UFLS and DER:
Shadows on the tombstone of old Under-Frequency Load Shedding

ESIG Spring Workshop 2021

Session 9: Distribution System Planning Evolution

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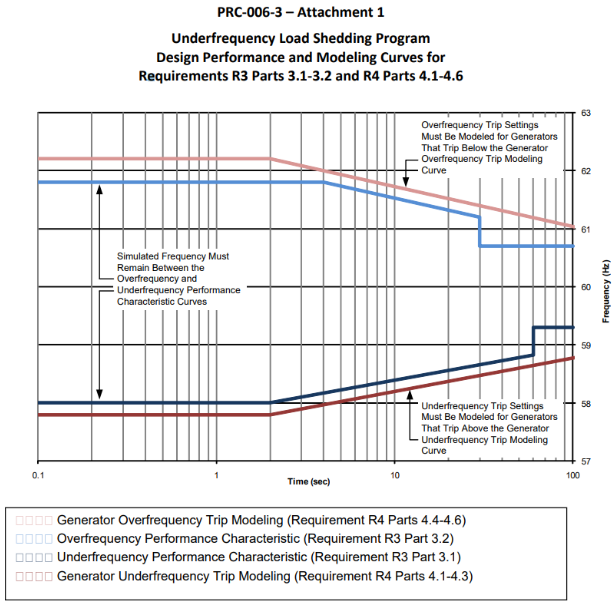
3-30-2021 Final Version

What is UFLS? (per NERC)



- Under Frequency Load Shedding (UFLS)
  - critical *safety net* to stabilize balance between gen & load
  - for *severe* lack of generation
  - *automatic* disconnection of end-use loads,
  - typically, through tripping of pre-designated distribution circuits
- NERC Reliability Standard PRC-006-3
  - establishes design/doc requirements for UFLS to
    - *arrest* declining frequency,
    - assist recovery of frequency
    - provide *last resort* system preservation measures.

UFLS and DER today

- (draft) NERC Guideline* discussions cover a significant amount of the present concern:
- DER today exacerbates some aspects of dynamics that require UFLS.
- DER creates uncertainties, and therefore can compromise the efficacy of traditional UFLS

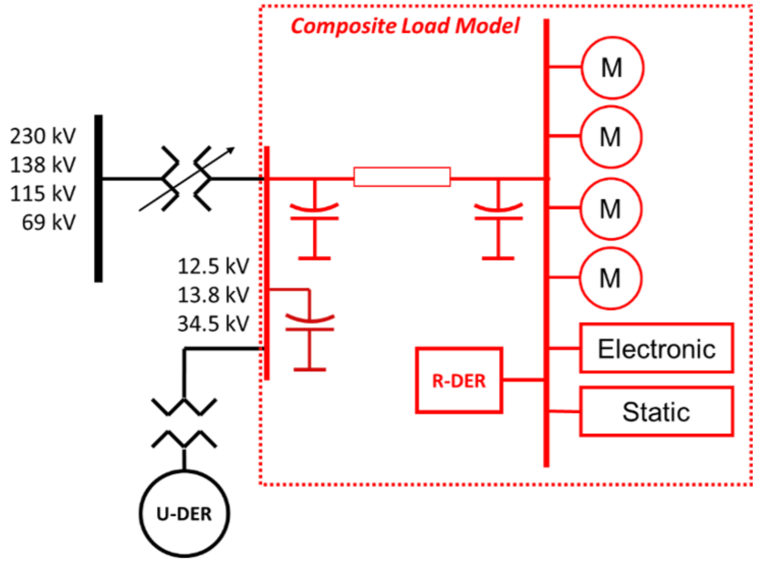


Figure 2.1: DER Modeling Framework

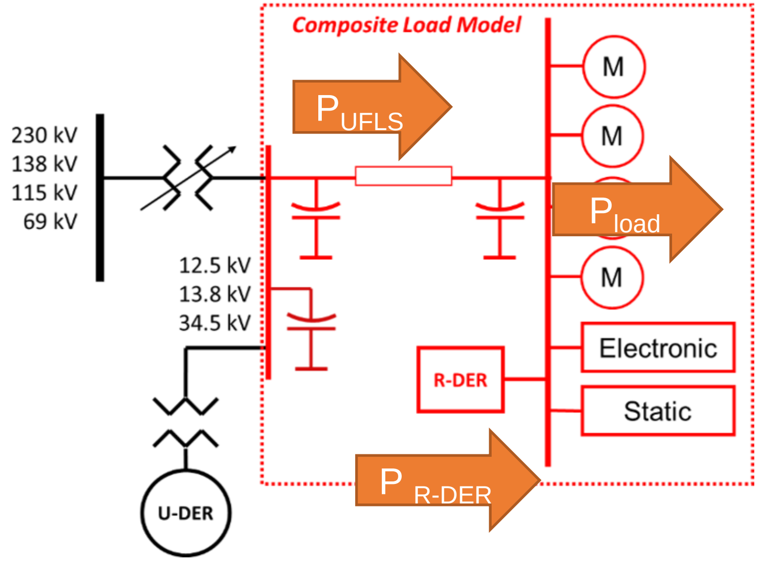
Source: NERC

*NERC Reliability Guideline: Recommended Approaches for UFLS Program Design with Increasing Penetrations of DERs
March 2020; June 2021 (latest draft; out 3/21)

Declining Efficacy of UFLS with (PV) DER

- Each added MW of DER generation reduces the efficacy of basic UFLS:

P_{UFLS}/P_{load} drops



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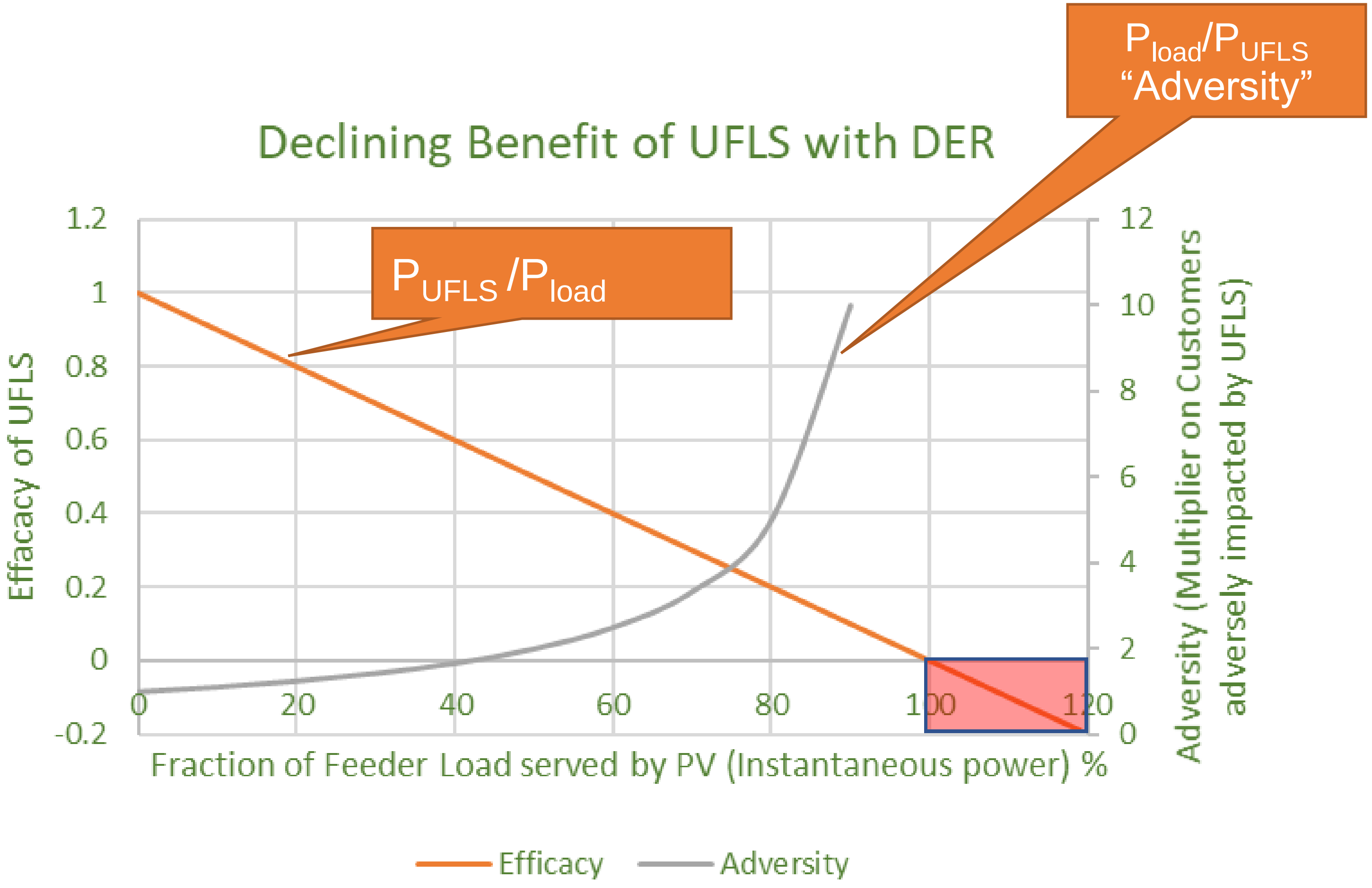
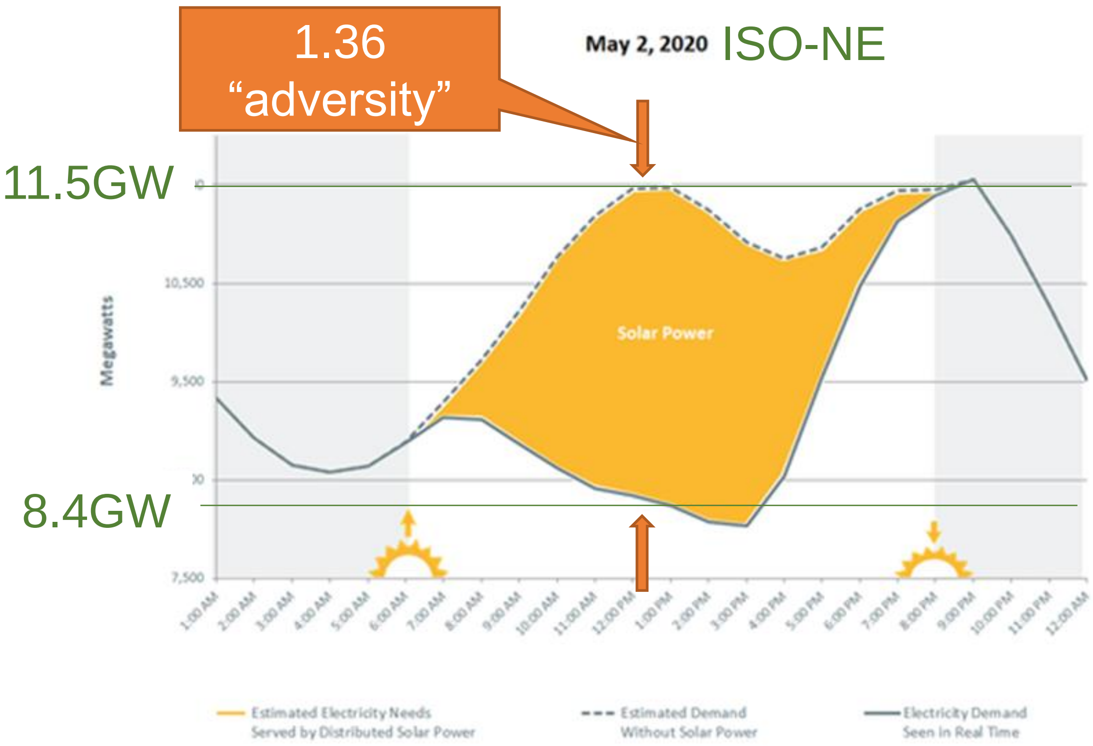
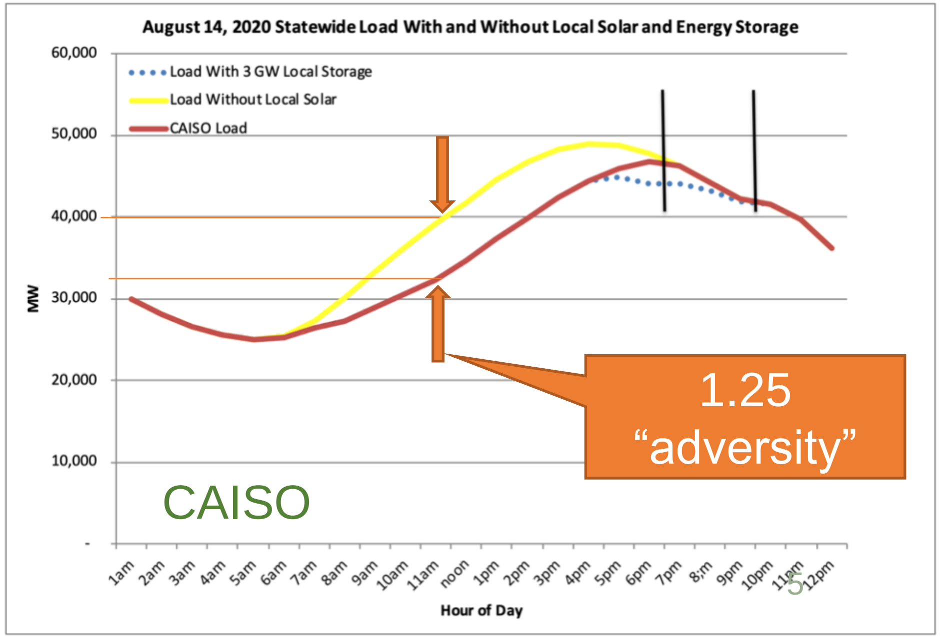


Not yet, but soon...

- Occasional high instantaneous penetration of (PV) DER is coming for many systems.
- Subsystems, that might depend on UFLS during breakups, and entire small (e.g. island) systems have reached this point today.

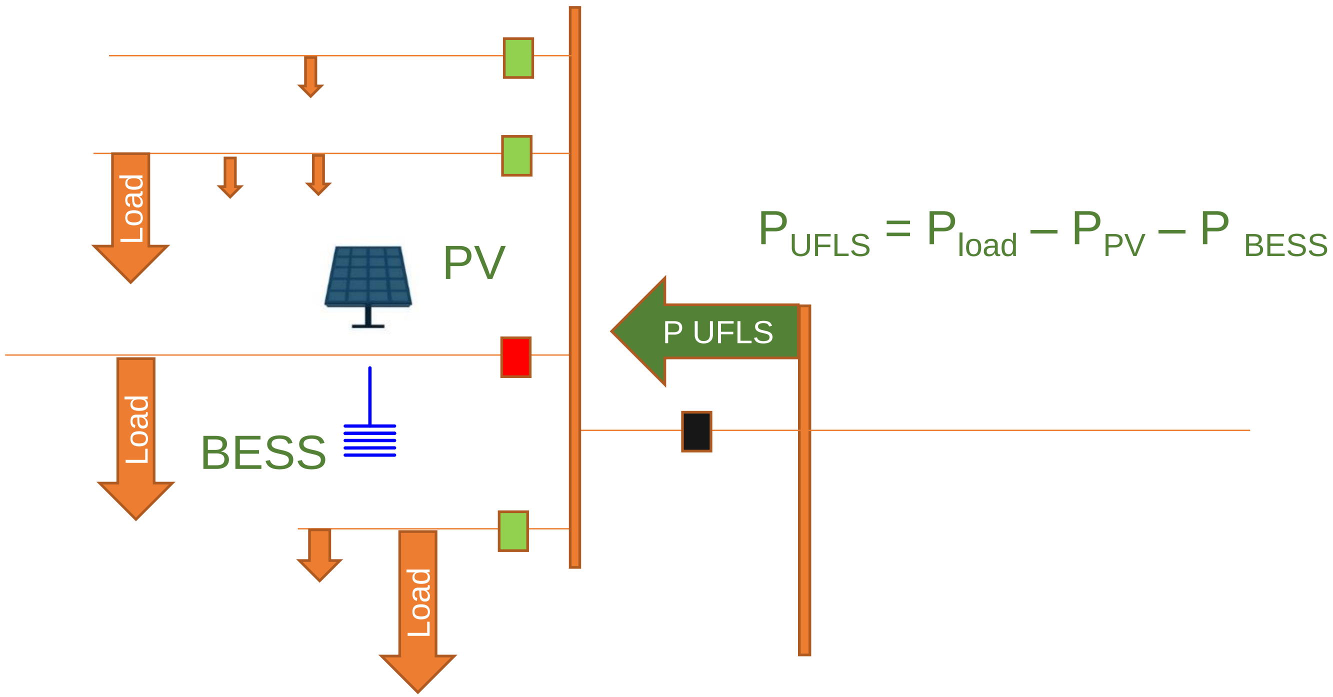




UFLS and High DER penetration, immediate future

- Some “adversity” tolerable. A cost of having DER.
- But what is the *threshold of pain*?
- At 50% DER instantaneous penetration, *twice* as many customers are impacted as with a scheme that avoided tripping DERs.
- Dynamic or adaptive UFLS.
  - Are a big step forward. Designed to decrease uncertainty introduced by distributed PV. Total P_{ULFS} MW seen by the BPS that is tripped per operation is dynamically set and known *a priori*.
  - Prioritization (based reducing adverse societal impacts and maintaining efficacy)

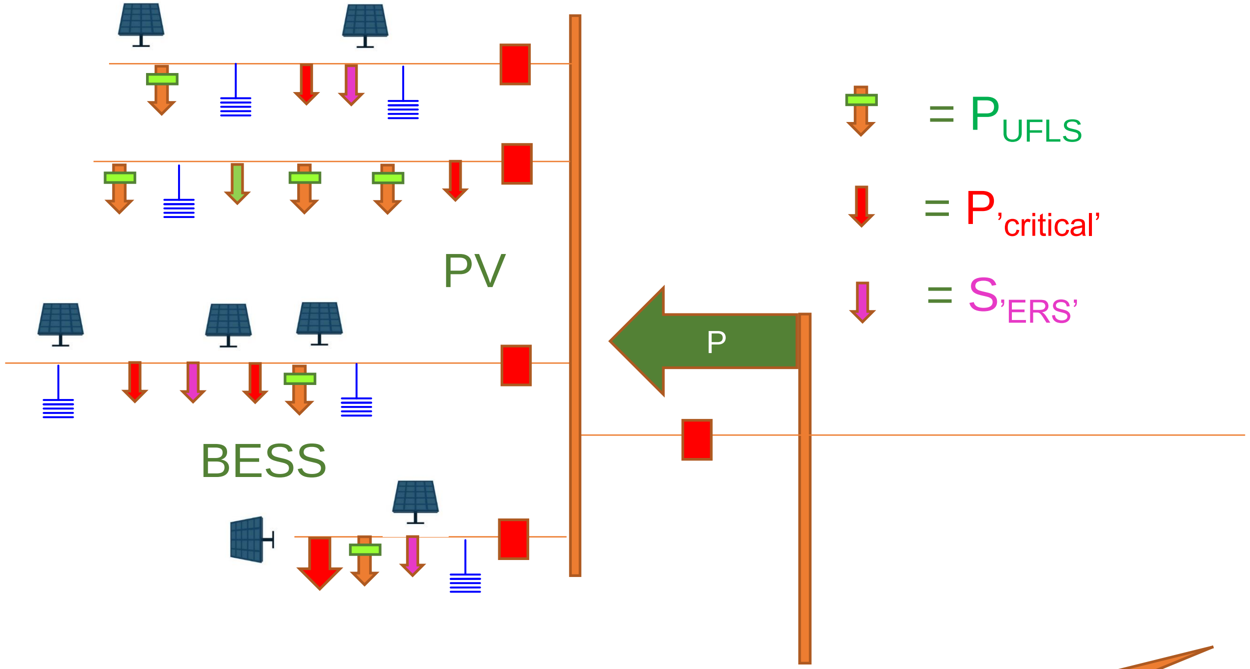
Cartoon of feeder and UFLS



Red: don't trip me!
Green: available trip (for $?)

- Gross simplification, but useful for discussion
- Basic: trip black breaker
- A systemically superior solution - trip the green switches, and leave the red switch closed.
- Not simple or cheap, and maybe not fair.
- But, yields a more secure system with fewer customers interrupted, for given event.
- Dynamic or adaptive concepts (like HELCO's) could be extended to this granularity (see 2nd bullet!)
- Retained DER can provide not only power, but other essential reliability services.
- Initially smarter/adaptive UFLS must have sufficient situational awareness to avoid tripping feeders with desirable resources.

Cartoon of future (?): where we're (possibly) going



Red: don't trip me!
Green: available trip (for $?)
Purple: providing services

How does this fit with broader Energy Network of previous speaker?

- With *gabboons* of DER, feeder level won't cut it.
- With really low inertia, speed is more important
- How to get there?
  - Autonomous? Communication?
  - Staggered? Adaptive?
  - Situation awareness?
  - Restoration?
  - Market/tariff design?
  - Consequences of mis-triggering?
- Some completely different paradigm needed?
- Are there complementary enabling technologies – i.e. other functions/benefits from "properly" specified requirements? (AMI? RT market functions? Other ERS? System restoration)

It's not just negative load: DER and ERS

- Question is much broader than just interrupting more customers than necessary.
- DER is more than just PV
- What essential reliability services are the DERs providing? Are those services needed during frequency events?
- Alternatively, will all ancillary/essential reliability services from distributed resources be barred from any feeders included in UFLS schemes?
  - Is that socially and economically acceptable?
  - *Is it even legal? Per FERC Order 2222*
- Eventually, UFLS must have sufficient situational awareness

Is situational awareness a natural part of broader energy networks?

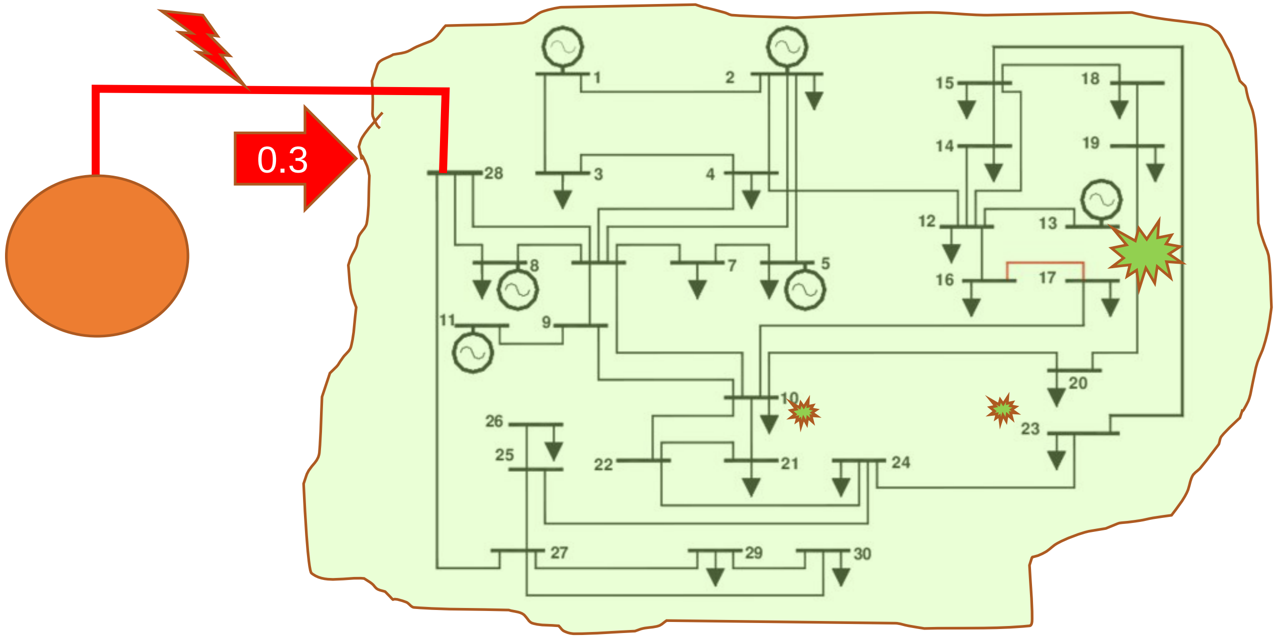
Not fast enough for the “big ones”

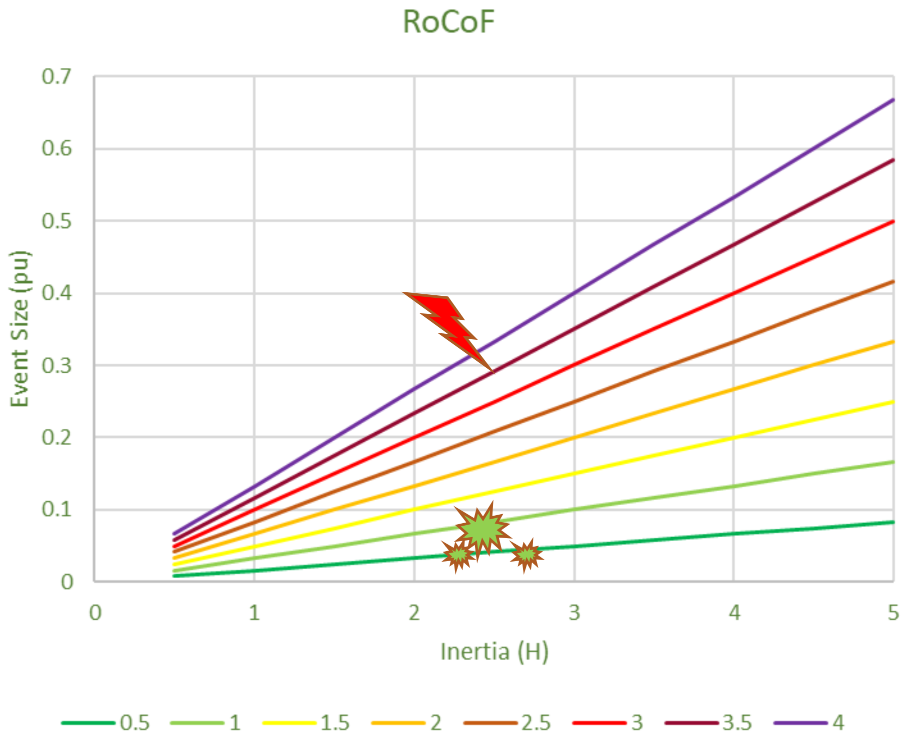
- In low inertia systems, subject to big events, UFLS is going to become progressively less secure.
  - Measuring frequency and RoCoF takes a few cycles to do well.
- Augmentation of UFLS with SPS, etc. for specific big events will extend the life of UFLS.
- Some systems are “bi-modal”:
  - A single or very short list of huge (terrifying events)
  - Lots of lesser, or N-x or HILF events for which UFLS still makes sense.
- *Institutional aversion to RAS, SPS and other information and communication-based remediation is expensive!*

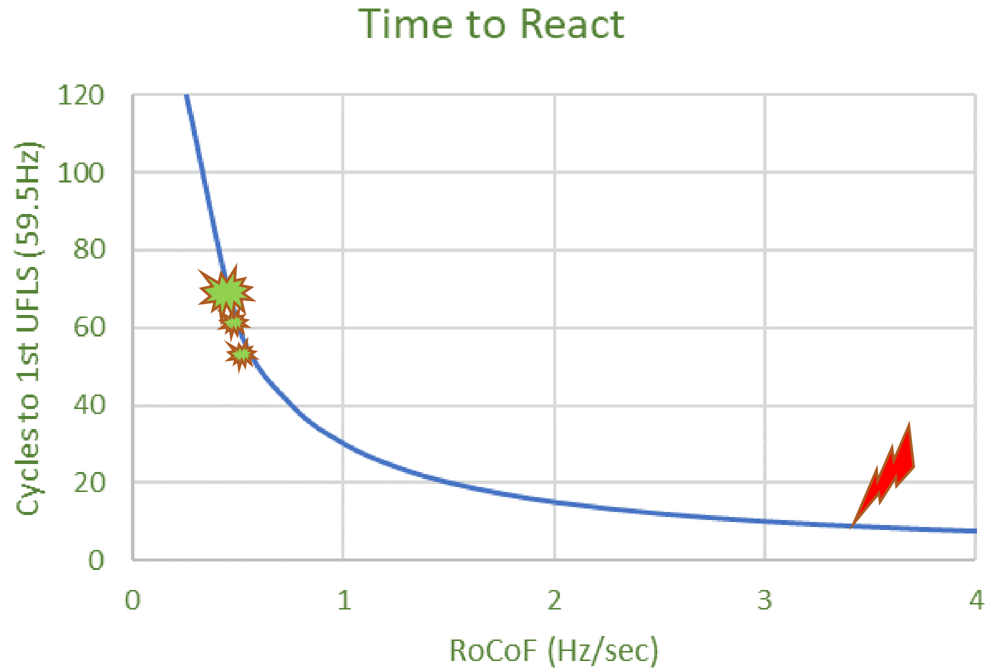
Breaker open signals are high fidelity

Bi-modal
Loss of infeed

- use UFLS
- use SPS







Synopsis

- Efficacy of present UFLS, in terms of adverse customer impact, will drop as more distributed resources are deployed.
- The days of traditional “set it and forget it” UFLS are drawing to a close.
- We are there in some places already .
- Next generation of UFLS (and supporting infrastructure) must be more selective and situationally aware.
- Move farther away from depending on UFLS: more autonomous and voluntary responses; evolve the need for UFLS into oblivion. Look for ways to achieve multiple benefits with new infrastructure/capability, which...
- Will increase reliability, reduce adverse customer impacts, allow for DER to provide a wider variety of essential reliability services, consistent with broader objectives of reliability, economy and fairness (and FERC Order 2222).
- There is good work underway (e.g. NERC, others), but we have a ways to go to get to some critical answers ...

Questions

- At what point is the coarseness of the present UFLS approach societally unacceptable?
- What is the line between protection and control?
- How to address the communications bandwidth problem?
- Could “slow” situational awareness with system-wide reach (per ‘open networks’ discussion), paired with fast autonomous action be a path forward?
  - i.e., are frequently updated, but autonomous (frequency sensitive) controls a solution?
- Why are we using involuntary disconnection as a tool anymore?
  - Aren’t there customers that would disconnect for a price?
  - Isn’t this just another ERS to be procured?
- What technologies are suitable?
- What economic/markets are suitable?
- What is fair?
- How will cyber-security be affected/built-in?
- Lots of others….