EXPERTISE TO ENABLE GRID TRANSFORMATION

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Smart Inverters

- ✓ Capabilities and Benefits
- ✓ How to access features
- ✓ Approach for enabling
- ✓ Guidance from other States

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Context

1. **IEEE-1547 2018** inverters based on this new equipment standard will be available soon. States and utilities are making decisions now.
2. **Capabilities vs. Requirements**. 1547-2018 is an equipment capabilities specification, not a prescriptive standard. States and utilities have to make decisions about what features to implement.
3. **Grid Features**: 1547-2018 includes new grid support functionality.
4. **Harmonize**. If we can agree on default settings for systems, we reduce complexity for installers, utilities, manufacturers.
5. **Early**, **Early**, **Early**. Don't wait until we have high DER penetrations to implement these features, the grid needs them now, and it will be hard to implement retroactively.

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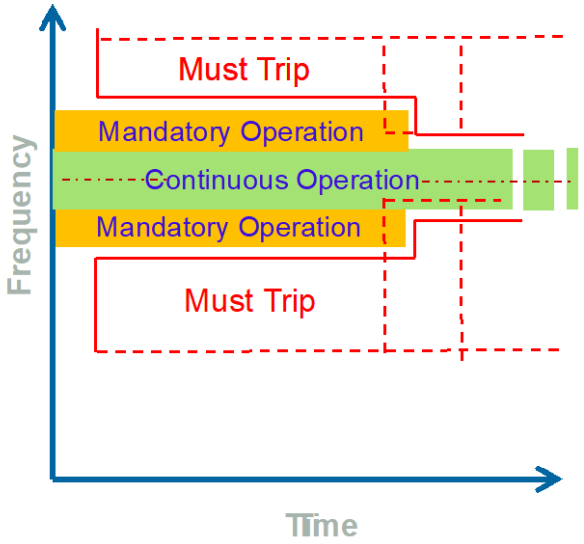
Grid Features: Ride Through

- IEEE 1547 compliant inverters have the capability to **ride through** voltage and frequency disturbances
- Supports bulk system reliability
- Maintains anti-islanding



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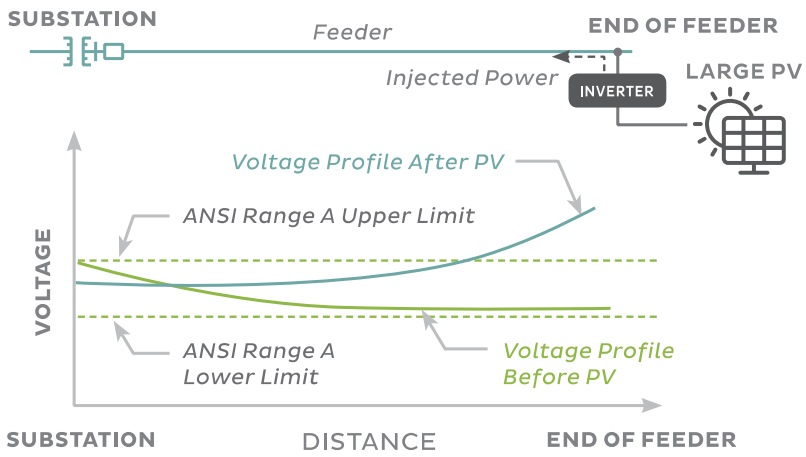
Grid Features: Voltage Regulation

- Earlier versions of IEEE-1547 did not allow inverters operate at non-unity power factors.
- Increased deployment of DER raises concern for voltage management on distribution circuits
- Voltage management features allows compliant inverters to mitigate their own voltage impact



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IEEE 1547-2018 Voltage Management Modes

One of these modes:

1. Constant Power Factor (default, unity)
2. Voltage-Reactive Power (**volt-var**)
3. Active Power-Reactive Power (**watt-var**)
4. Constant Reactive Power

With the potential addition of:

- Voltage-Active Power (**volt-watt**)

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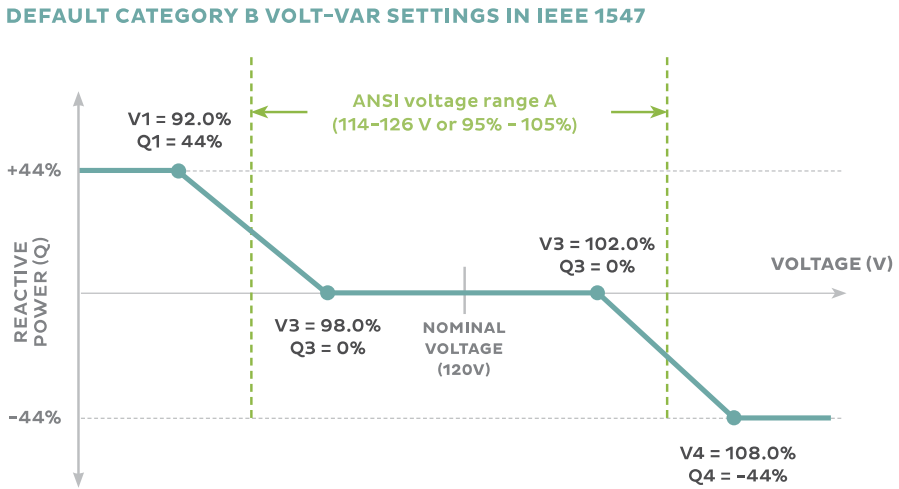
Voltage Management: volt-var



- **Pro:** Can address both high and low voltage impacts, does not create reactive power
- **Con:** Can result in curtailment w/o headroom, may challenge coordination with traditional voltage management

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Voltage Management Modes

Voltage-Active Power (**volt-watt**)

- **Pro:** Mitigates impacts from reconfiguring circuits, can increase hosting capacity
- **Con:** May result in curtailment

Constant Power Factor

- **Pro:** Simple, Can mitigate voltage
- **Con:** Absorbs reactive power at all times, even when not needed, can curtail active power if no "headroom"

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Grid Features: Visibility and Control

Communications **capabilities** are required in 1547-2018 compliant inverters, but that does not **require** distribution utilities to communicate or control these devices. many systems will likely have communications enabled with aggregators/owners.

Grid features are designed to be **autonomous**, e.g. the inverter responds to grid conditions based on a predefined set of instructions. This allows for **real-time** response by the device.

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RELIABILITY ASSUMPTIONS

Do we need communications and control?

- Control required
  - Many utilities assume communications and control of DER will be needed to maintain *reliability*.
  - Focus has been on effects of distribution reconfiguration, anti-islanding concerns
- Autonomous Approach
  - California, Hawaii continue to progress with autonomous controls (e.g. volt-var, volt-watt in some cases.
  - Illinois, Minnesota following

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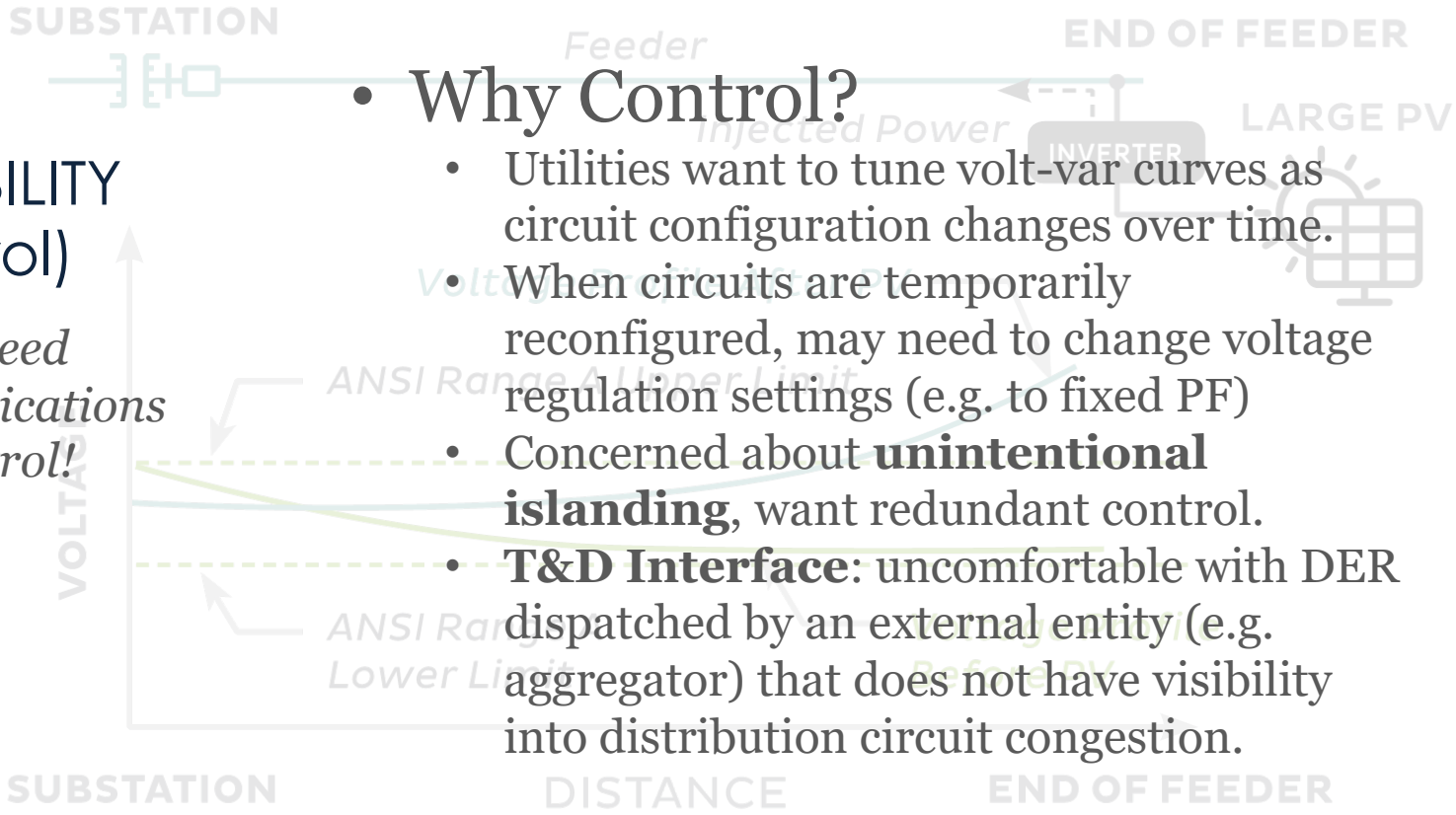
RELIABILITY (Control)

We do need communications and control!

- Why Control?
  - Utilities want to tune volt-var curves as circuit configuration changes over time.
  - When circuits are temporarily reconfigured, may need to change voltage regulation settings (e.g. to fixed PF)
  - Concerned about **unintentional islanding**, want redundant control.
  - **T&D Interface**: uncomfortable with DER dispatched by an external entity (e.g. aggregator) that does not have visibility into distribution circuit congestion.



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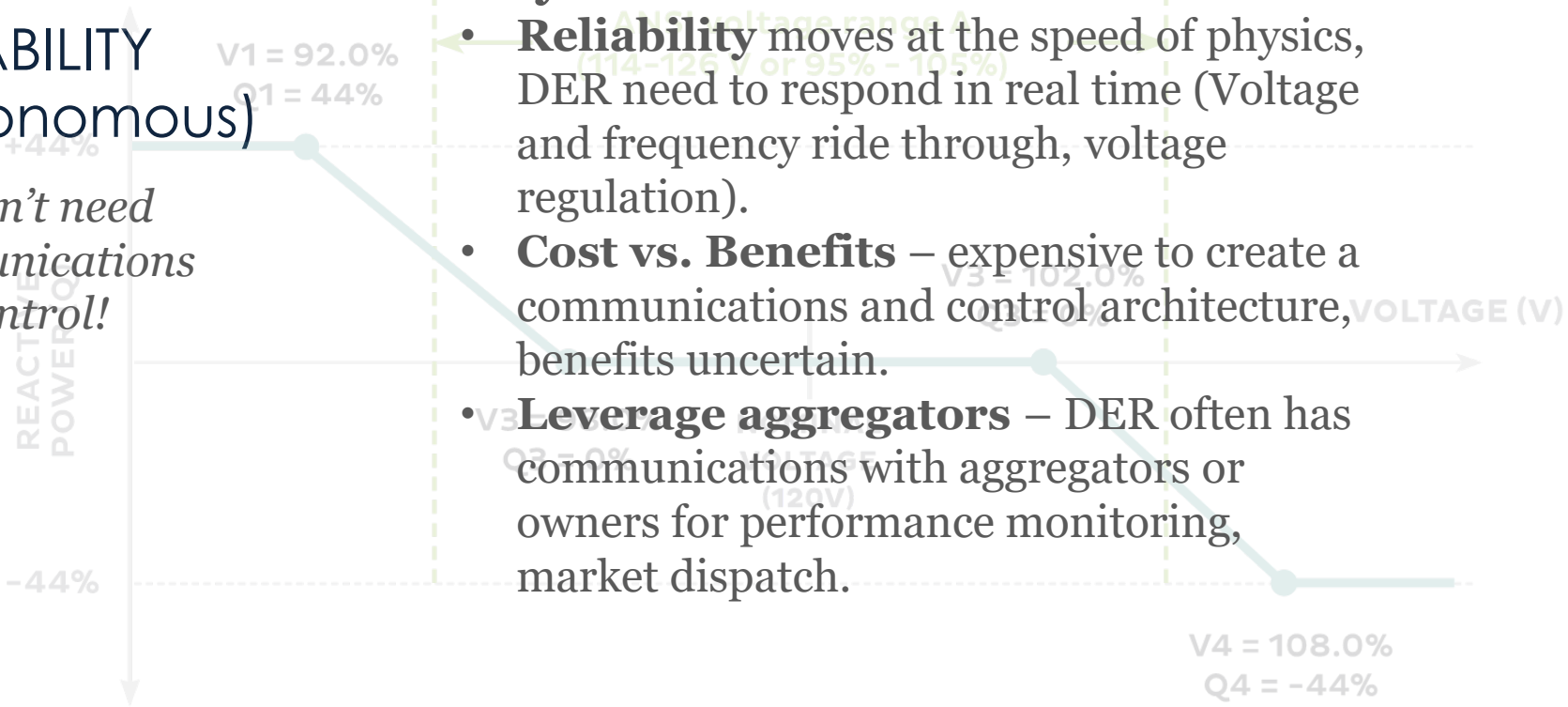
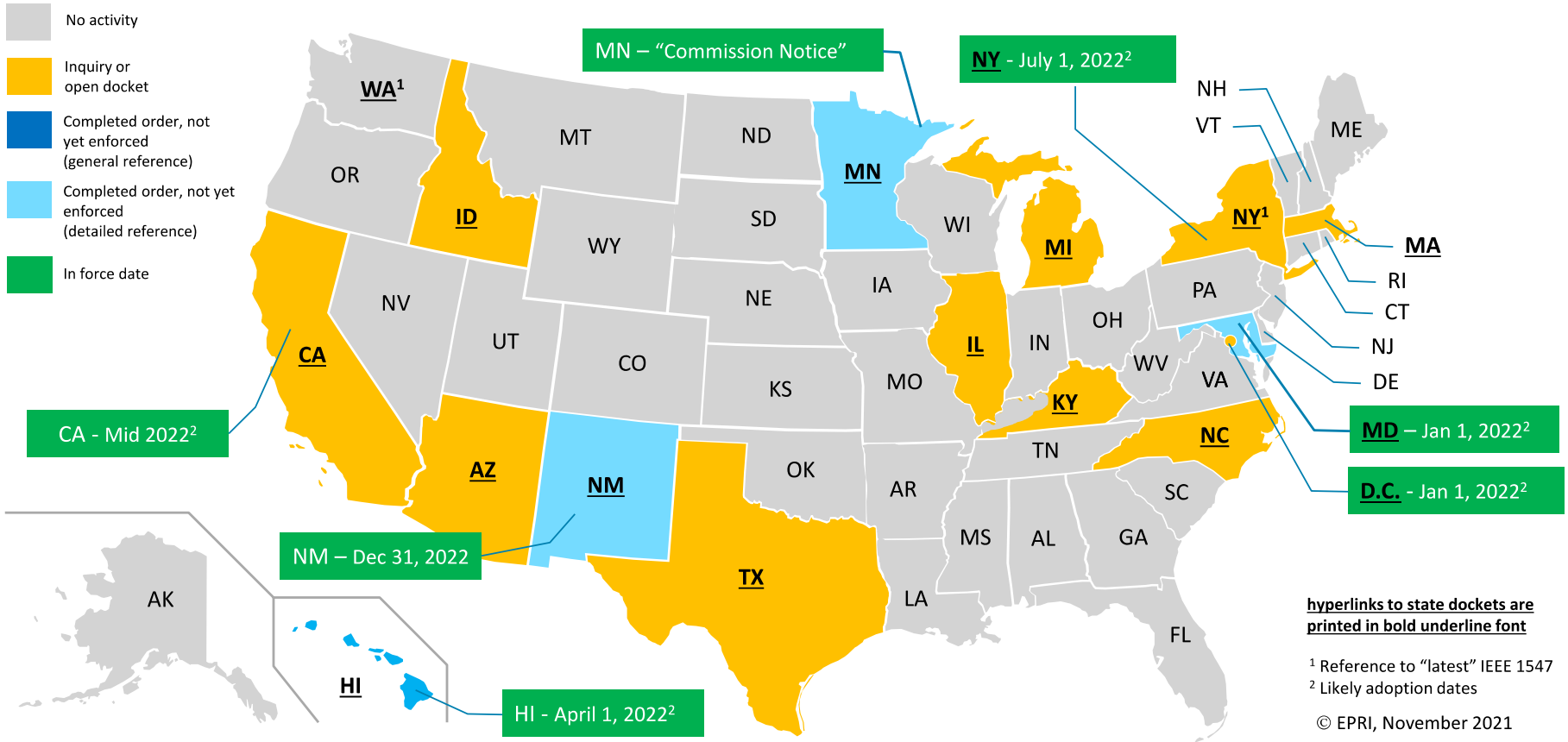
RELIABILITY (Autonomous)

We don't need communications and control!

- Why Autonomous?
  - **Reliability** moves at the speed of physics, DER need to respond in real time (Voltage and frequency ride through, voltage regulation).
  - **Cost vs. Benefits** – expensive to create a communications and control architecture, benefits uncertain.
  - **Leverage aggregators** – DER often has communications with aggregators or owners for performance monitoring, market dispatch.



U.S. States adopting IEEE Std 1547™-2018



hyperlinks to state dockets are printed in bold underline font

[1] Reference to "latest" IEEE 1547
[2] Likely adoption dates

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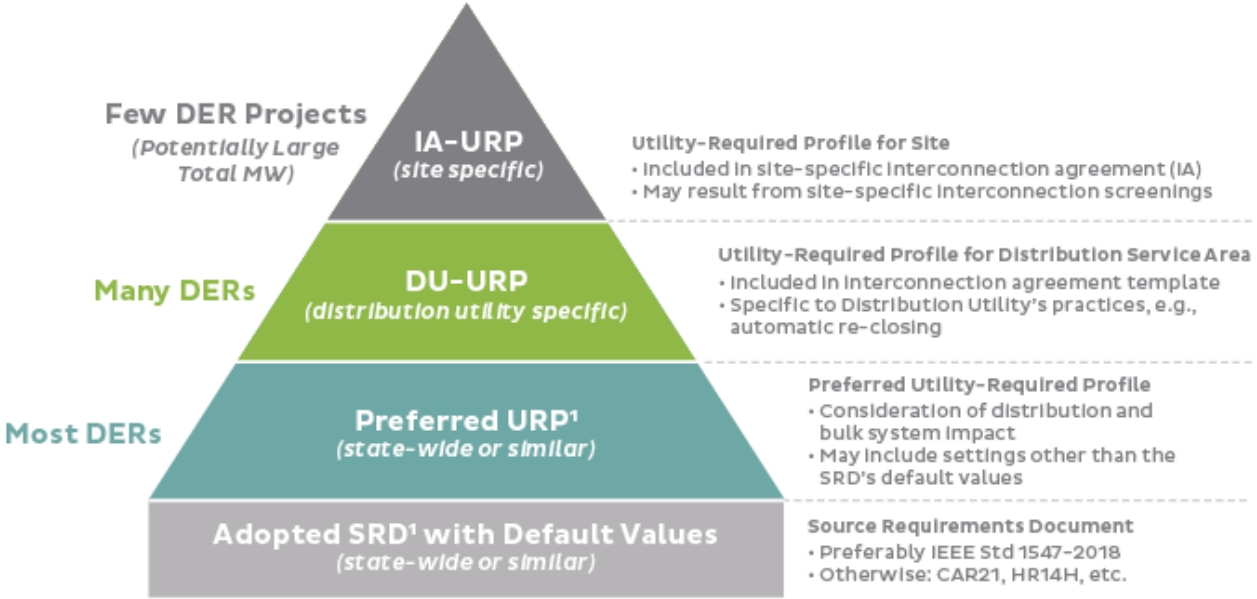
Recommendations: For "Most DER"



Source: EPRI

[1]Based on decision by Authority Governing Interconnection Requirements (AGIR)

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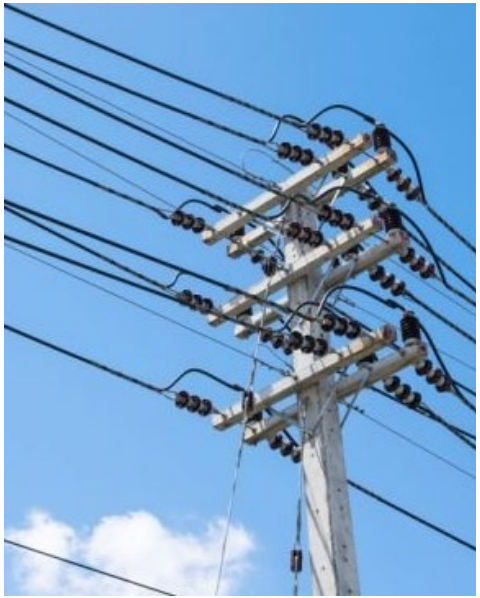
Recommendations

Implement early, don't over-analyze

Deploy standard settings for most systems

- Volt-var for voltage regulation
- Default Category II or III for ride-through settings



Resources:
NREL IEEE 1547 Education
https://www.nrel.gov/grid/ieee-standard-1547/
GridLab Voltage Regulation
https://gridlab.org/works/regulating-voltage-report/

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THANK YOU

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