

GRID EMT

SIMULATION INITIATIVE

SPP Model Requirements & Needs for large loads

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Who is SPP

501(c)(6) nonprofit corporation

One of 9 regional grid operators

147 member companies in 17 states

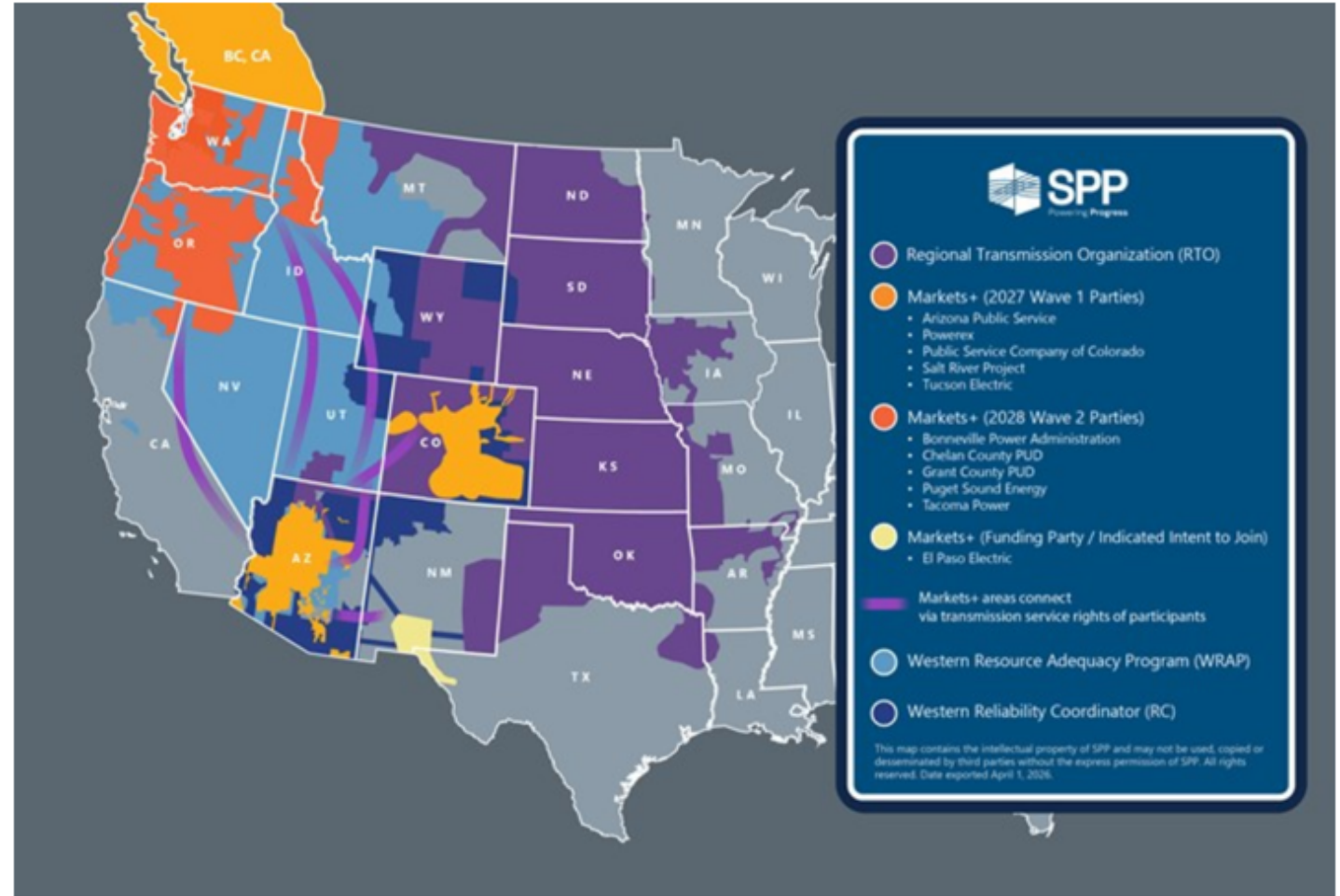
“Air traffic control” for high-voltage grid

Balance supply and demand across region

Maintain reliable grid operations

Operate wholesale energy market

Plan future transmission needs



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Motivation

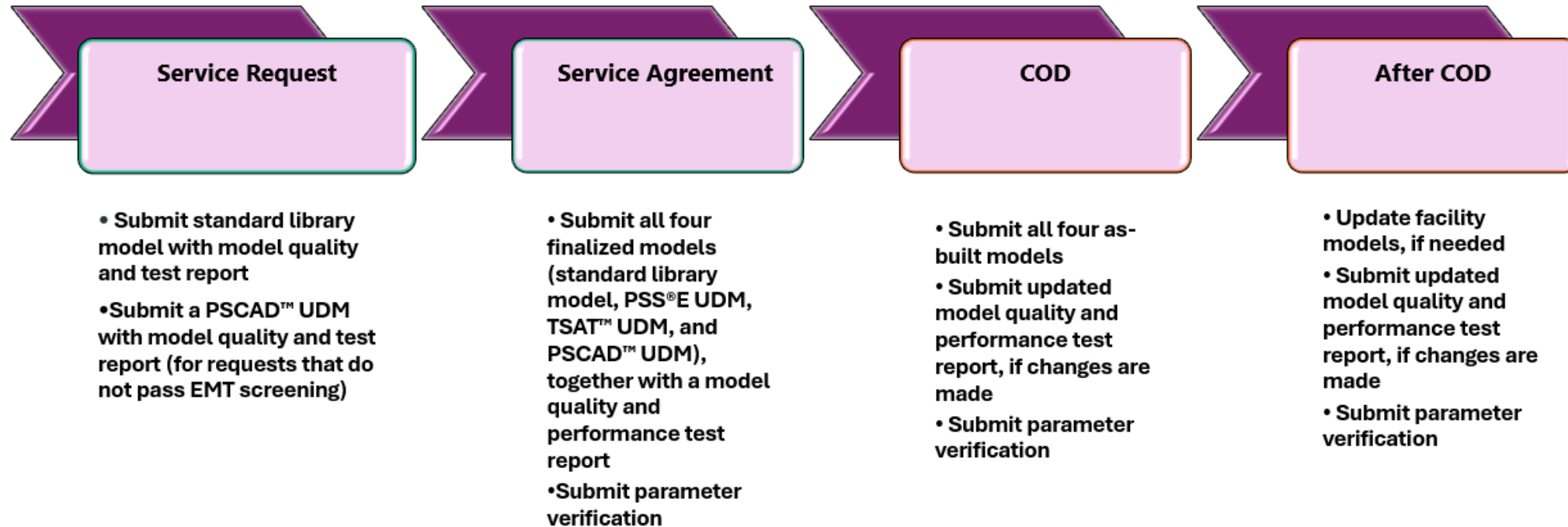
- **Why Is SPP Developing Large Load Modeling Requirements?**
 - Rapid growth of AI data centers and other large loads.
 - Existing models do not adequately capture large load dynamic and EMT behavior
 - Improve the accuracy of planning, interconnection, and reliability studies.
 - Assess interactions between large loads, generation plants (IBRs), and the transmission system.
 - Establish standardized modeling requirements across SPP.
- **What Is the Implementation Timeline?**
 - **Q4 2026:** SPP stakeholder approval.
 - **Before April 1, 2027:** Target FERC approval and implementation.



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Process Flow Diagram for SPP Large Load Modelling Req.



This process is currently under stakeholder review and has not yet been approved by SPP stakeholders.



Model Evaluation

- **Model Verification:** Confirm components models accurately represent planned/installed equipment and settings, supported by OEM attestations, firmware-to-model mapping, or documentation of control/protection parameters.
- **Model Validation:** Demonstrate that facility models reasonably reproduce expected equipment behavior under representative disturbances using OEM data, factory/commissioning tests, HIL testing, or field measurements.

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Model Quality Tests for Large Loads

- **Model Initialization Testing:**
 - A model passes validation if the PSS[®]E, TSAT[™], PSCAD[™], and other required software models initialize successfully, PSCAD[™] reaches steady state within 5 seconds, simulations remain stable, results are consistent across platforms, and no unacceptable warnings or errors are present.
- **Large Load Sub synchronous Test:**
 - Performs a frequency scan from 5 to 55 Hz (1 Hz increments) by applying a small voltage perturbation and measuring the converter's sub-synchronous impedance. Results shall be provided as plots and tables of resistance and reactance (ohms), along with the device rating and operating voltage.

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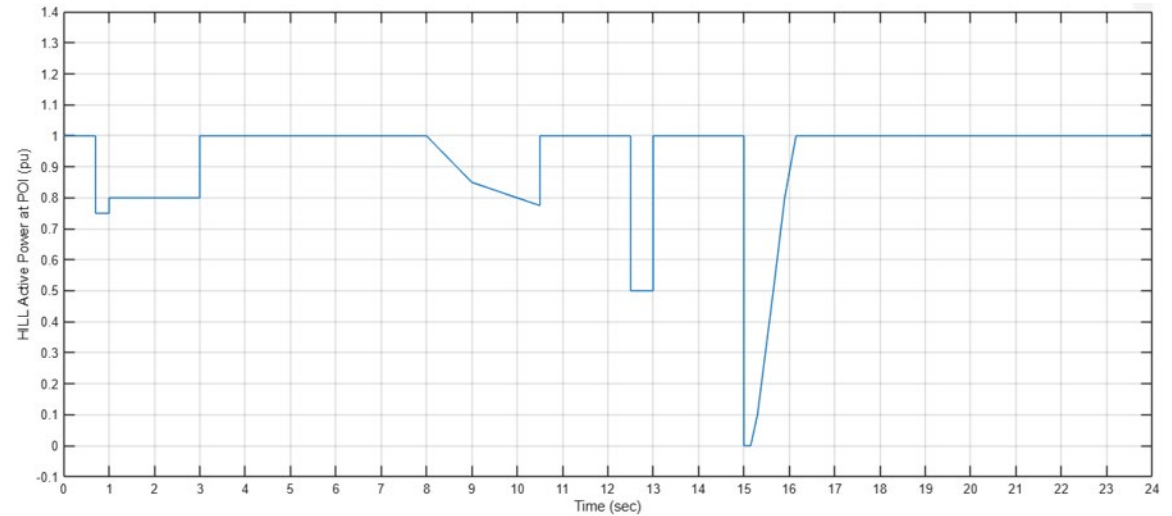
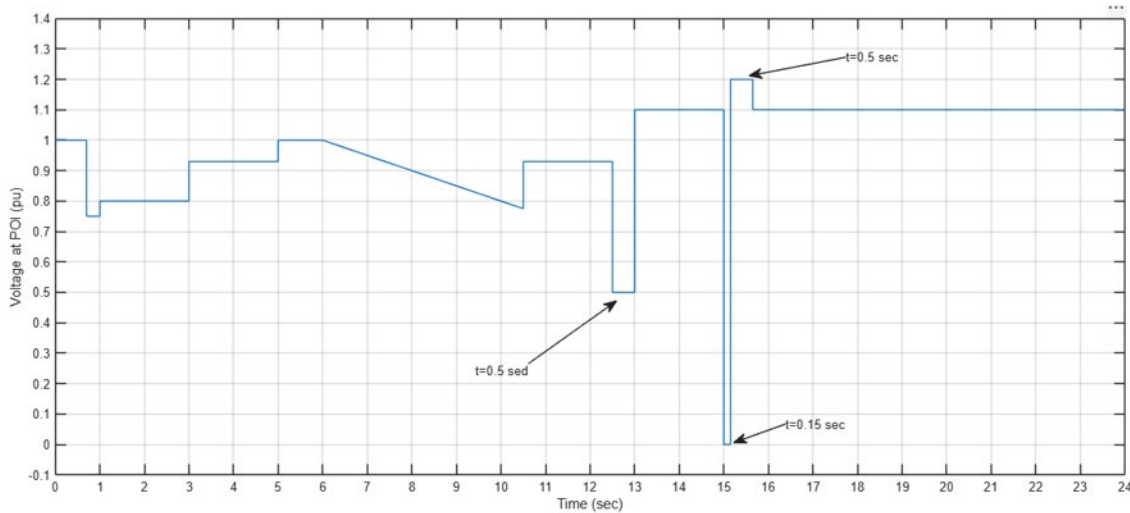


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Model Quality Tests for Large Loads (Cont.)

- Large Load Voltage Ride Through Test:



- Large load shall maintain pre-disturbance power consumption for 0.9–1.1 pu voltage and 1.1–1.2 pu for up to 0.5 seconds. For 0.5–0.9 pu voltage, large load may reduce consumption proportional to voltage but shall return to 90% consumption within 1 second after POI voltage recovers above 0.90 pu, unless exempted per the SPP HILL Ride Through Requirements Manual.
- **Consecutive voltage ride through:** at least 6 attempts in 90 seconds.

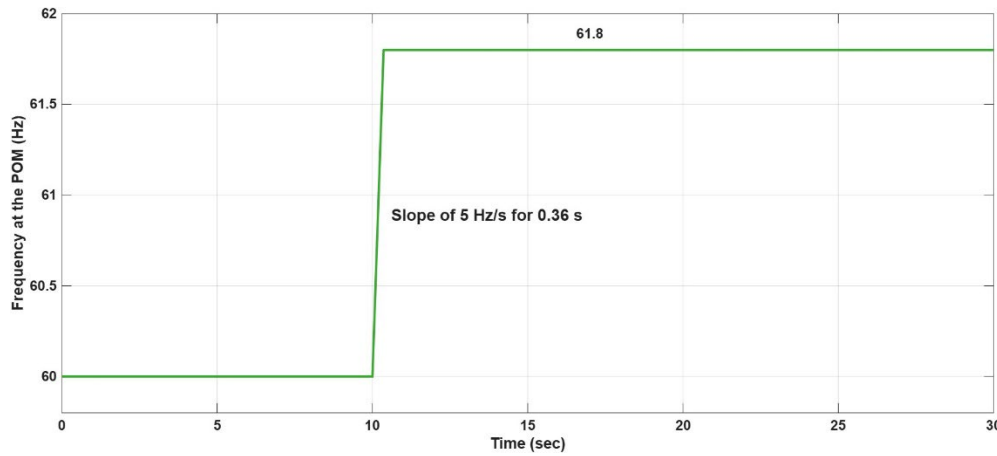


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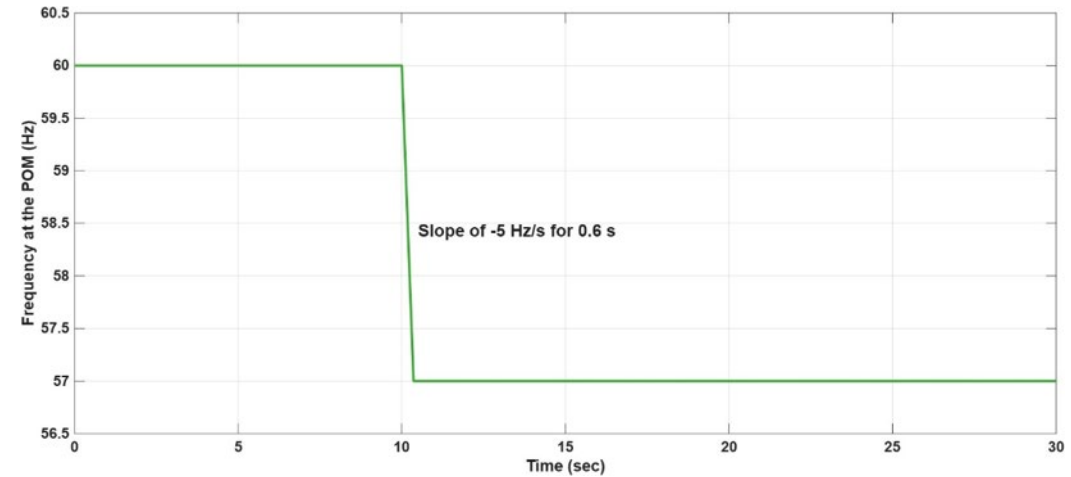
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Model Quality Tests for Large Loads (Cont.)

- Large Load Frequency Ride Through & ROCOF Tests:



HFRT test



LFRT test

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Model Quality Tests for Large Loads (Cont.)

- **Phase Angle Jump Tests (only for EMT models):**
- **Disturbance**
Execute the simulation for 30 seconds. At $t = 10$ seconds, introduce a phase angle shift of ± 25 degrees in the positive-sequence voltage of the system, then continue the simulation until $t = 30$ seconds.
- **Pass/Fail:** The facility remains connected and maintains a stable, well-damped response, with a damping ratio of 0.3 or higher.

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Challenges

- **Vendor/model variability:** Large load characteristics can vary significantly depending on facility type, controls, and operating modes; therefore, a one-size-fits-all model validation approach may require flexibility.
- **Data availability challenge:** Obtaining sufficient field measurements or manufacturer test data may be challenging, especially for new technologies without operational history.



Conclusions/Next Steps

- **Benefits of Large Load Model Quality Test Process for SPP:**
 - **Improved model confidence:** Ensures accurate large load representation in studies.
 - **Consistent evaluation:** Provides clear test criteria and acceptance requirements.
 - **Better coordination:** Requires early engagement with customers and OEMs.
 - **Continuous improvement:** Test requirements can evolve with operating experience.
- **Future Work:**
 - **Refine requirements:** Update test procedures based on project experience and operational data.



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