Pterra
CONSULTING

MODEL QUALITY TEST & BENCHMARKING STUDIES for INVERTER-BASED RESOURCES

Innovation
Independence
Leadership

Overview

As inverter-based resources (IBRs) such as solar PV, battery energy storage systems (BESS), and wind plants continue to become dominant contributors to grid operation, their behavior should be accurately represented in power system studies.

ENERGY RESOURCES

Sync. Generators (coal, gas)	IBRs (solar, BESS, wind)
Well-understood for over 100 years.	Governed by computer logic and IP-protected control.

Model Quality Tests (MQT) and Benchmarking studies helps system planners and operation engineers to understand the behavior of the inverters to ensure that the desired response is achieved.

Power System Revolution

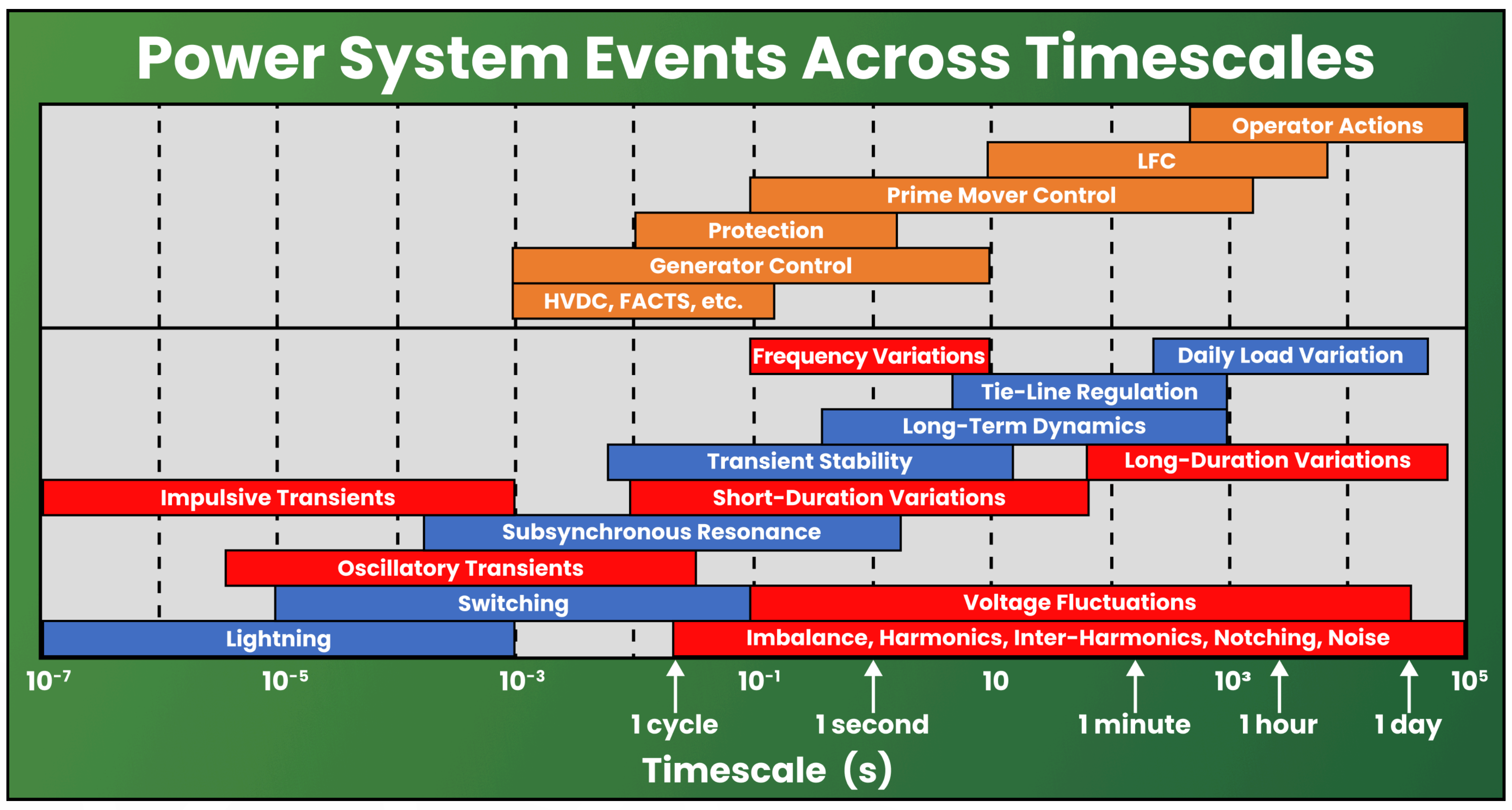
IBRs Characteristics

IBRs are governed by fast software-based controls, increasing response time during disturbances

Impacts on Power Systems

Reduced system strength, larger frequency deviations, higher rate of change of frequency, and less robust system voltages

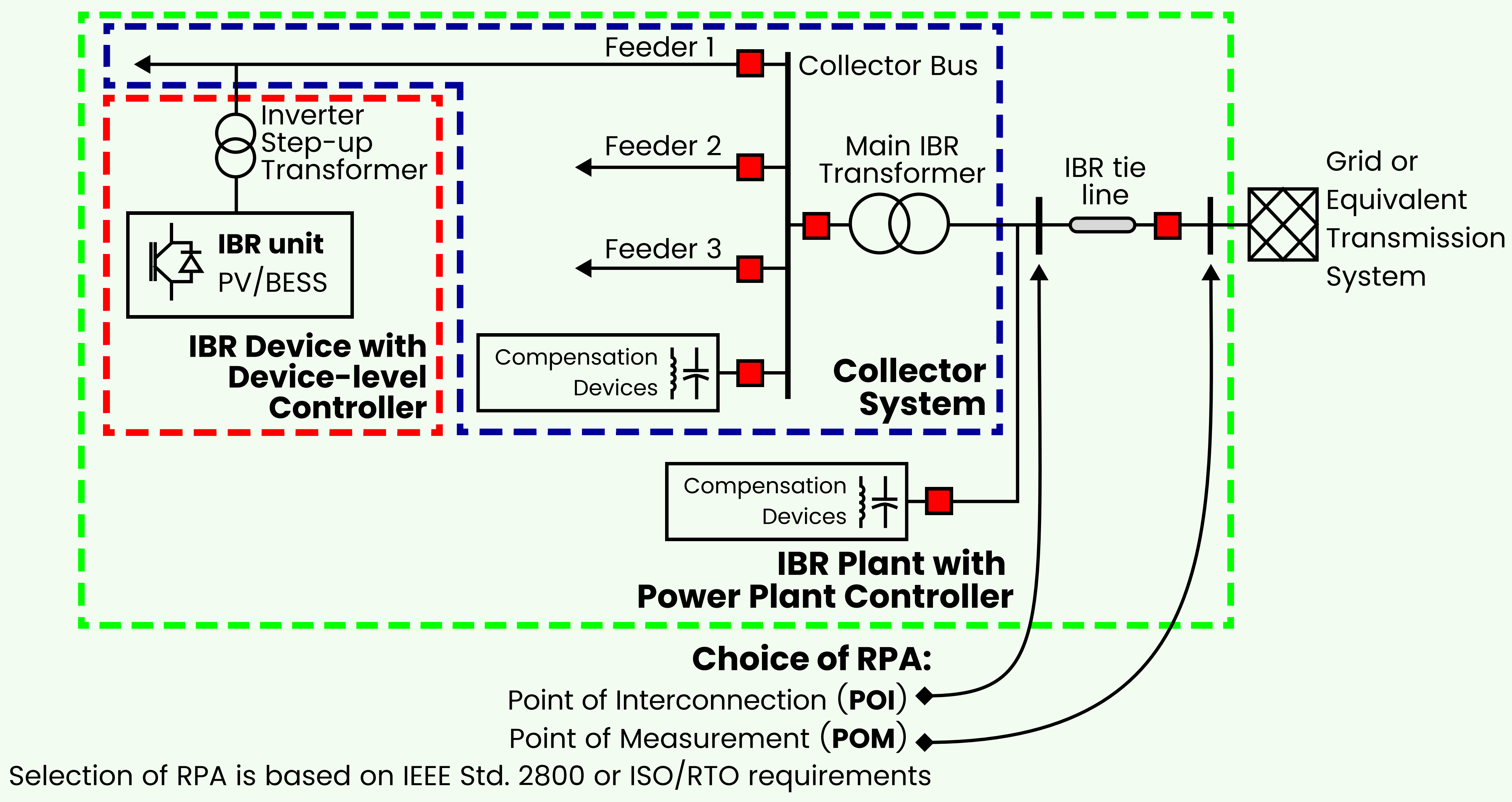
Power System Events Across Timescales



MQT and benchmarking studies provide confidence that IBR models represented in Phasor and EMT domains behave consistently with each other and the manufacturer-validated performance. Completed MQT and Benchmarking studies oftentimes are pre-requisite prior or after grid interconnection, including:

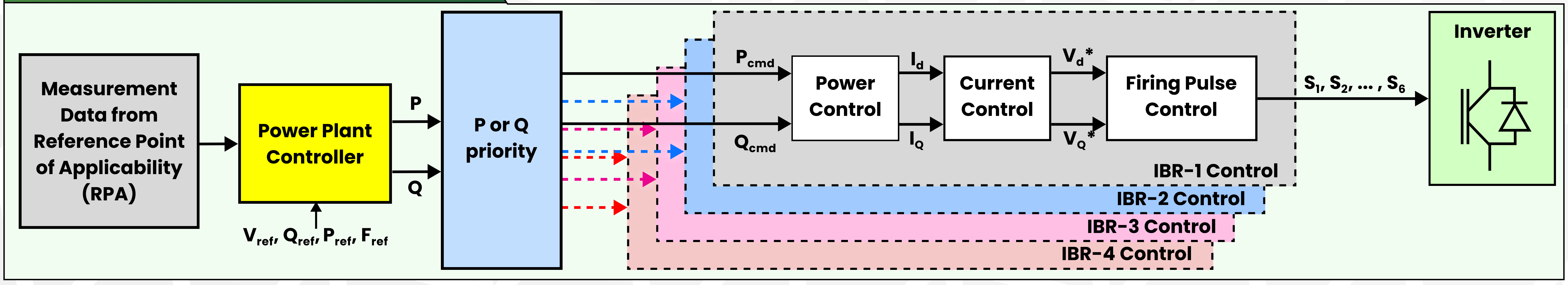
- Interconnection/impact studies
- EMT and phasor model validation
- Verification of plant-level and device-level `
- Support for NERC MOD, PRC, and ISO-specific requirements
- Model integration with online dynamic security assessment tools

Typical Layout of an IBR Plant



Selection of RPA is based on IEEE Std. 2800 or ISO/RTO requirements

Inverter Control Structure



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Typical Scope of Work of MQT and Benchmarking Studies

1

EMT MODELS

Securing inverter and plant controller EMT models and signing off confidentiality agreements.

2

DATA COLLECTION

Obtaining and reviewing Balance of Plant (BOP) system data.

3

MODEL BUILDING

Combining all information to form the model, then representing and applying site-specific parameters and controls.

4

BENCHMARKING

Comparing response of a model to another model or to response of the actual equipment.

Model Testing and Evaluation

Standardized tests are performed to confirm that plant responses follow the desired criteria:

IEEE Std. 1547-2018

IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

IEEE Std. 2800-2022

IEEE Standard for Interconnection and Interoperability of IBRs Interconnecting with Associated Transmission Electric Power Systems

Standards by ISOs or Utilities

Specific standards by ISO/RTOs or utilities for IBRs interconnection, including phasor domain and EMT models requirements.

Pterra have performed and supported IBR MQT for following ISO/utilities:

ISO new england · ercot · MISO · pjm · EVERSOURCE · nationalgrid · New York ISO Independent System Operator · Hawaiian Electric

Typical test to confirm IBR response:

- Active and reactive power control response.
- Ride-through performance (LVRT, HVRT, FRT).
- Voltage and frequency step response.
- Balanced and unbalanced faults.
- Initialization and flat-run.

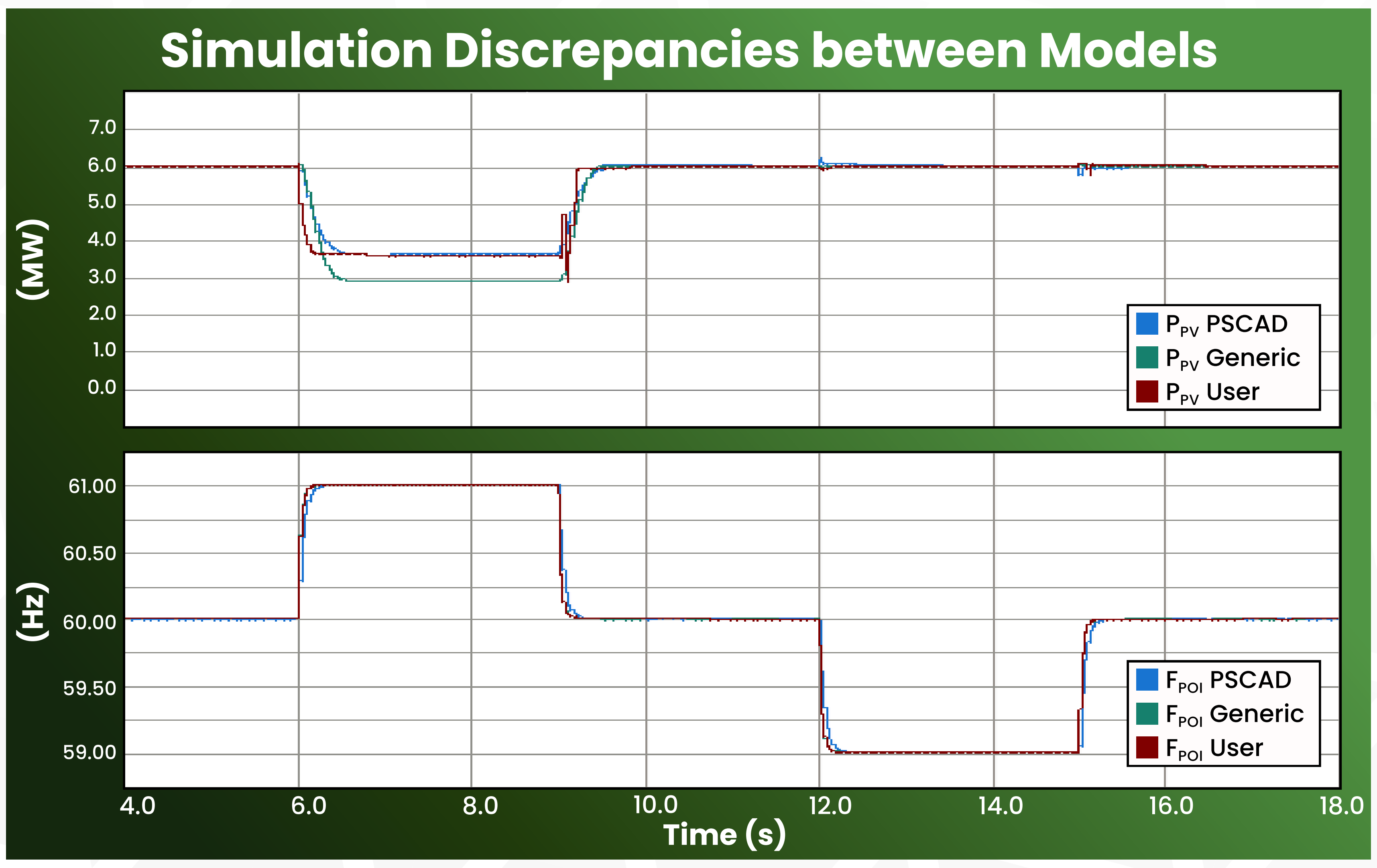
Pterra developed in-house modeling and benchmarking tool in PSS/E and PSCAD which are tailored to follow ISO-specific MQTs. Modeling tools and templates (e.g. ERCOT DMView and PMView) are also used to achieve accurate model submission and documentation.

Benchmarking Evaluation

Discrepancy between Phasor and EMT models often arise during benchmarking due to inherent difference between the way models are represented on the two types of simulation platforms.

Pterra combines **quantitative** and **qualitative** approach to evaluate benchmarking results coupled with sound understanding of software capabilities and limitations to arrive at correct conclusions.

Simulation Discrepancies between Models



Quantitative Evaluation

Simulation results are evaluated using standardized metric for acceptable errors. Currently, no single metric is available yet in the industry.

Qualitative Evaluation

Simulation results are evaluated through visual inspection. Prone to subjective judgements and lead to variance in acceptable performance.

Conclusion

At Pterra, we ensure that the models developed complies with the requirements, supports bulk power system reliability and de-risks projects against longer downtimes and additional costs.

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