because it is difficult to accurately measure ROCOF on the very short time windows needed to trigger UFLS in an island power system.

The TAP asked whether impacts of motor load on UFLS effectiveness are in scope.

- HECO response: Our current PSCAD models include frequency-dependent load but not motor load.

HECO notes they have an FFR grid service. The TAP recommends that the impacts of UFLS on resources providing FFR should be considered. This would not be mitigated by the adaptive UFLS scheme, as currently designed.

- The TAP asked how the FFR1 and FFR2 programs are going.
- HECO response: The program is on all three major islands. Hawaii and Maui have about 6 MW.
- The TAP requests more information on the FFR1 and FFR2 programs.
- HECO and the TAP discussed the challenges with frequency control using a discrete response (like HECO's FFR programs). A discrete response can overshoot or undershoot, potentially worsening frequency control. A proportional response (i.e., a droop curve) is preferable for this reason. The TAP notes it is possible in theory for an aggregation of many small discrete responses to act like a proportional droop response. We are not aware of this being implemented in practice, and there would certainly be practical challenges, but it could be considered for the future. (This would not be a form of UFLS, but rather of frequency control. Impact of UFLS on FFR effectiveness should be considered.)

HECO noted that one challenge with moving UFLS closer to loads is that low-voltage breaker trip times are too slow to be used for UFLS. The TAP notes that it is certainly possible to design a LV breaker/relay to trip very fast on frequency – perhaps vendor products can be researched further to determine whether this capability can be found or developed. Cost would of course also be a factor.

The TAP asks whether HECO uses UVLS.

- HECO response: Yes, but it is rarely or never triggered and the study it was based on is outdated.

The TAP notes that a dynamic simulation whose outcome seems obvious to HECO may still be of value to other stakeholders. This could include simulations of events with UFLS disabled, simulations of frequency controls that can reduce the use of UFLS (including potential future controls that are not available today), or other scenarios.

The TAP notes that HECO should consider equity issues when studying and designing UFLS schemes. For example, one downside of adaptive UFLS may be that by selecting feeders with less DER power, it is unintentionally selecting feeders serving disadvantaged communities.

The TAP notes that the tradeoffs between UFLS and frequency responsive reserves/programs present a mix of technical, economic, and policy considerations. This is somewhat analogous to the discussions in California related to mitigation of fire risk.

- If possible, a cost-benefit type analysis can be useful in these situations.

The TAP also discussed with HECO longer-term issues with UFLS and potential alternatives to UFLS:

- While one can carry more fast reserves to reduce the likelihood of UFLS being triggered, it would not be recommended to completely replace UFLS with fast reserves. ULFS is the last line of defense against a system-wide blackout and potentially severe, long-lasting equipment damage. Even if the plan is for UFLS never to be triggered (as is generally the case on the mainland), it should still exist as a protection against unforeseen events.
- In an extremely high DER future, it could be difficult to find circuit-level UFLS segments that reliably reduce load. This might be true even under an adaptive UFLS scheme such as Hawaii island's. This possibility should be analyzed, either in this study or in a future study. Possible mitigations could include more granular UFLS controls (for example, customer-level or load-level). The technical and economic aspects of such controls should be considered.
- In a future system with no synchronous machines, a wider range of operating frequencies may be tolerable, leading to adjustments in UFLS settings. The impact on loads would need to be considered. This scenario may or may not occur because some renewable resources are synchronous, and synchronous condensers are likely to play a role, at least in the near future.
- In the longer term, the TAP encourages HECO to examine forms of fast frequency control that are not commercially available today but that could potentially be designed and deployed in the future. This current UFLS study could simulate the basic characteristics these future forms of frequency control should have to improve frequency control (and potentially reduce the likelihood of ULFS triggering). Future forms for fast frequency control would come with challenges including obtaining commercially available products and ensuring their reliability and ride-through capability, but may still be worth investigating. It is not necessary to include a high level of model granularity to perform an initial study of the general effect of various potential

fast frequency control responses (including step, proportional, and other responses). Instead, an initial study can focus on response measurement time delay, response time dynamics, response magnitude, trigger mechanism, etc. The aim is to understand the concept and impact without getting lost (at least initially) in a lot of granular details. Such future forms of control could include:[2]

    - EVs that automatically control charging power in response to frequency (e.g., following a droop curve)
    - DER frequency response. (This is not so futuristic – it is required for all 1547-2018 compliant inverters, though headroom/reserve is not required.)
    - Smart power strips
    - Load-level controls, for example as explored in https://ieeexplore.ieee.org/document/9720247 (potentially including load-level UFLS).
    - Combined DER and load controls (for example as explored in https://ieeexplore.ieee.org/abstract/document/8586166)
    - Other emerging solutions
- Although these are long-term issues (that's why they are blue), they are not simple or easy and will take a lot of time to make implementable, so it behooves HECO and Hawaiians to start planning now rather than to wait until it is truly needed, when only fewer, more costly options may be available.

One benefit of this study could be to consolidate information that stakeholders can reference to understand UFLS-related issues. Such information could include:

- describing the traditional role of UFLS as a system protection, and why it exists
- the relation of frequency control to UFLS
- the blurring of the line between protection and frequency control when UFLS is used as an alternative to carrying additional reserves
- the impacts of DER and IBRs on UFLS
- the potential roles of energy storage, FFR, or other technologies (including technologies yet to be commercially developed) in reducing the amount that UFLS is triggered

[2] These examples are not meant to be exhaustive. In addition, the links to research works provided are just examples, and are not meant to imply that such an approach could easily be implemented at a large scale today.