Lessons Learned from NOGRR 245 Ride-Through Evaluations

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Today's Presenters and The Elevate Team

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New Team Member Joining Soon

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Disclaimers

- These views reflect the insights and learning of NOGRR 245 ride-through evaluations across many sites and do not reflect any singular site necessarily.
- These views do not reflect the views of Elevate industry partners and clients.
- These views should not be interpreted as compliance advice or guidance; they are solely for the purpose of discussion and *elevating* industry understanding of practical and pragmatic issues.
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Background: Software Updates Address Most Risks

(3) If protection systems (including, but not limited to protection for over-/under-voltage, rate-of-change of frequency, anti-islanding, and phase angle jump) are installed and activ… Type… parag…

(3) If protection systems (including, but not limited to protection for over-/under-frequency, rate-of-change-of-frequency, anti-islanding, and phase angle jump) are installed and activated to trip the IBR or Type 1 WGR or Type 2 WGR, they shall enable the Resource to ride through frequency conditions beyond those defined in paragraph (1) above to the maximum extent equipment allows.

(4) An IBR or Type 1 WGR or Type 2 WGR shall inject electric current when required to ride-through voltage conditions. When the POIB voltage is outside the continuous operating voltage range, an IBR shall continue to deliver pre-disturbance active current unless reduction is needed for voltage support or otherwise specified by ERCOT or the inte… cur… red… wit… sett… IBR interconnects and ensure sufficient active current is available for protection system sensing. An IBR or Type 1 WGR or Type 2 WGR shall return to its pre-disturbance level

(5) Plant controls, turbine controls, or inverter controls of an IBR or Type 1 WGR or Type 2 WGR shall not disconnect the Resource from the ERCOT System or reduce its output during voltage conditions where ride-through is required unless necessary for providing appropriate frequency response.

(6) If instantaneous over-current or over-voltage protection systems are installed and activated to trip the IBR or Type 1 WGR or Type 2 WGR, they shall use filtered quantities or sufficient time delays to prevent misoperation while providing the desired equipment protection. Any instantaneous over-voltage protection that could disrupt power output shall use a measurement period of at least one cycle (of fundamental frequency).

(8) An IBR or Type 1 WGR or Type 2 WGR shall not use measurements of quantities such as phase angle jump and rate-of-change-of-frequency to trip or reduce the output of the Resource during fault conditions where the POIB voltage remains within the ride-through profiles specified in paragraph (1) above, unless the Resource has an approved exemption or extension under Section 2.13.

Location		Identified Issue	Odessa Events?	Software Fixable?
Inverter	☑	Momentary Cessation*	X	Yes
	☑	Inst. Frequency		Yes
	☑	Inst. AC Overvoltage	X	Yes
	☑	DC Reverse Current		Yes
	☑	PLL Loss of Sync/Phase Jump	X	Yes
	☑	Slow Active Power Recovery	X	Yes
	☑	AC Undervoltage		Yes
	☑	Inst. AC Overcurrent	X	Yes
	☑	DC High/Low Voltage		Yes
	☑	DC Voltage Unbalance	X	Yes
	☑	Ride-Through Misconfiguration	X	Yes
	☑	DC Overcurrent		Yes
	?	Auxiliary Equipment		Maybe
	?	Subsynchronous Oscillation		Maybe
	☑	AC Current Unbalance		Yes
Plant-Level	☑	Inverter-PPC Interactions	X	Yes
	☑	Feeder Underfrequency	X	Yes

*Except for some legacy inverters

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Definition of Maximization

Fundamental Definition of Ride-Through Maximization used in NOGRR 245 Assessment:

IBR protection system settings shall be coordinated, within equipment ratings, to maximize the ride-through capability of the inverters and supplemental IBR devices within the facility.

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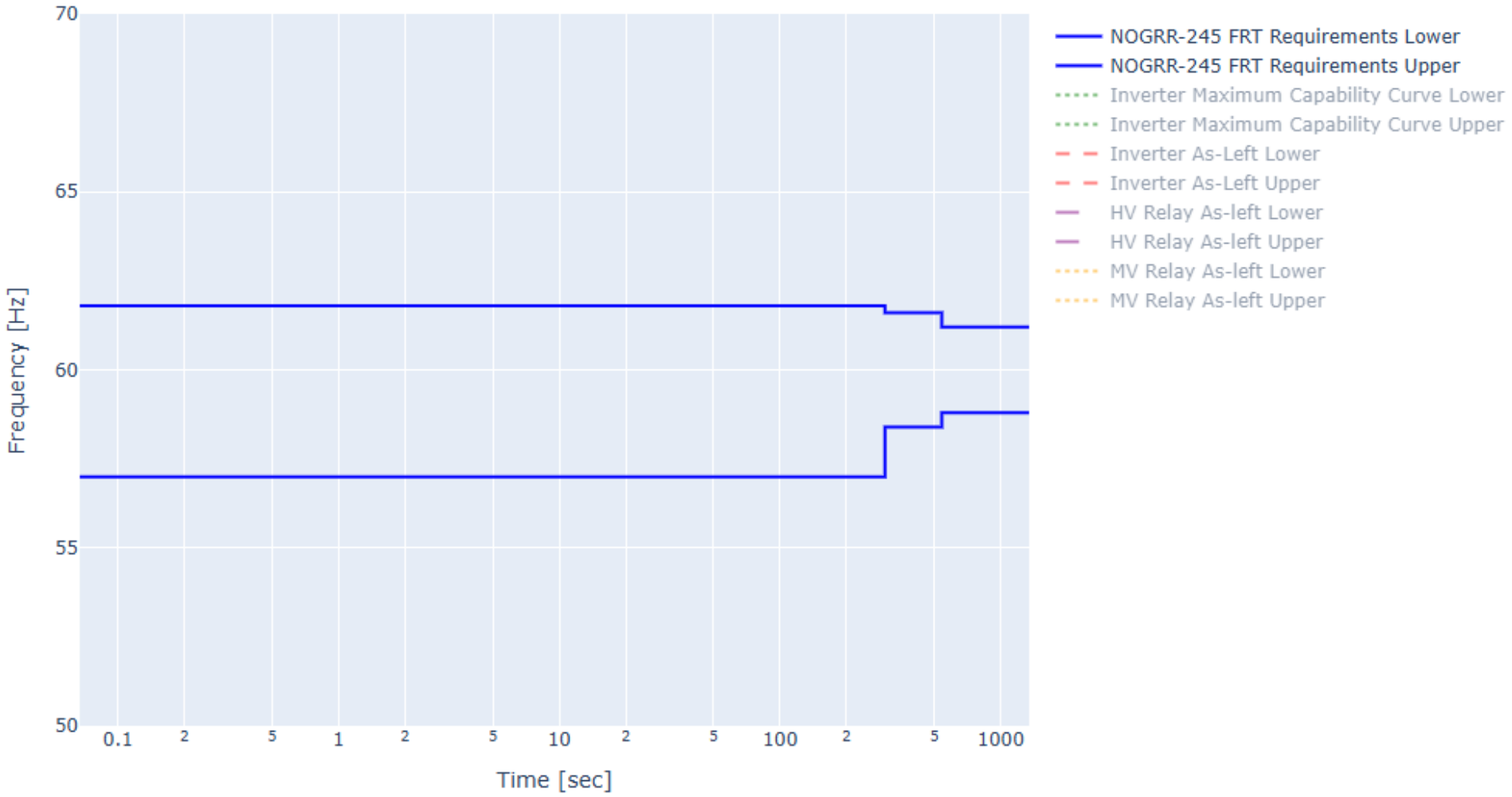
Frequency Ride-Through (FRT) Example



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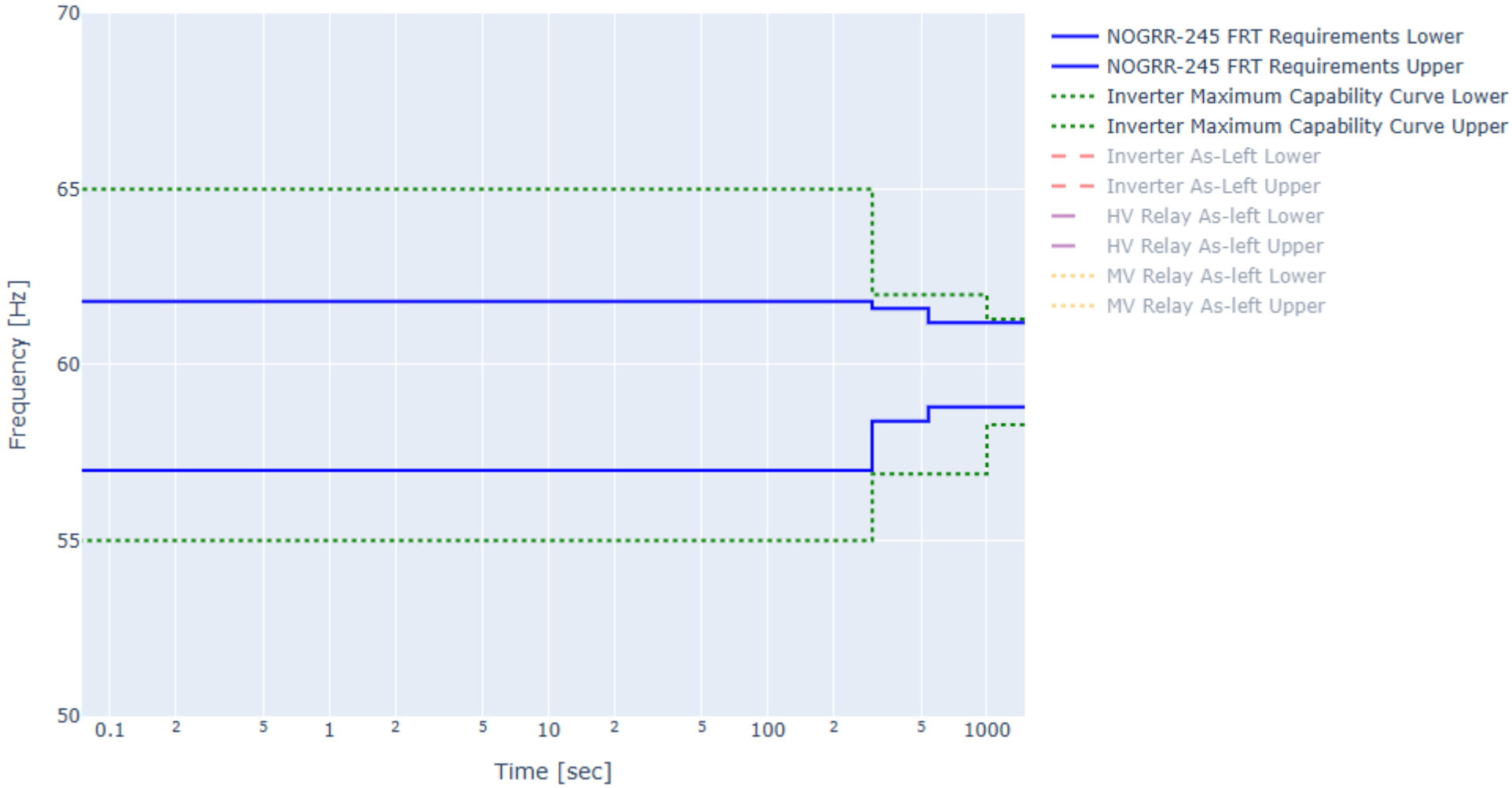

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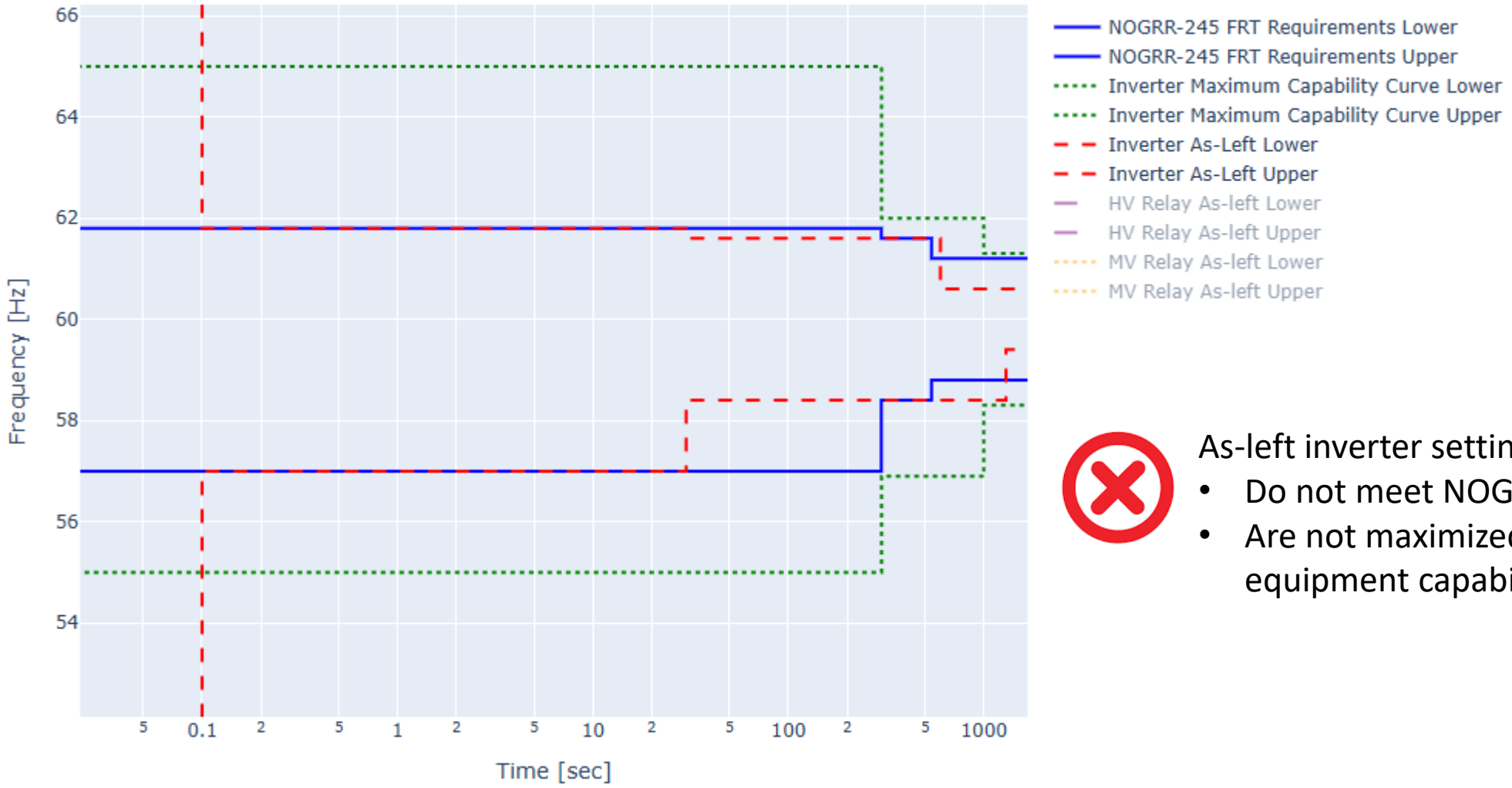

As-left inverter settings:

- Do not meet NOGRR curves
- Are not maximized to equipment capability

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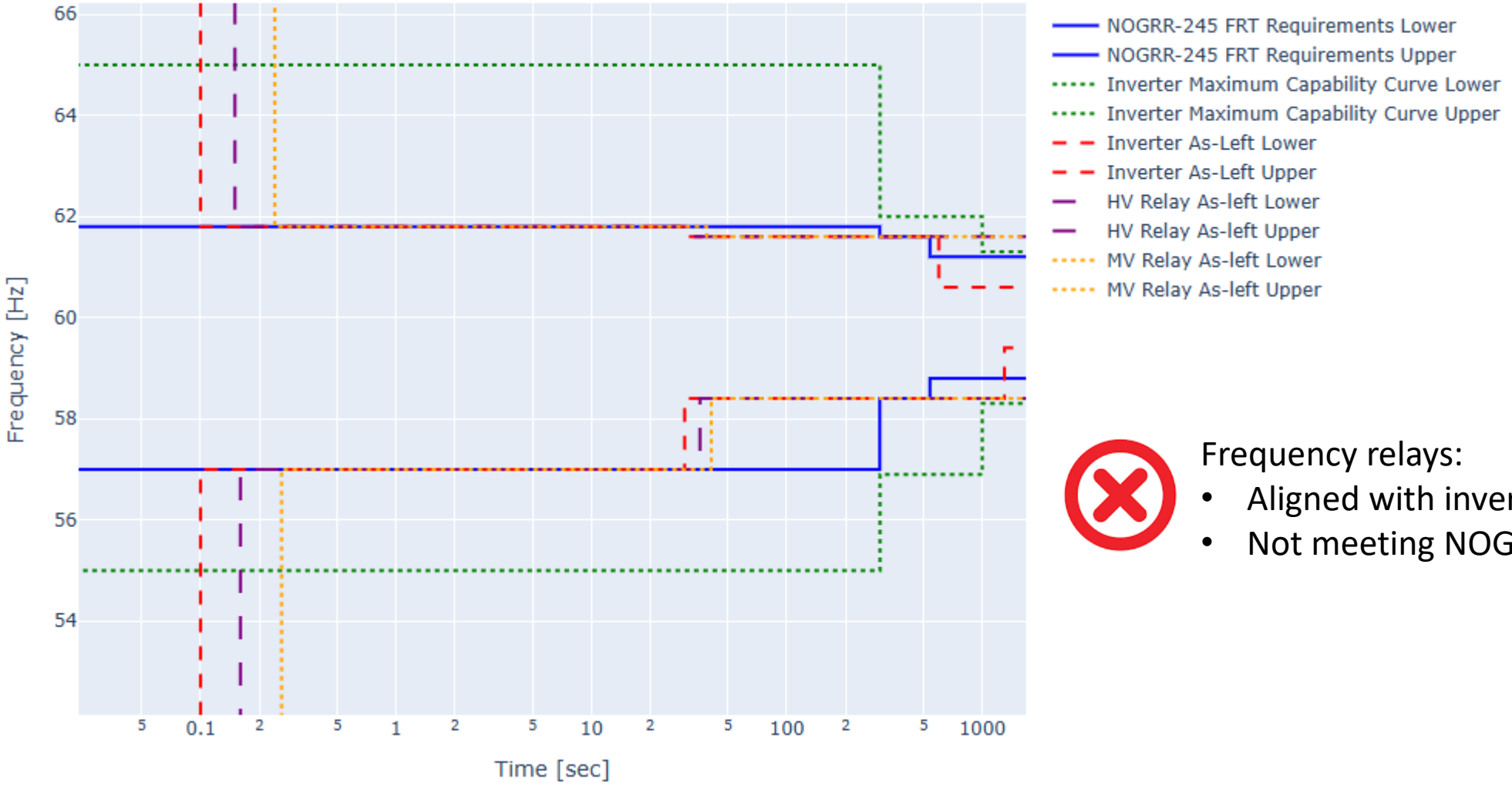
Frequency Ride-Through (FRT) Example



Frequency relays:

- Aligned with inverter
- Not meeting NOGRR curve

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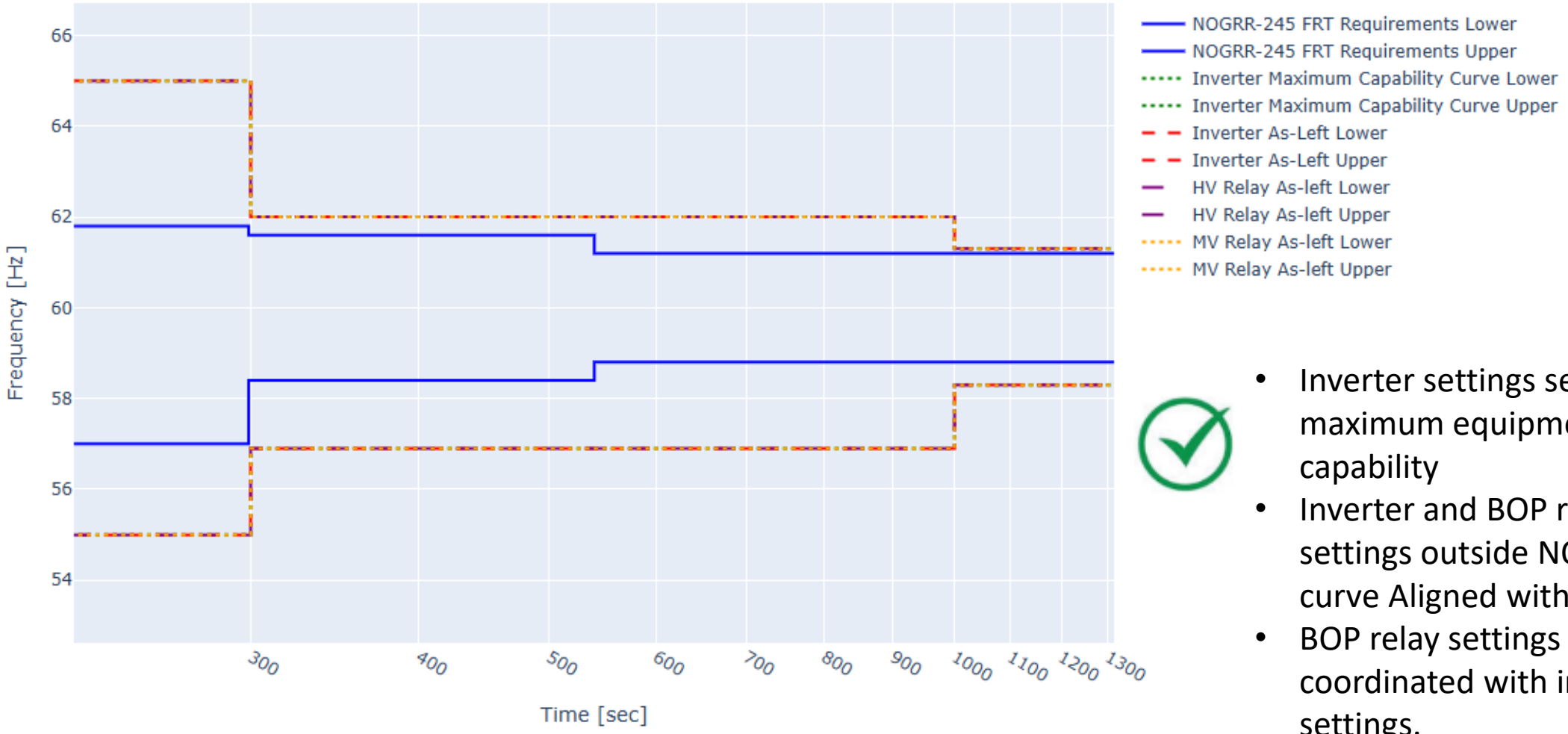
NOGRR 245 Compliant FRT Curves



- Inverter settings set to maximum equipment capability
- Inverter and BOP relay settings outside NOGRR curve Aligned with inverter
- BOP relay settings coordinated with inverter settings.

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Successes

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NOGRR 245 Successes

- IBR ride-through maximization will likely ***dramatically improve*** the capabilities and operational performance of IBRs across the ERCOT system
- **Maximization is a successful concept –** many instances of IBR facilities commissioned with settings meeting requirements at the time but below maximum equipment capabilities
- **Expanded ride-through capabilities** at inverter level and balance of plant relaying, **using software-based upgrades**
- **Disabling protections prone to tripping** (phase jump, ROCOF, anti-islanding, instantaneous protection, unfiltered quantities, etc.), where possible
- **Upcoming improved IBR model quality** that aligns with as-left equipment in the field
- **Resource Entities strongly leaning in to maximize ride-through capability and support the ERCOT system**; seeking information from OEMs persistently, directly, and clearly

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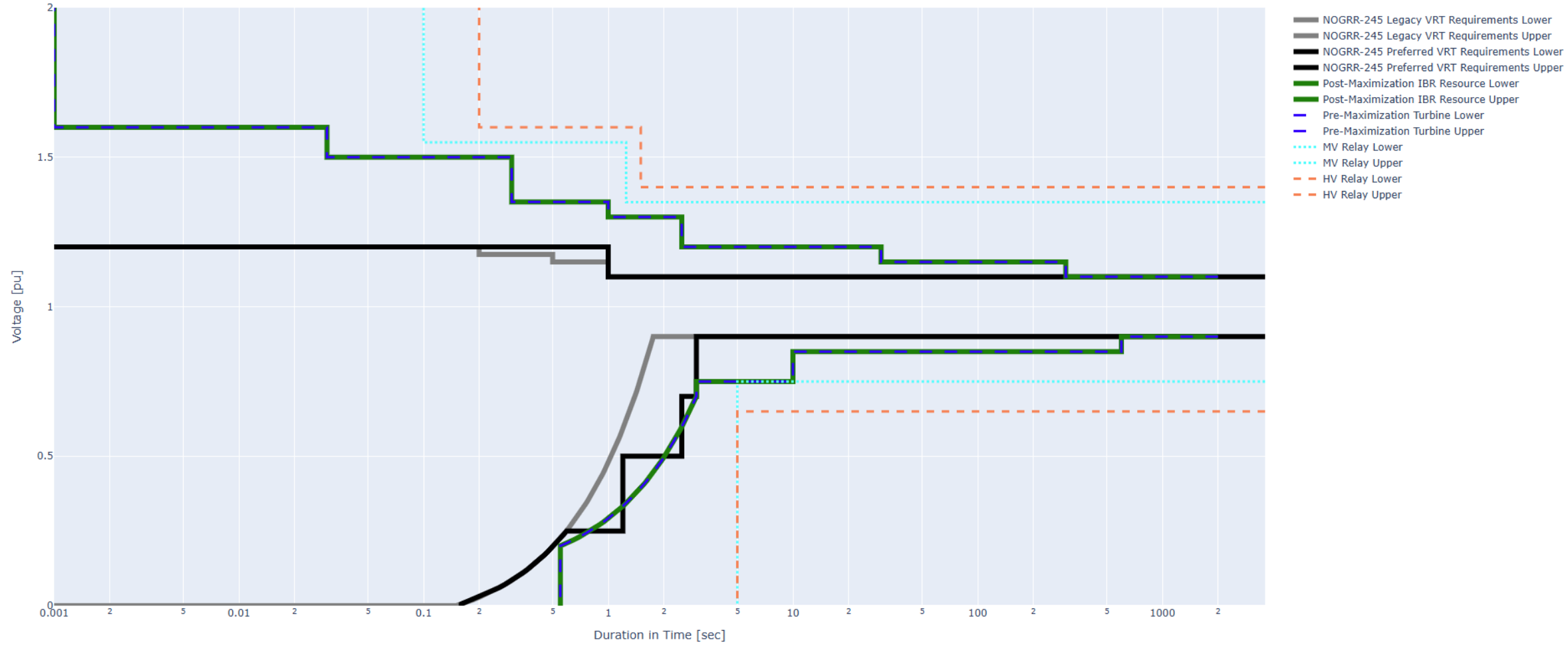
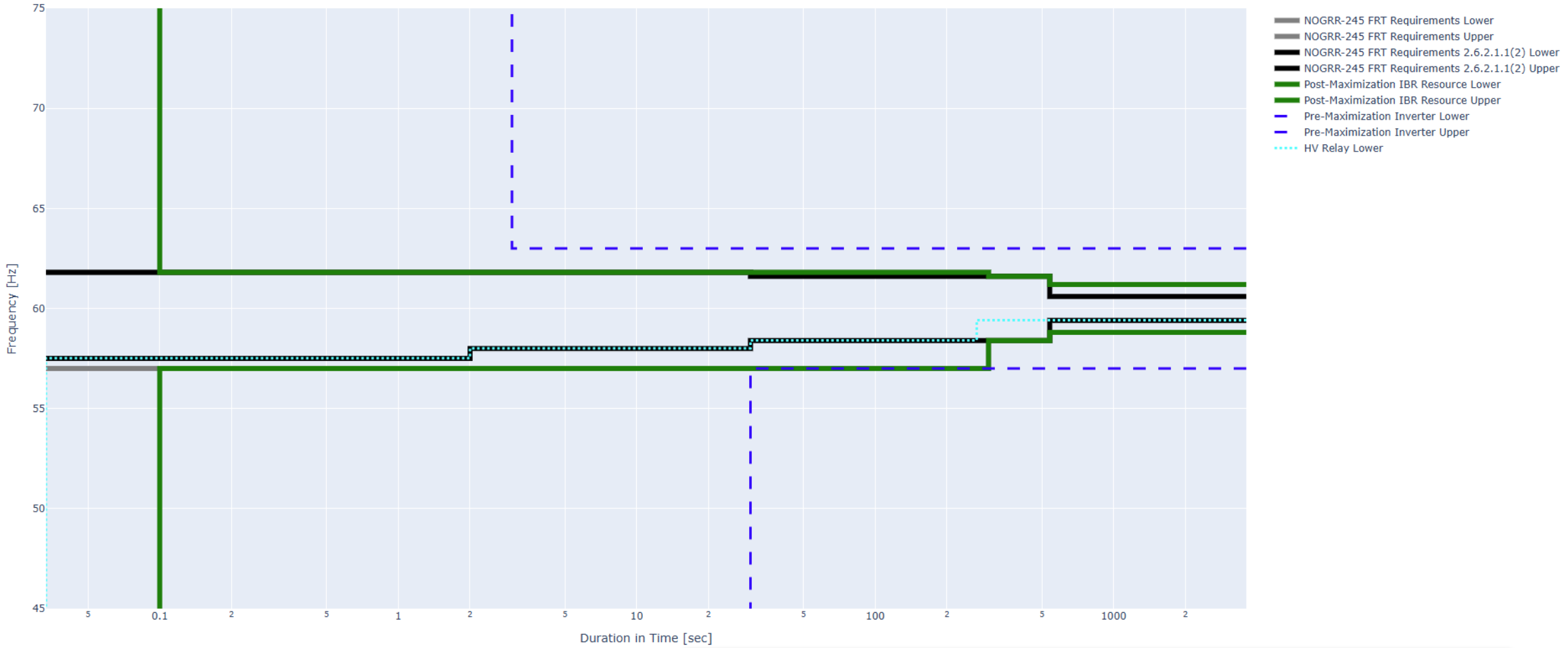
Sites Already Maximized



- IBR unit protections set based on capabilities
- Balance of plant protections well outside IBR unit ride-through capability
- Tripping-prone protections already disabled

Relays Inside Ride-Through Curve



- Relay settings unexpectedly inside IBR unit ride-through curves
- Relay settings unexpectedly inside ride-through curve (legacy)
- Relay settings being expanded to eliminate these risks

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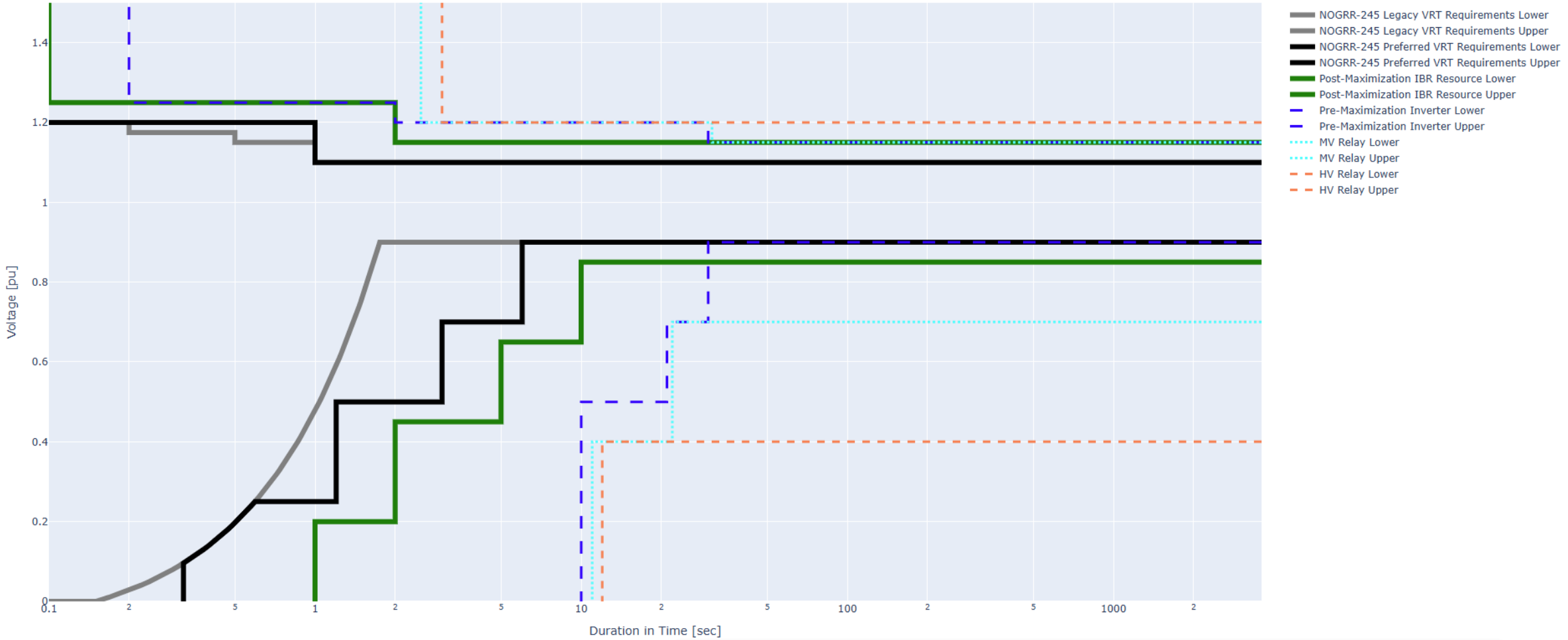
Inverter Protection Beyond Equipment Capability



- IBR unit protections set well beyond stated capabilities unexpectedly
- OEMs recommend bringing them in to protect inverters
- Aligning with concepts of maximization and well outside requirements

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Challenges and Opportunities for Improvement

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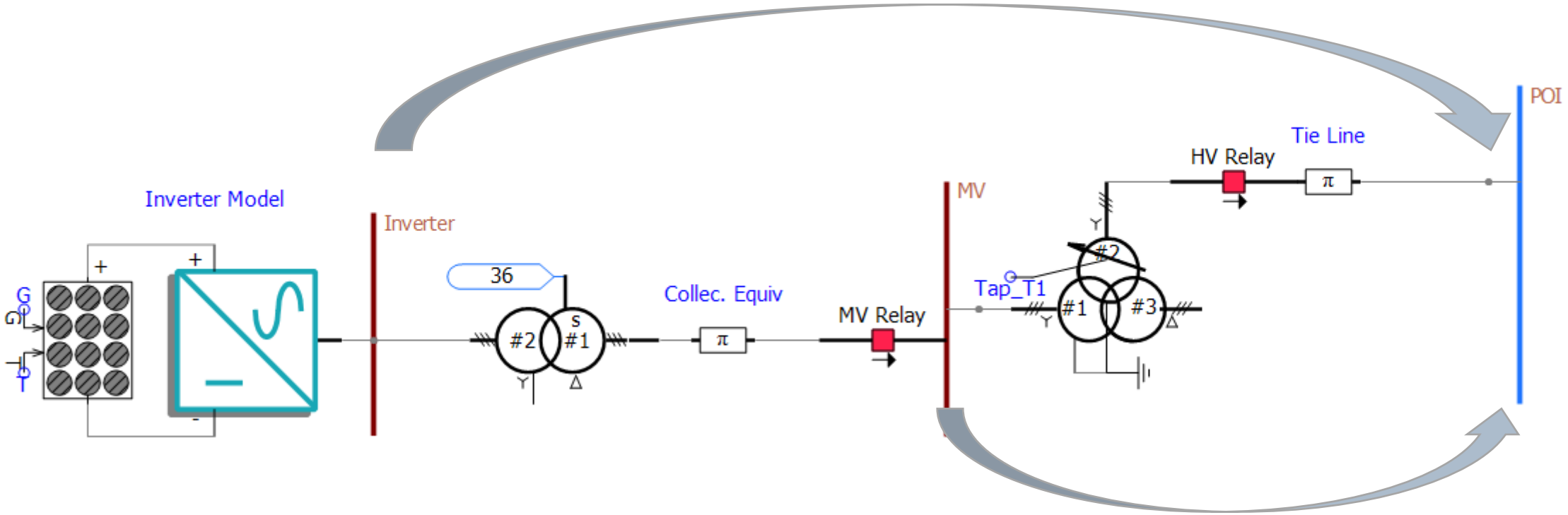
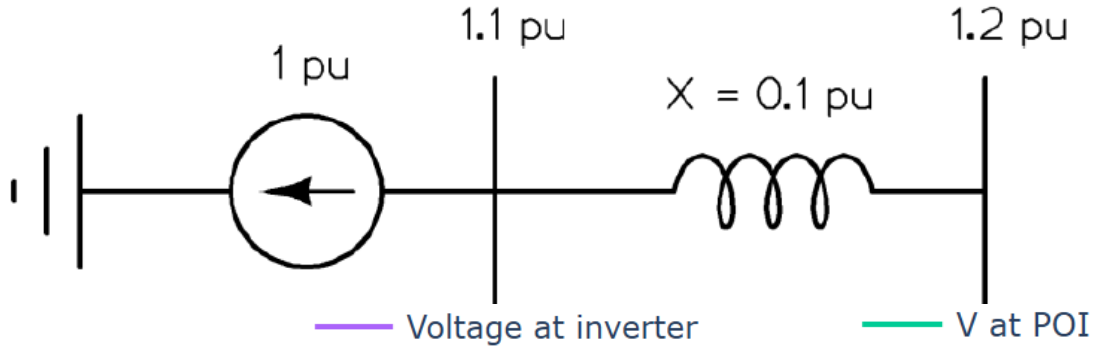
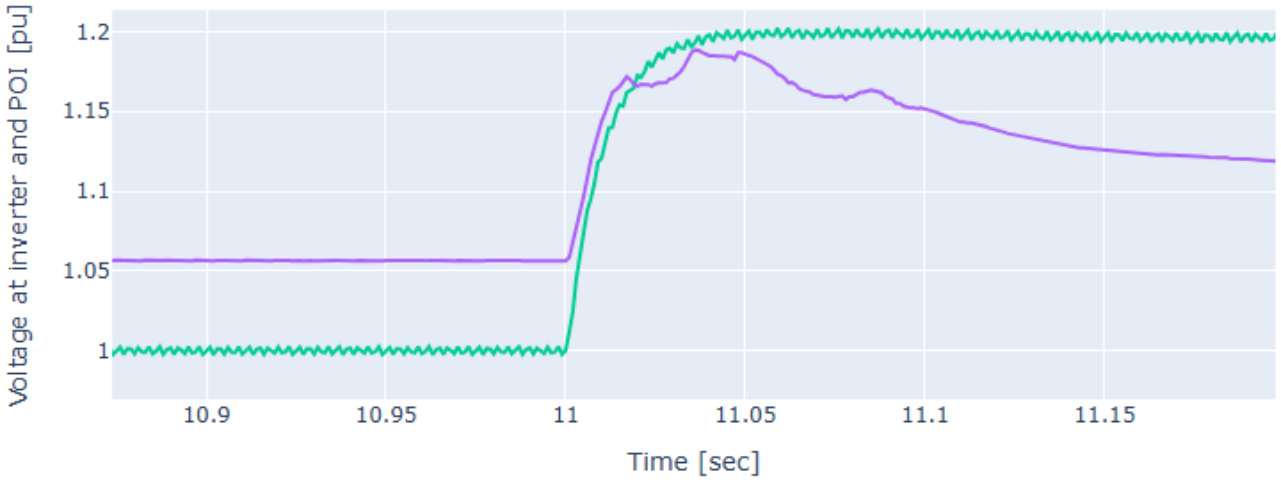
Maximization Reflection Issue

- Reflecting performance expectation from POI to inverter terminals is straightforward
- However, reflecting IBR unit-level capabilities and settings *up* to the POI requires more clarity
- No guidance was given (although requested) on *how* inverter-level protection settings should be **“reflected”** up to the MV or HV voltage levels
- Will lead to broad interpretations that make data submitted across entities vary widely



Reflecting Capabilities for IBR Plant





Considerations:

1. Protection philosophies vary widely
2. Pre-disturbance operating point(s) – Qmax/Qmin, Pmax
3. Current injection assumptions during dynamics
4. Main power transformer online tap changer assumptions
5. Static or dynamic reactive devices
6. IBR plant network impedances
7. Models used, and model accuracy, if used

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Instantaneous Protection and Filtering

- This sub-requirement, particularly for legacy assets, is requiring exemptions that may not be serving a significant purpose
- Instantaneous protection is rather prominent on legacy assets – required careful (and multiple) discussions with OEMs
- Maximization required expanding these protections as wide as possible

ERCOT NOGRR 245 Language

(6) If instantaneous over-current or over-voltage protection systems are installed and activated to trip the IBR, Type 1 WGR or Type 2 WGR, they shall use filtered quantities or sufficient time delays to prevent misoperation while providing the desired equipment protection. Any Alternating Current instantaneous over-voltage protection that could disrupt power output shall use a measurement period of at least one cycle (of fundamental frequency).

ERCOT modification to IEEE 2800-2022 original language leaves out *critical* language that changes meaning entirely

IEEE 2800-2022 Language

All instantaneous overvoltage protection used within the *IBR plant* shall use filtered quantities (Schweitzer and Hou [B105]) to reduce the possibility of misoperation while providing protection to the desired equipment and system. Any instantaneous overvoltage protection(s) that has the possibility of disrupting the power output of the entire plant shall use at least one cycle (of fundamental frequency) measurement window to reduce such possibility and the related impact on the TS. Protection margin shall be coordinated with the *TS owner*, wherever applicable.

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Inconsistencies in Data

- Inconsistencies between data source:
  - Inverter documentation, as-left settings, specification sheets, narratives, etc.
  - OEM-supplied information
  - Relay .rdb files
  - Dynamic models (PSS®E, PSCAD™, TSAT™) discrepancies or omissions
  - Version control issues
- Inabilities for Resource Entities to easily extract useful information
  - Room for human error
  - Need machine readable files/forms, computer vision to identify inconsistencies
  - Standardized framework encouraged
- Errors exist in protection settings, imagine errors in the inverter settings

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Process Complications

- Resource Entity reads NOGRR 245 and needs to take action
- May bring in consultant; companies align on approach; coordinate with ERCOT on questions
- They combined reach out to the OEM to gather necessary information
- OEM may pull in a sales engineering rep (not technical SMEs, necessarily)
- Group sets up a call, which then grows to 15+ people, rather high sensitivity because of demands
- Hours and resources wasted coordinating and holding meetings to educate and inform stakeholders
- Weeks later, OEM shares information requested; not 1:1 match of needed information
- Resource Entity and consultant quickly reviews data; realize gaps
- Cycle repeats, often numerous times
- Divergent answers being received by OEMs and Resource Entity
- OEM goes radio silent 1-2 weeks before deadline

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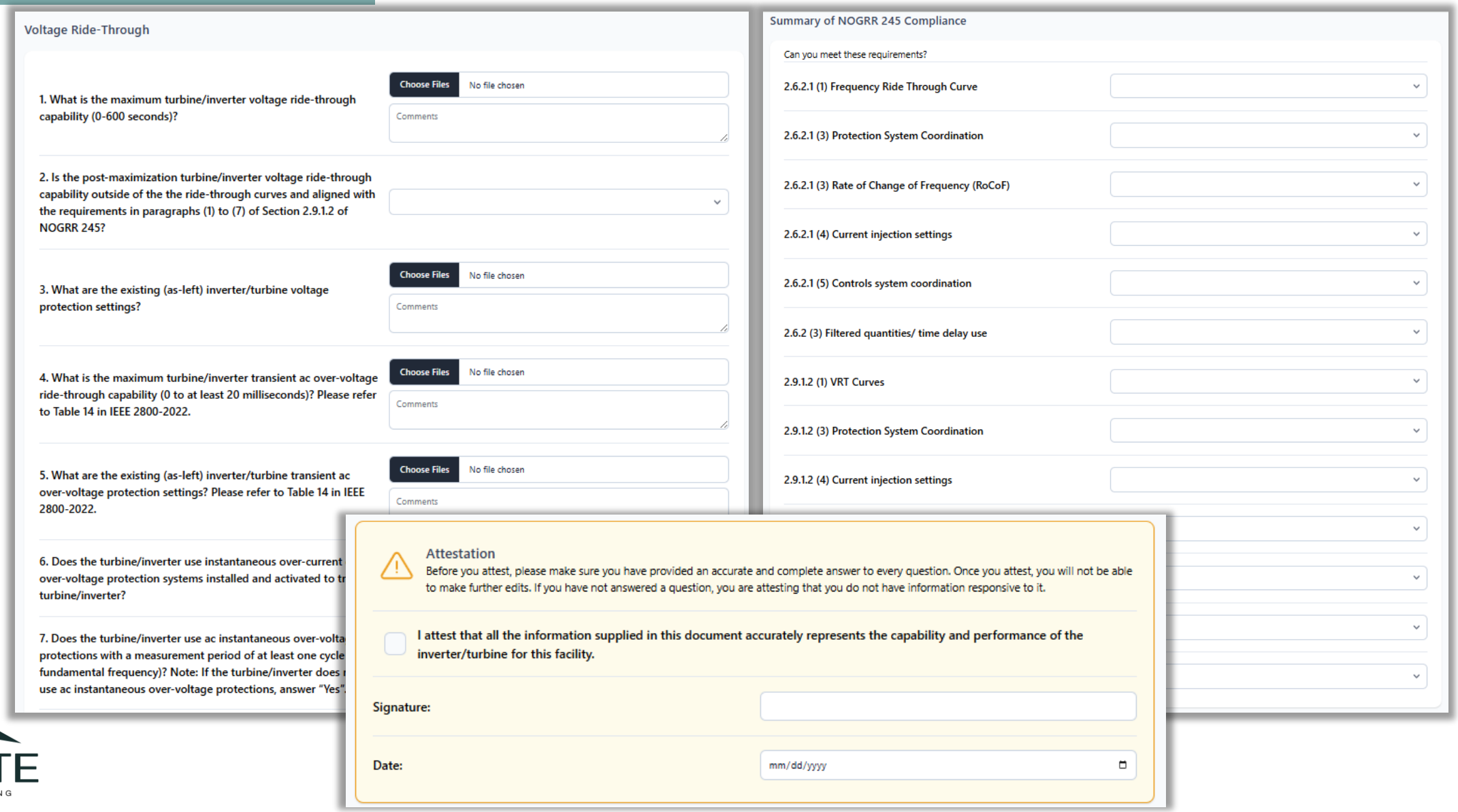
NOTE: This is not representative of all OEMs yet is a real illustrative example of the challenges faced which must be recognized.

Innovation and Streamlining



Coordination with OEMs

- OEMs largely resource constrained under system-wide requests
  - Different people within same OEM provided different answers to Resource Entities
  - “Bird’s eye view” across OEMs helped align responses and get consistent data
  - Handful of responses didn’t arrive until days before deadline
- Site-specific support not provided in some cases; generic letters fleet-wide by inverter type
- More information needs documented by default when delivering or modifying equipment
  - Compare relay manuals (1500 pages long) and inverter/turbine narratives (30 pages long).
- Verifying as-left parameters/settings is painful – rounds of clarifications and field checks
  - Why can’t this be like pulling .RDB files? Can we create .IBR files?
- Many IBR owners do not have access to IBR unit parameters of equipment they own
  - Why is Resource Entity responsible for attesting compliance when they have no access?
- ***Status quo needs to change globally; possible adverse effects on reliability***
  - *Aligns with key finding from recent NERC Alert Report on IBR Model Quality Deficiencies*

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Artificial Panacea

- OEMs have clearly documented IBR unit ride-through capabilities
- OEMs can quickly retrieve information and share with Resource Entities
- OEMs effectively identify and share as-left settings at the site
- IBR units shipped with maximized settings by default, based on equipment capability
- Balance of plant protection coordination studies based on equipment limitations, not requirement
- Balance of plant protection philosophy is standardized and settings justifications are clearly documented
- Simulation models are reflective of as-left settings and fundamental parameters are readily available in consistent format for Resource Entities (and consultants) to be able to identify and analyze

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~~Artificial Panacea~~ Reality

- OEMs have clearly docu d IBR unit ride-t h capabilities
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IN MANY CASES (***NOT ALL***), THIS IDEAL PERCEPTION IS NOT REFLECTIVE OF REALITY

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Standardized Framework

.IBR file

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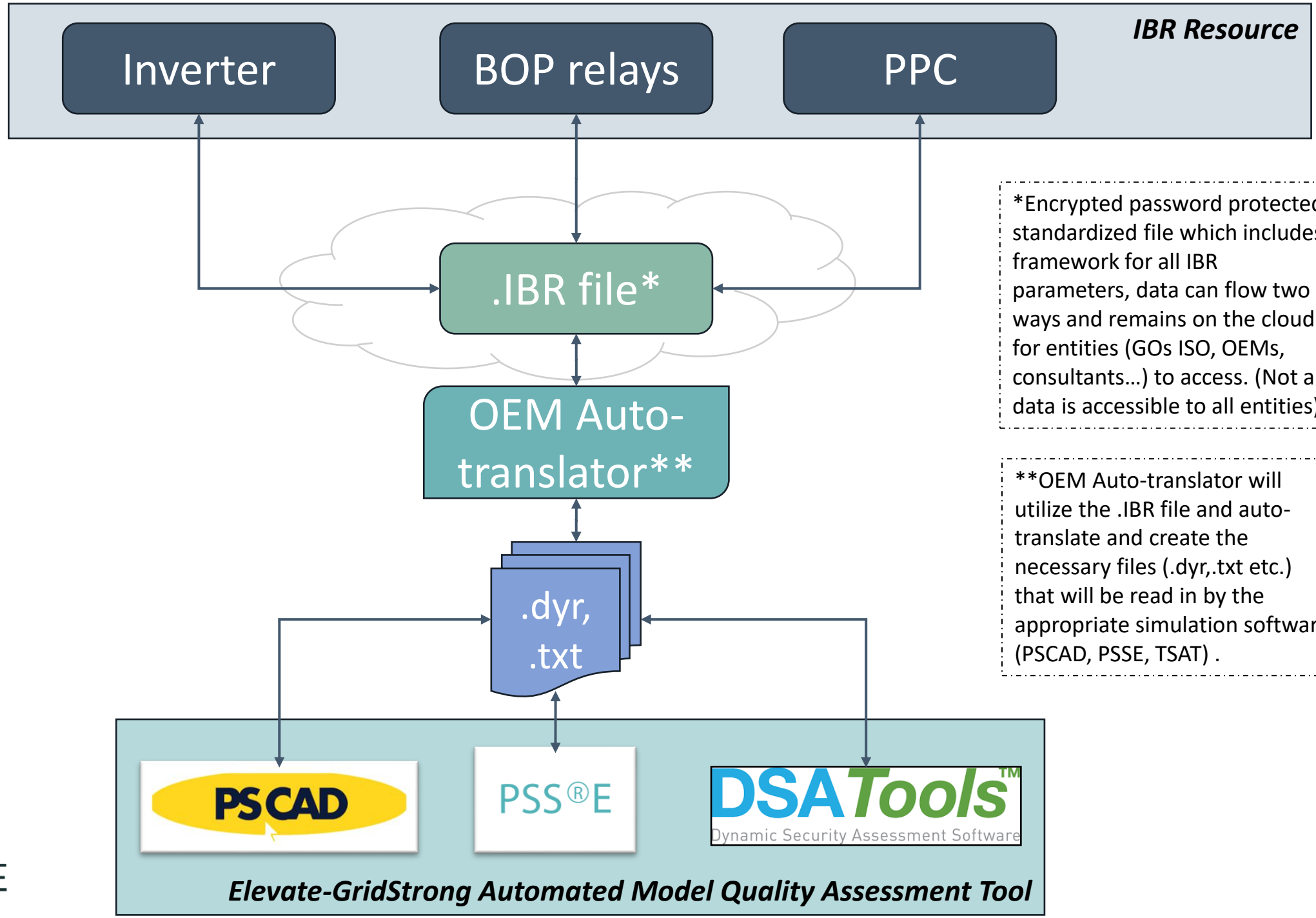

*Encrypted password protected standardized file which includes framework for all IBR parameters, data can flow two ways and remains on the cloud for entities (GOs ISO, OEMs, consultants…) to access. (Not all data is accessible to all entities)

**OEM Auto-translator will utilize the .IBR file and auto-translate and create the necessary files (.dyr,.txt etc.) that will be read in by the appropriate simulation software (PSCAD, PSSE, TSAT) .

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What NOGRR 245 with .IBR file?

- What would NOGRR 245 have been like with a standardized framework?
  - Pull latest .IBR file from cloud
  - Extract BOP + inverter protection settings and plot against curve requirements and maximum capability provided by OEM
    - ***Answers if the IBR resource is maximized***
  - OEMs supply indexes of parameters for ROCOF, anti-islanding, and phase jump settings to be extracted from .IBR file
    - ***Allows owner to know if these settings are enabled and can be disabled or set to max setting.***
  - As-left settings and compliance can be auto-filled from .IBR file to repository
- Special answers such as IEEE 2800 compliance, instantaneous measurements, etc., would still require intervention or shared to owner from an online form (e.g., GridStrong)

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Next Steps and Recommendations

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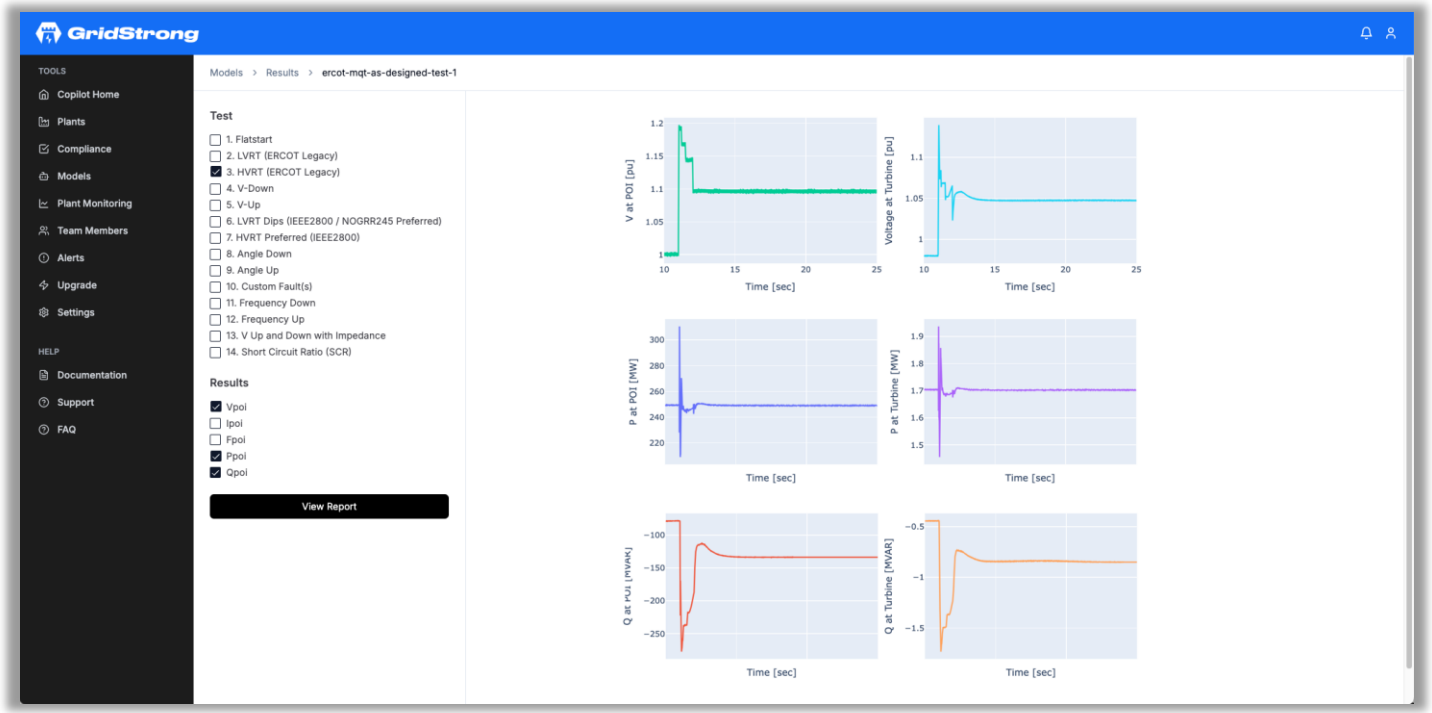
High-Level Recommendations

- Develop best practices for tracking and retaining various data sources
- Explore how a standardized framework for accessing IBR plant information, as described, could be implemented by (or required of) the OEMs
- Spot check or validate that requested info is available from OEMs ahead of large comprehensive RFIs
- Update NOGR Section 9 to address ambiguities and technical uncertainties
- More flowcharts, timeline recaps, etc., can help stakeholders understand expectations and process
- As recognized by all, DocuSign approach was painful – need more innovative software-forward approaches that enable streamlined submittal, collaboration, updates, etc.
- Think through RFI questions and goals of asking them. Don't mix "nice to have" with mandatory compliance.

Next Steps

- **Line up reported maximizations** – IBR unit, BOP relays, settings changes, etc.
- **Coordinate with OEMs, gather updated IBR models**
- **Update IBR plant models** and **follow PGRR 109 modeling process**
  - **Conduct MQTs** for proposed changes (majority of resources)
  - **Streamlined, efficient, and high-quality MQTs** to minimize back-and-forth will be critical
- Submit for **ERCOT approval**, then implement
- **Update ERCOT as changes made** according to NOGRR 245 rules
  - Awaiting ERCOT reviews of extensions and exemptions
- **<u>Be proactive; start early!</u>**



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Other Issues

- Many IEEE 2800 capabilities relatively unknown by OEMs for legacy assets
- Mixing questions in RFI that were informative and requirements/obligations created uncertainties and concerns
- Some RFI questions were unclear or oversimplified
  - E.g., IEEE 2800 – current blocking, maximizing response time, etc.
- Situations where answers from ERCOT differed between OEM and Resource Entity
- Extension and exemption processes, and supporting documentation had issues (e.g., OEM letters for extensions)
- Putting information gathering on each Resource Entity where the singular source of data comes from 6-8 OEM organizations is fraught with error and inefficiency

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