Southern Company

Application of IEEE Standard 1547-2018 Considering Impact of DERs on FIDVR

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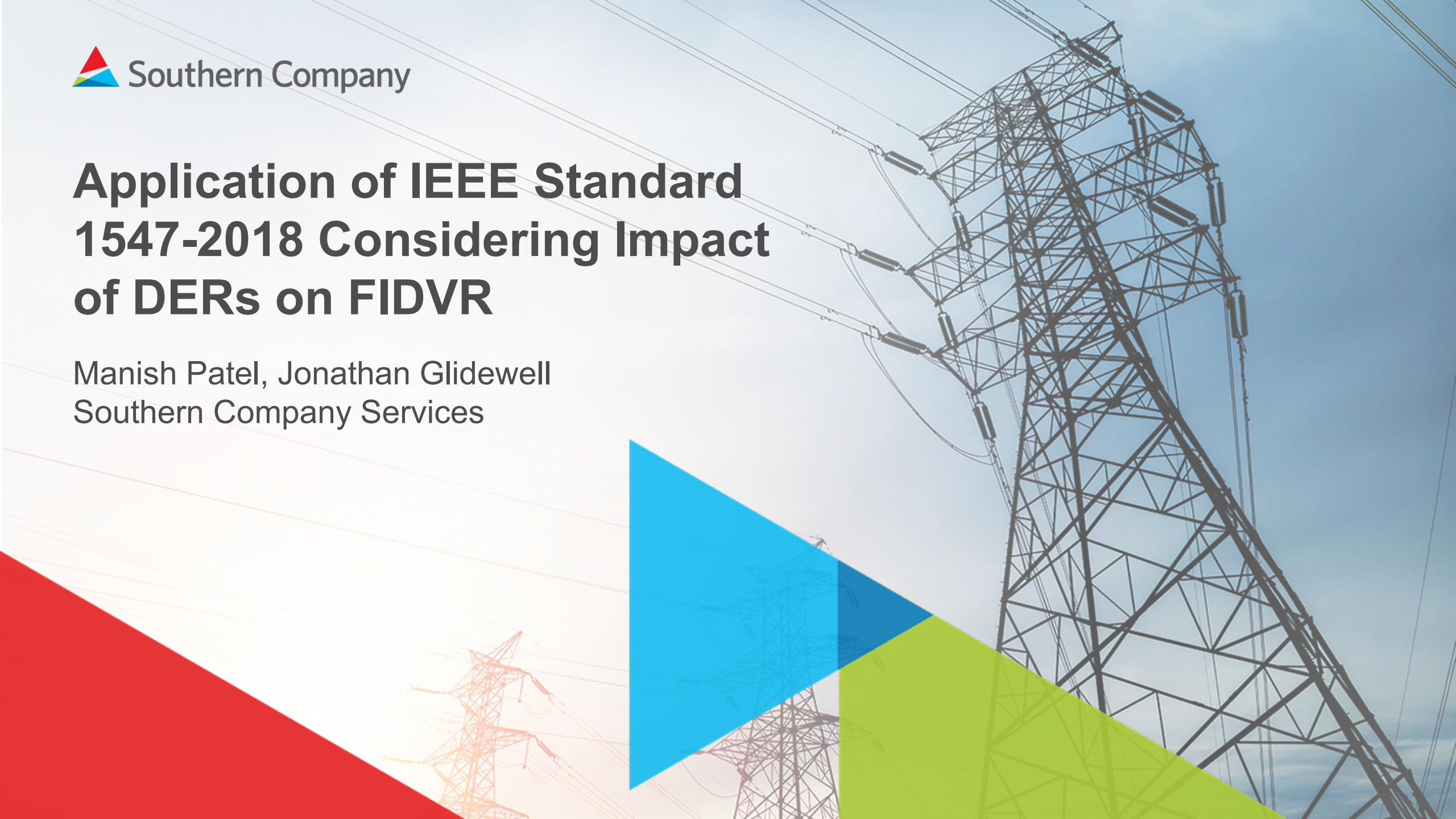


Outline

- Objective:
  - Configure DER controls based on the IEEE standard 1547-2018 considering FIDVR.
    - ➢ Can DERs replicate benefits provided by traditional generation, which is being replaced?
  - Develop recommendations for consideration by Distribution Organization as interconnection requirements for DERs are being developed.
- FIDVR
- Study Assumptions
  - Penetration level
  - Modelling of R-DERs and U-DERs
- Application of IEEE standard 1547-2018
- Summary

Fault Induced Delayed Voltage Recovery (FIDVR)

– Phenomenon in which voltage remains at significantly reduced levels for several seconds after a fault is cleared.

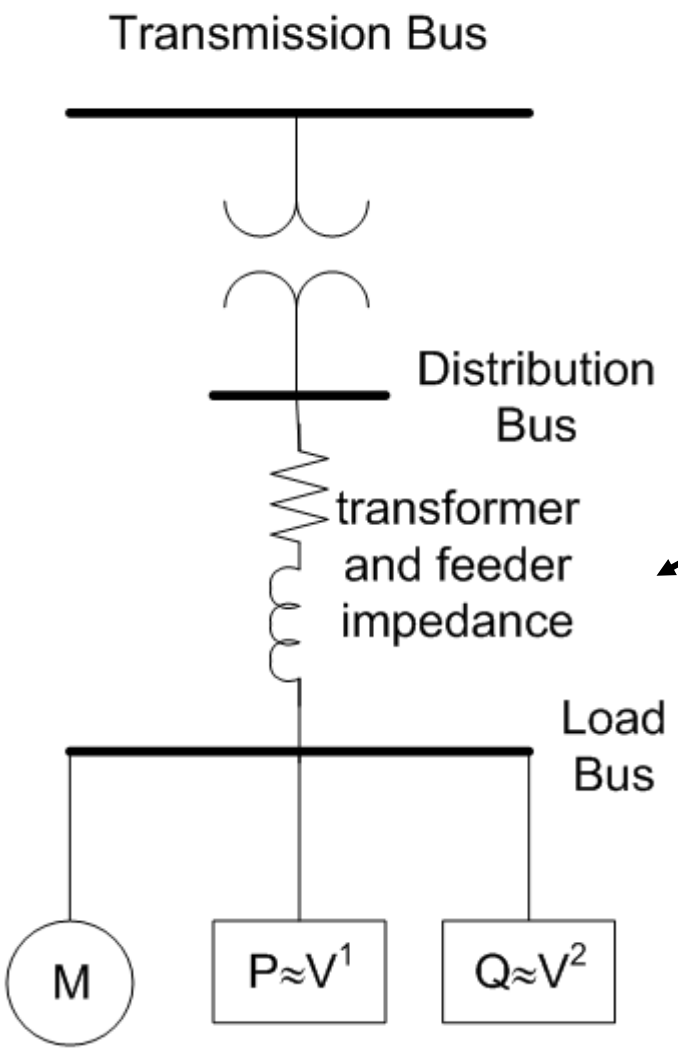
– Key factors:

- Highly concentration of induction motor loads
- Fault location, type & duration
- Availability of dynamic reactive support

– Voltage Recovery Criteria:

- All transmission buses should recover to above 80% of nominal voltage within:
  - Two (2) seconds for normally cleared three-phase faults
  - Four (4) seconds for three-phase faults followed by BF

FIDVR – CLOD Model



Load is represented behind a fictitious impedance of *0.01+j 0.10* pu at load MW.

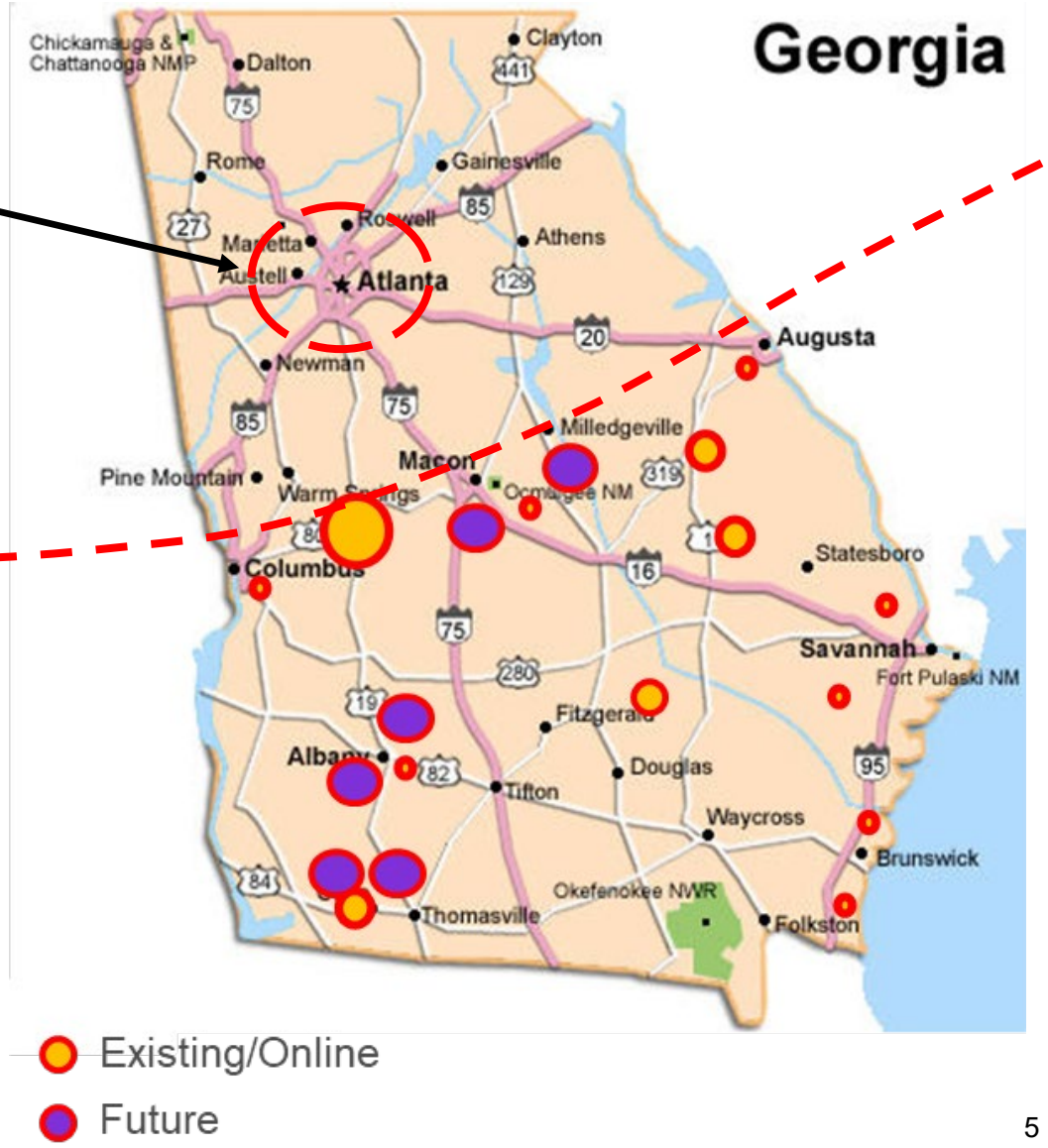
50% of total real power load during summer peak is assumed as small induction motor load

Study Assumptions

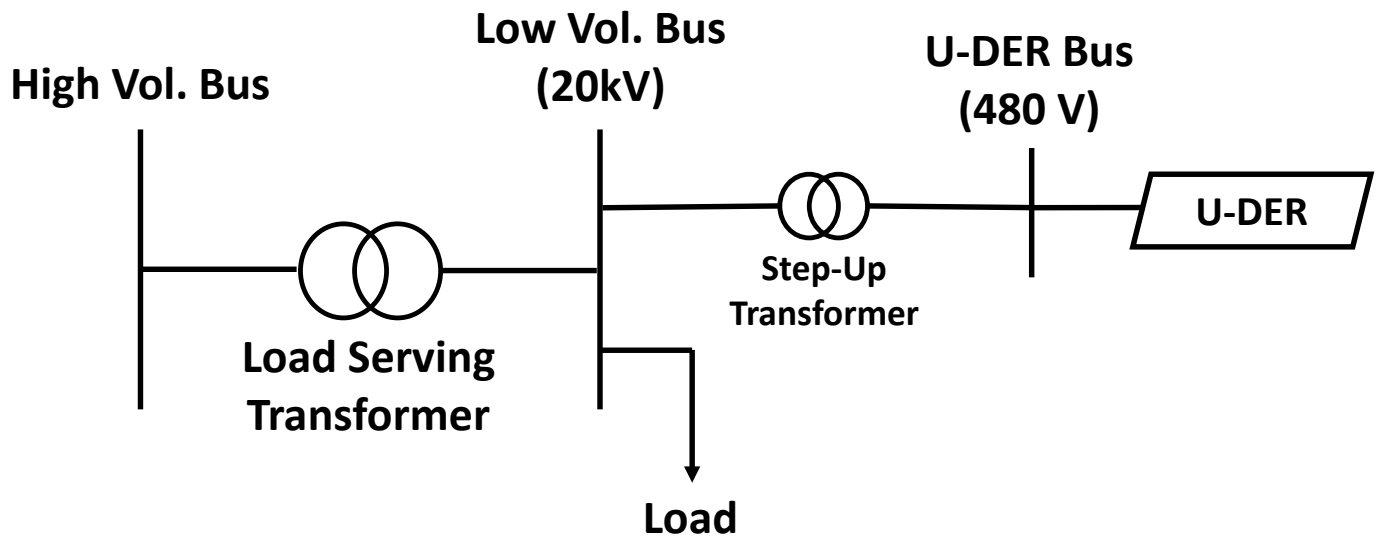
Roof Top Solar (R-DER)
(Behind the Meter)
2.5% of the GA ITS Load
Approx. 750 MWs

Transmission
Interconnected Solar
(Mostly south of this line)

Distribution Interconnected (U-DER) solar scattered through out the state except for metro-Atlanta area
5.0% of the GA ITS Load
Approx. 1500 MWs
~600 MWs in N. GA and ~900 MWs in S. GA

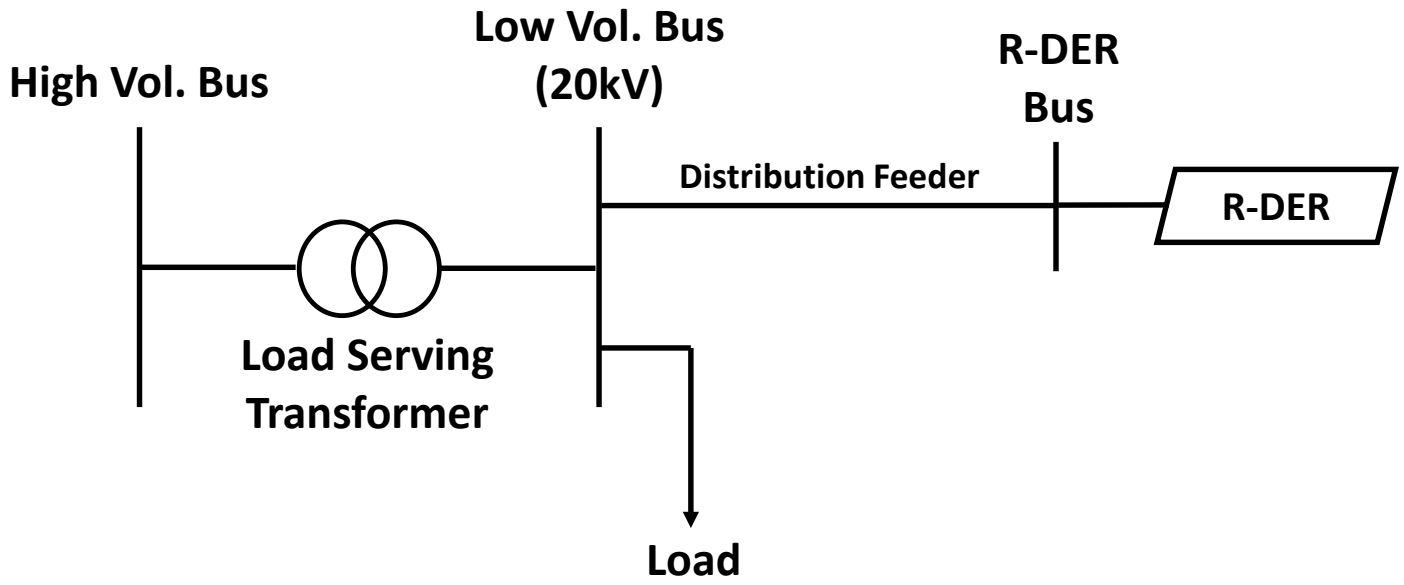


Study Assumption – U-DER Model



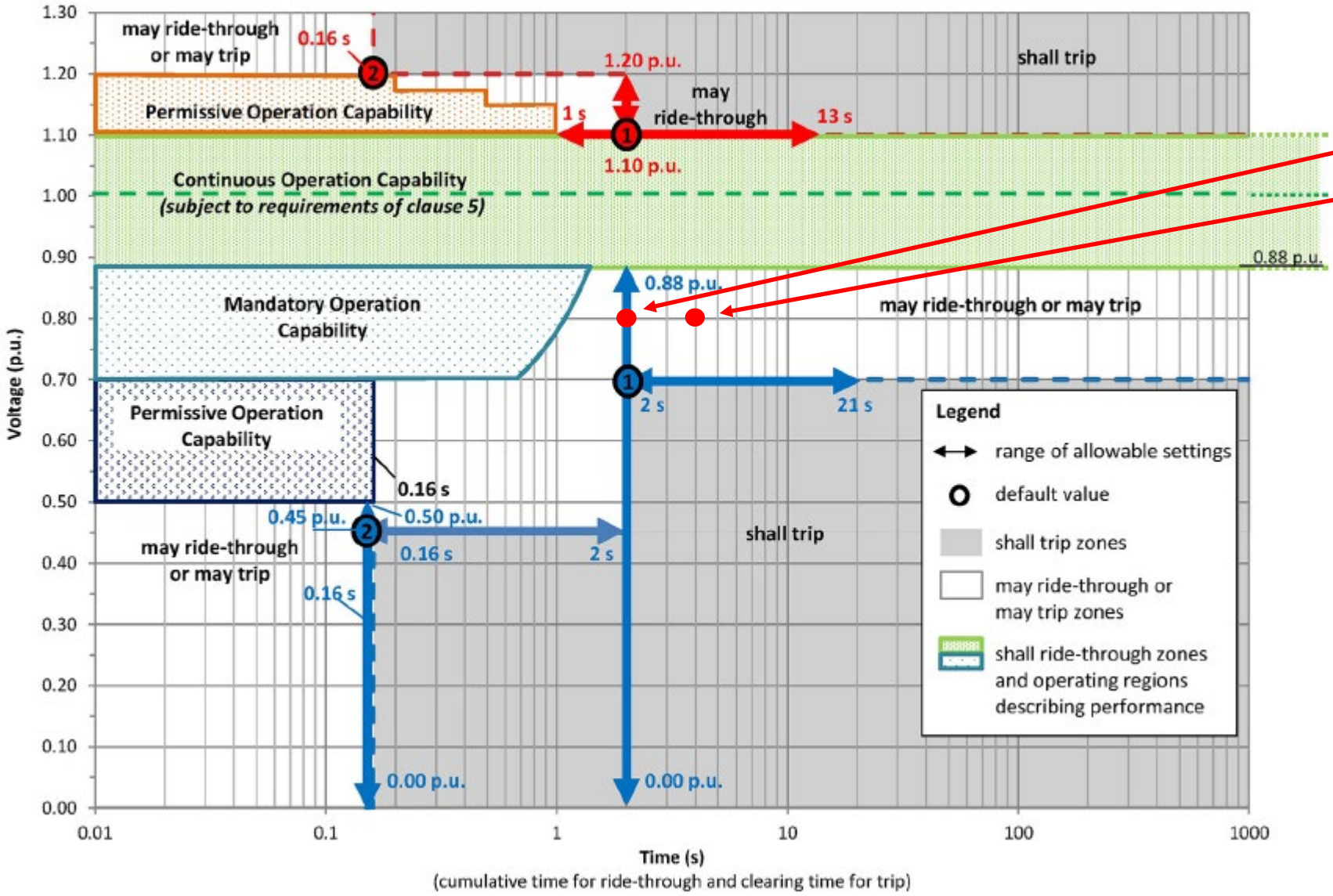
- Each U-DER is rated at 5 MVA, & is connected close to the load serving transformer
- U-DER step-up transformer – 10% impedance at 5 MVA base.
- Load Serving Transformer impedance: 6.5% at load base.
- Load – modeled behind 3.5% impedance at load base.

Study Assumption – R-DER Model



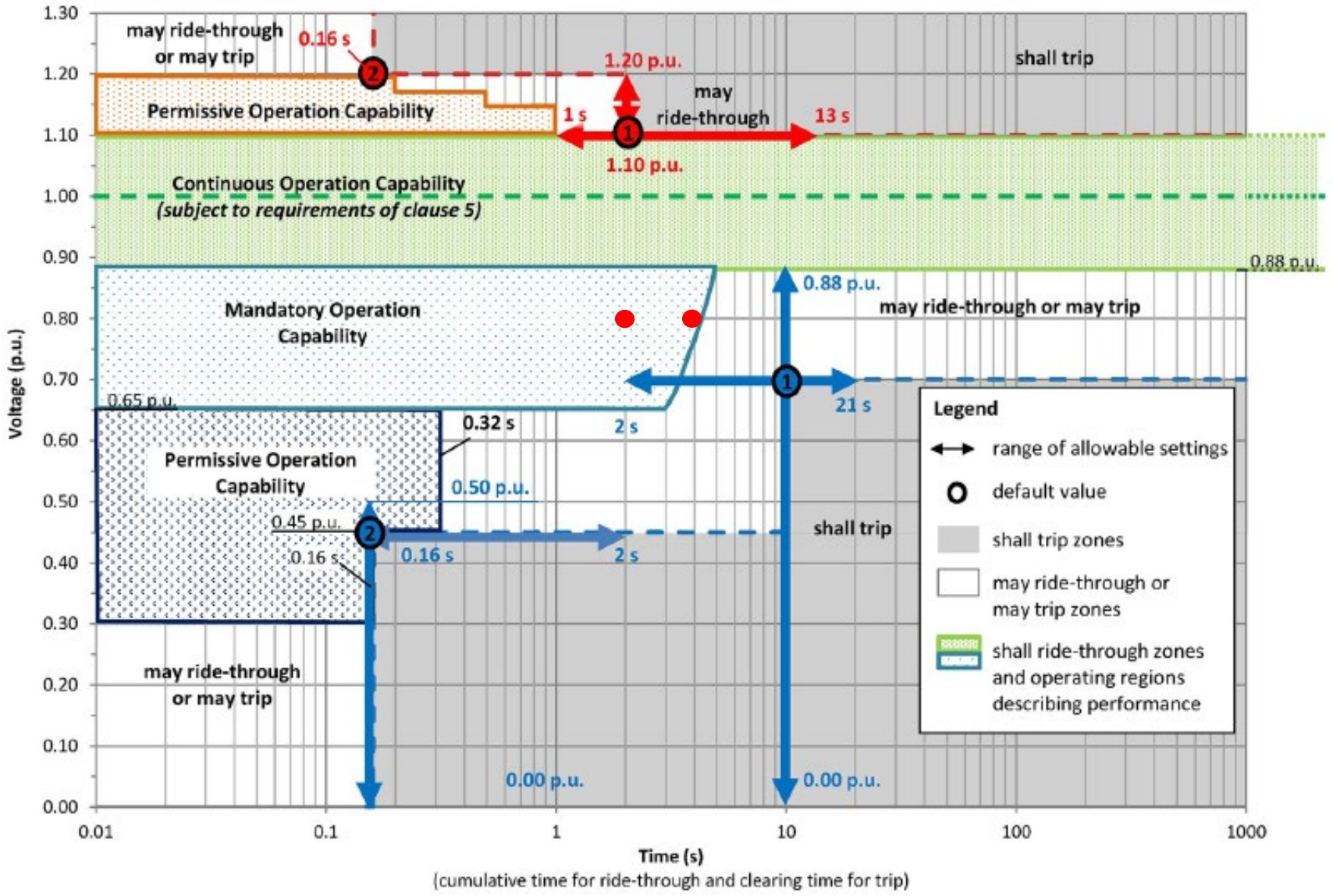
- Distribution Feeder impedance – 3.5% impedance at load base.
- R-DERs are connected towards the end of distribution feeders.
- Load Serving Transformer impedance: 6.5% at load base.
- Load – modeled behind 3.5% impedance at load base.

IEEE 1547 – Category I Voltage Ride-Through Requirements



- Voltage recovery criteria
  - NC - 80% in 2 seconds
  - BF - 80% in 4 seconds
- Mandatory operation zone does not encompass the voltage recovery criteria

IEEE 1547 – Category II Voltage Ride-Through Requirements



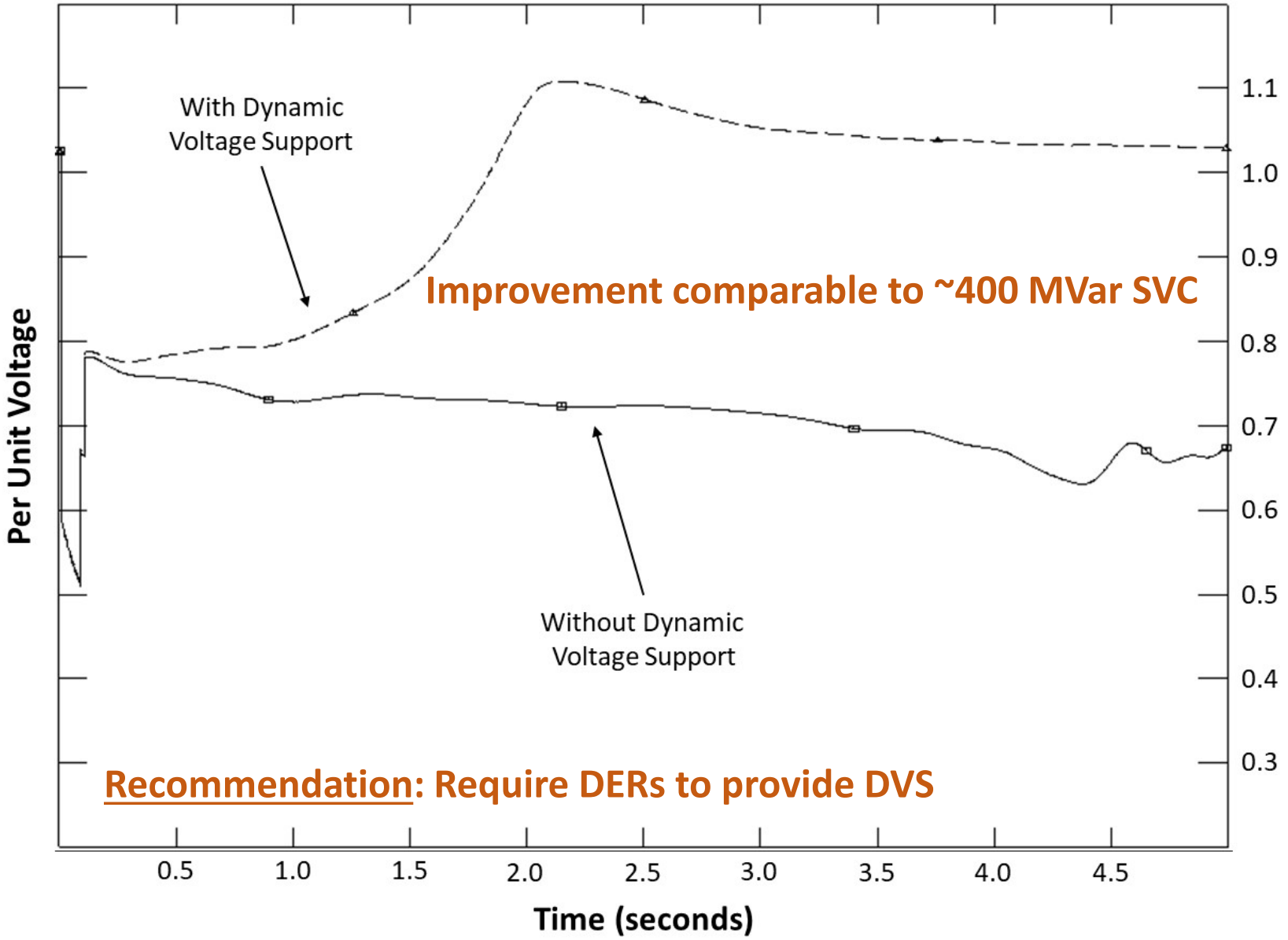
- Mandatory & Permissive operation regions are wider.
- Mandatory region aligns better with the voltage recovery criteria for FIDVR.

Recommendation: require DERs to provide "Category II" ride-through capability

Dynamic Voltage Support

- Per IEEE standard 1547-2018:
  - DERs may have a capability to provide dynamic voltage support (DVS).
  - DVS capability may be utilized under a mutual agreement with the local utility (service provider).
  - Can this be required from DERs?

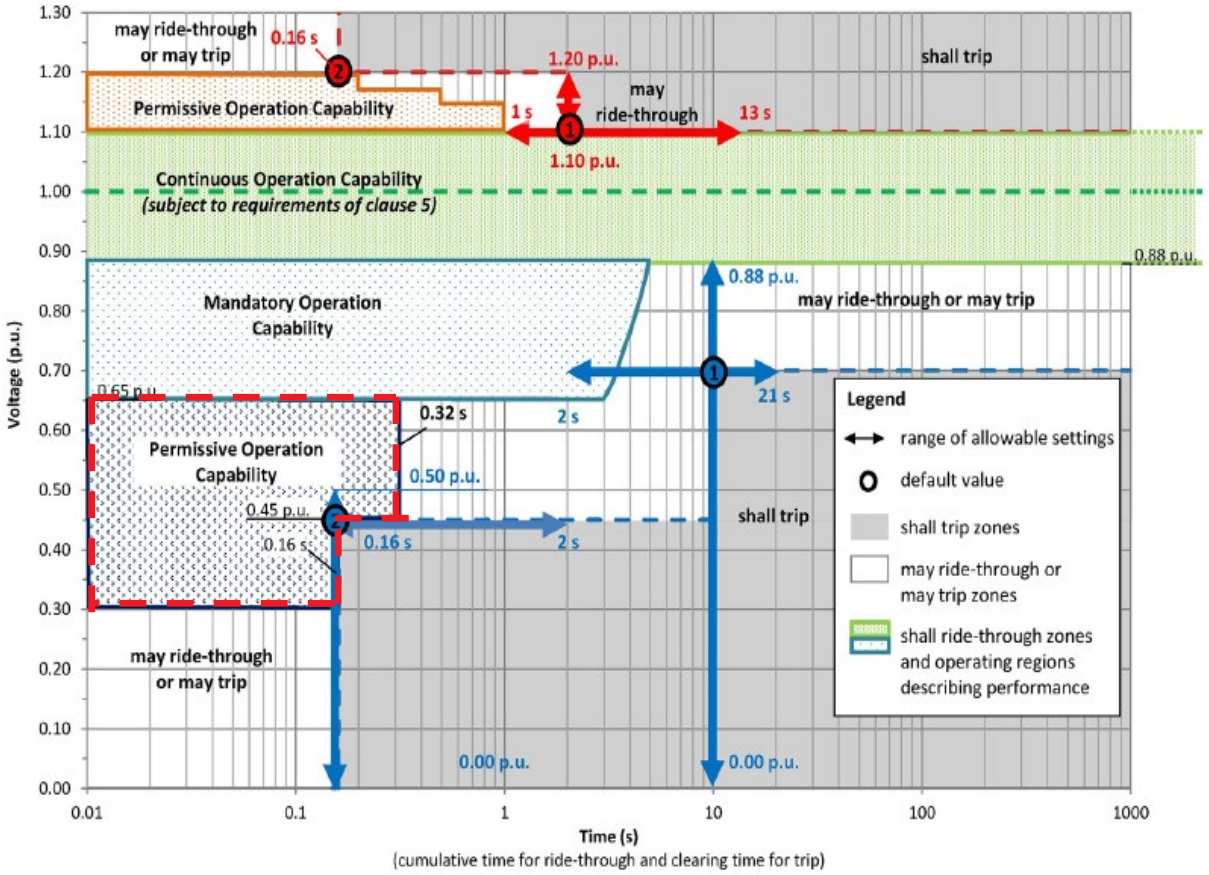
Voltage Recovery – with & without Dynamic Voltage Support



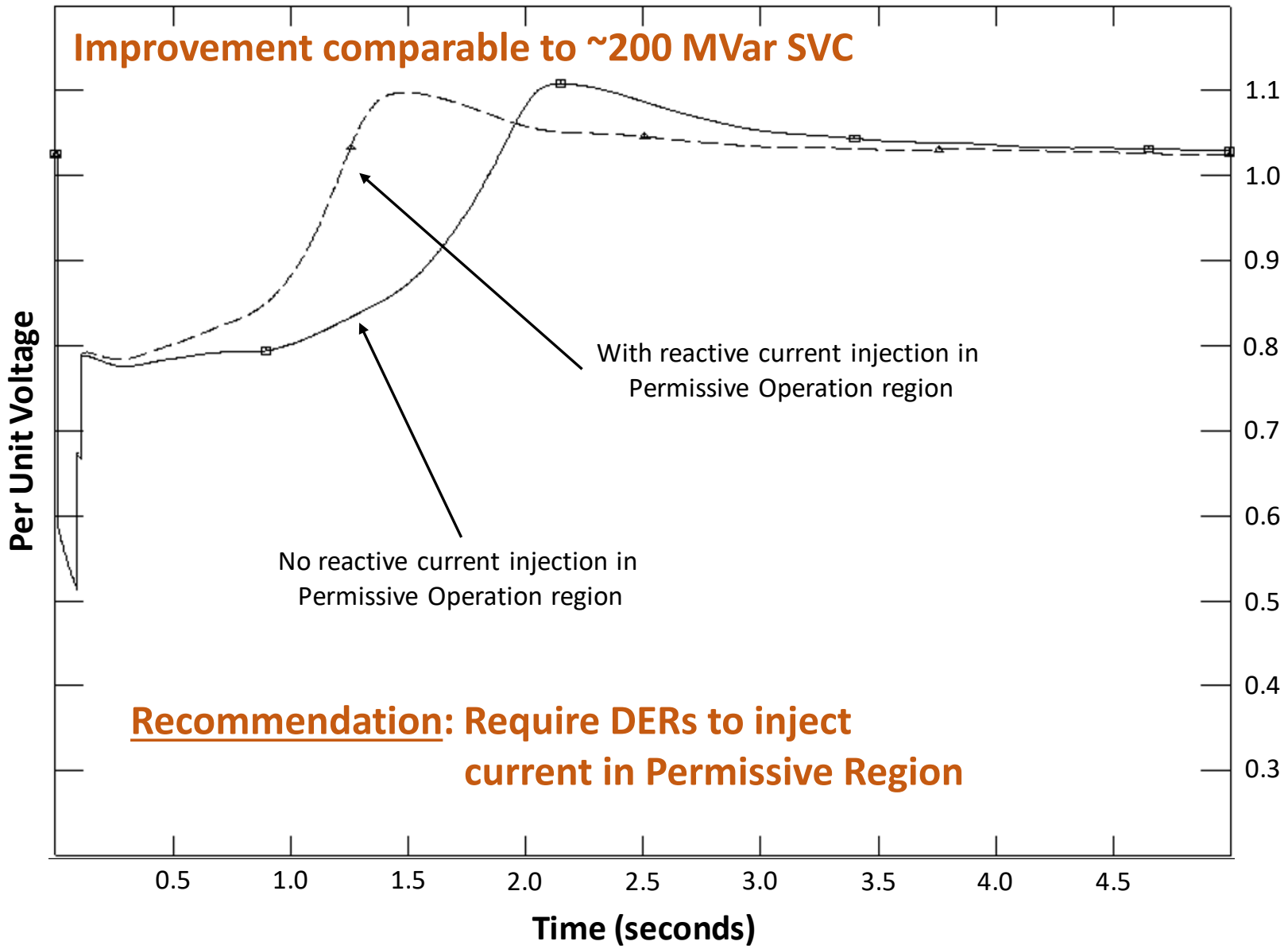
Recommendation: Require DERs to provide DVS

Current Injection in Permissive Operation Region

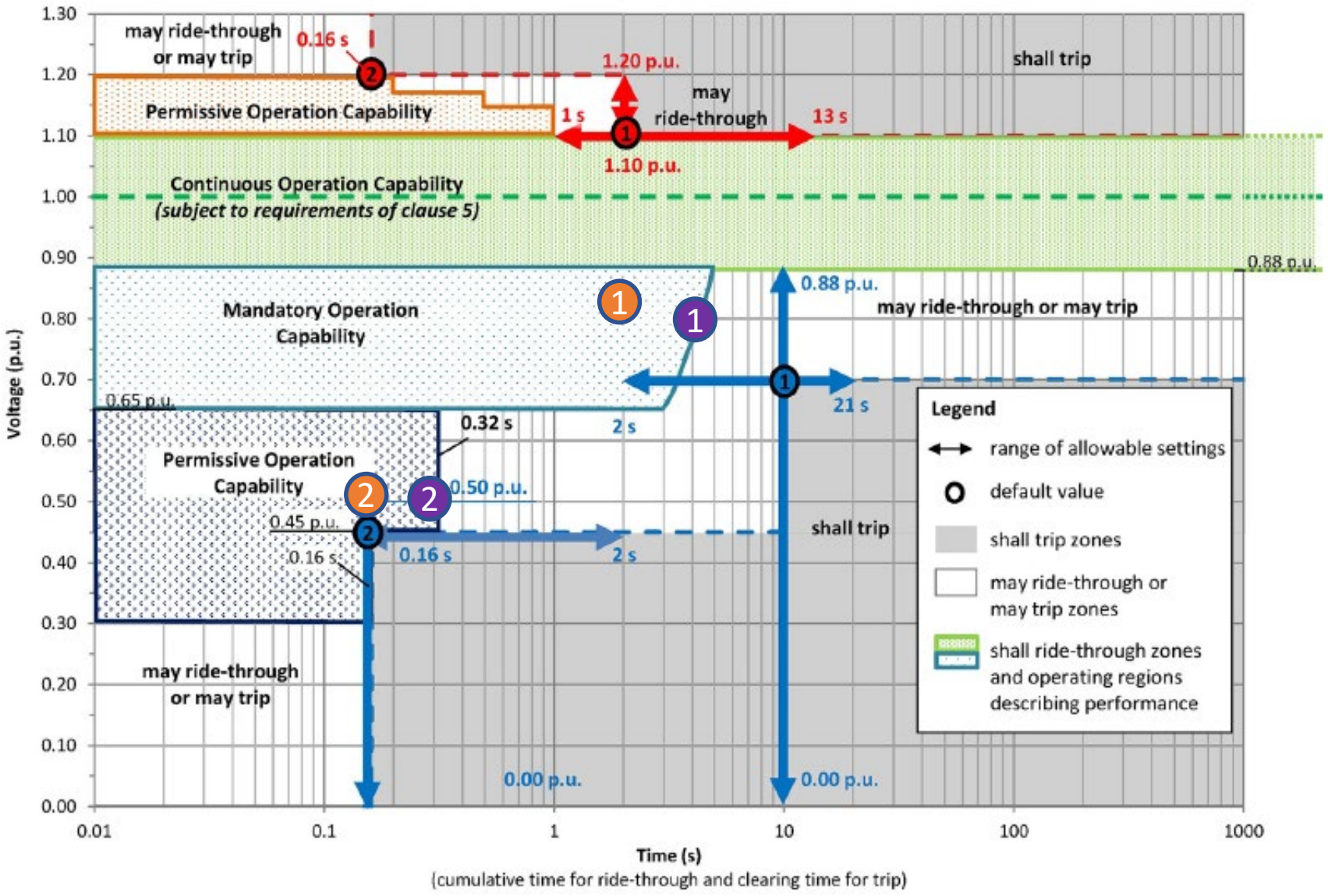
- Per IEEE 1547 standard –
  - DERs may continue to exchange current with the area EPS or cease to energize.
  - Up to interconnecting utility to decide if DERs should continue to exchange current in the permissive operation region.



Voltage Recovery – with & without Current Injection in Permissive Region



Abnormal Voltage Protection



Distribution's Proposal

Transmission's Recommendation

Recommendations for U-DERs & Distribution's Viewpoint

- Require DERs to
  - Provide category II voltage ride-through performance requirements.
    - Accepted
  - Implement "shall trip" settings that aligns with voltage recovery criteria.
    - Not comfortable with 4 second clearing time due to concerns with possibility of a long duration fault. Prefers a 2 second delay.
  - Provide DVS & inject current in permissive operation region.
    - No concerns with enabling these features, if equipment is capable. However, there is a concern about a lack of process to test and validate enforcement of this requirement.

Challenge: Consistent application across all distribution providers.

Application of IEEE Standard 1547-2018 to R-DERs

- Small scale residential and commercial rooftop installations
  - Very little control over how they are configured
- Modeled with “category I” ride-through requirements and to operate in:
  - Active power priority mode
  - Constant power factor mode
- If configured in this manner, R-DERs are not expected to support voltage recovery
- Not a concern for now as penetration of R-DERs remains very low.

Summary

- DERs are expected to displace traditional generation which provides dynamic voltage support to the grid.

- U-DERs could provide a meaningful grid support during FIDVR events, if configured properly.
  - Some distribution concerns remain for industry to solve
  - Consistent application across all DPs is a challenge
  - Actual benefit may not be as much as identified in this paper

- R-DERs:
  - Very little control over how they are configured