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NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

NERC Inverter-Based Resource (IBR) Webinar Seven:

Session 7: Studies – EMT, Special Studies, Interconnection Studies

June 27, 2023

EMT Studies

June 27, 2023

Presented by Andrew L. Isaacs

ELECTRANIX

SPECIALISTS IN POWER SYSTEM STUDIES

Why do we need EMT?

- Simply... to obtain the accuracy needed in our studies to design our power grid reliably.
 - Some phenomena are difficult or impossible to predict using traditional Phasor Domain (PD) tools.
 - The **transition to inverter based generation** is challenging our ability to predict outcomes.
- **Events are reinforcing the need for advanced studies and tools!!**
- **Using EMT, we are catching issues before projects go in service every day!**

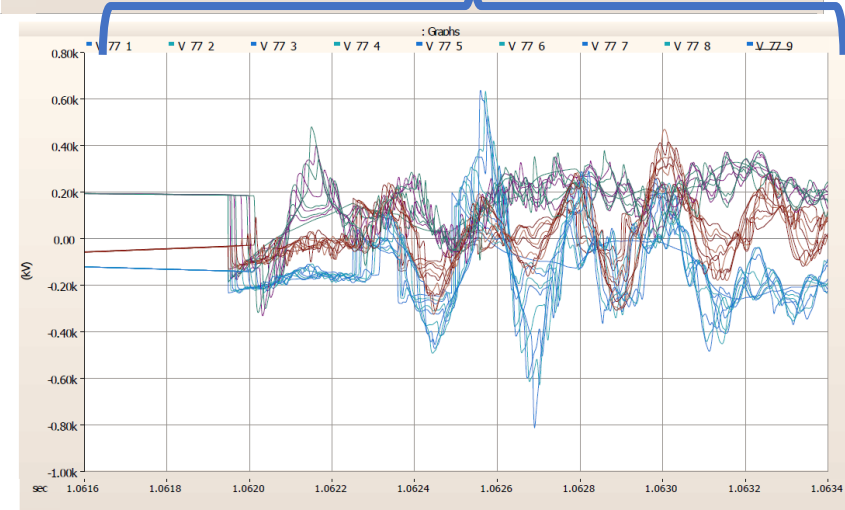
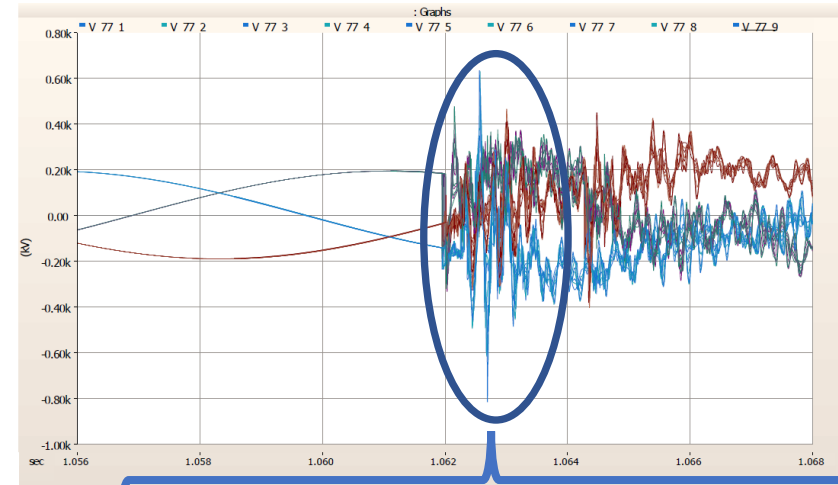
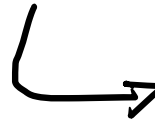
Note:

- We don't always need EMT!! But when we do need it, we need to have the tools, models, and expertise ready.
- EMT supplements and adds to our existing tools and processes. It generally doesn't replace them.

Classical Transient Studies – Last 50 years!

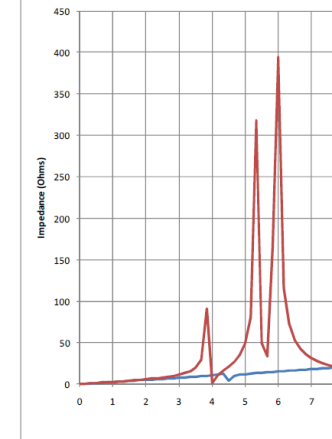
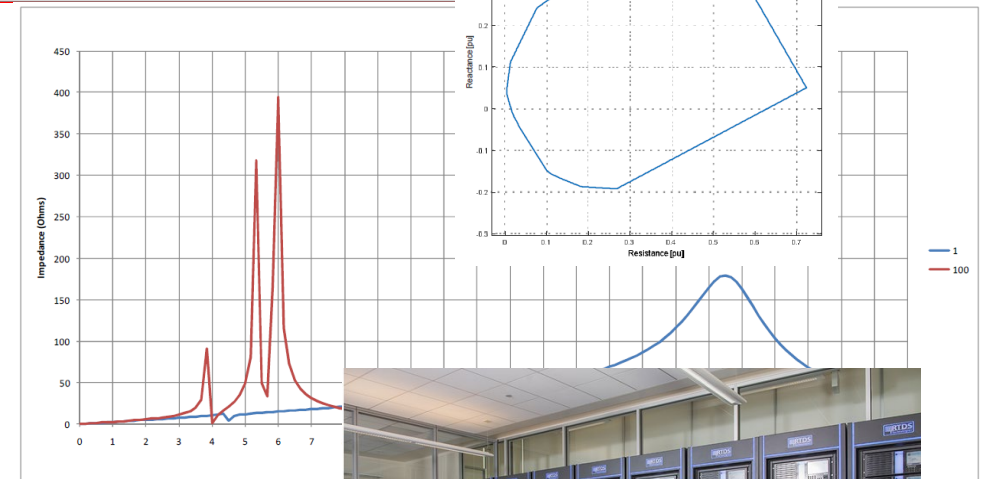
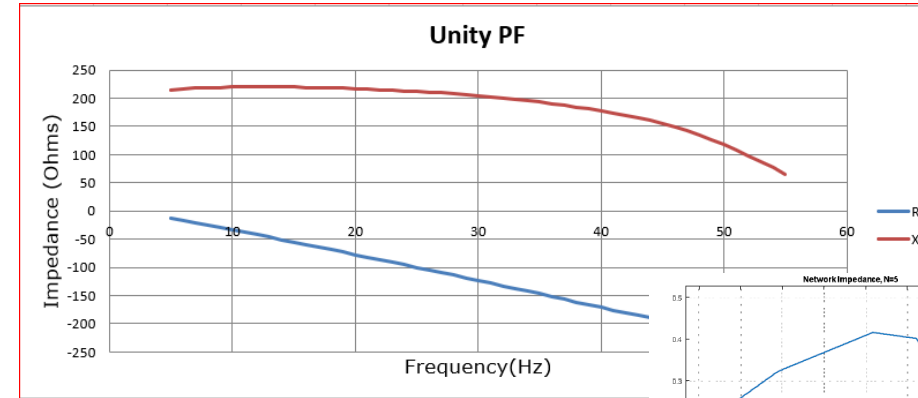
- Sub-categories
 - Lightning
 - TOV, TRV, IRRV
 - Line/Transformer/device switching, fault transients
 - Insulation coordination or design
- What kind of model is used?
 - Generally high bandwidth (in some cases *very* high bandwidth)
 - IBR models often simplified or neglected
 - Extent of system model is generally limited. Can be run using “ordinary” computers

Capacitor
breaker re-strike



Special Studies

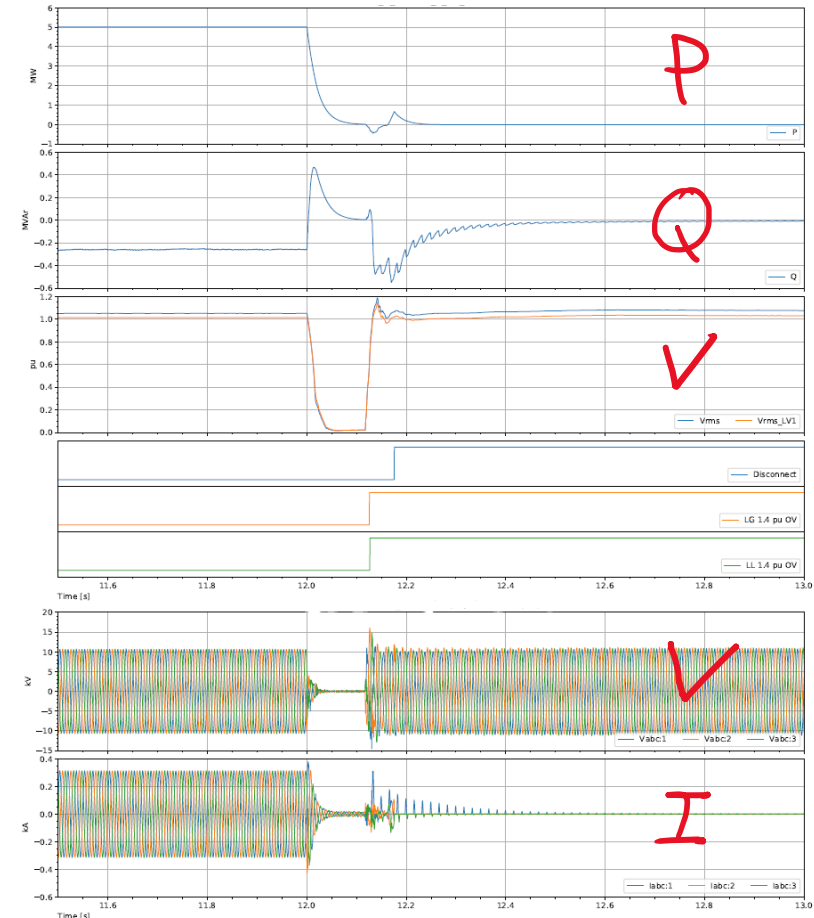
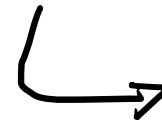
- Sub-categories
 - Protection (validating or checking detailed fault current behaviour)
 - Control design (tuning or designing complex control algorithms)
 - Harmonic analysis (evaluating harmonic performance or system characteristics)
 - Real-time simulation (testing hardware against simulated networks)
- What kind of model is used?
 - These study model assumptions are centered around the specific need.



Dynamic Performance Studies – not new but... New focus driven by energy transition!

- Sub-categories
 - Control interactions
 - Sub-synchronous oscillations
 - Weak grid performance evaluation
 - Fault ride-through evaluation
 - Performance capability verification according to standards
 - Event replication or analysis
- What kind of model is used?
 - Varying, but may be extensive, requiring large sections of power system to be modelled. May require unusually powerful computers.
 - Overlaps or supplements with conventional planning Phasor Domain studies

IBR Ride-through failure



Dynamic performance EMT models can be very large! For example...

Note, boldface indicates studies which require very powerful computers to run. Remaining computers need “ordinary” powerful computers (eg. 16-32 Cores), and benefit from more power. These models are all used in routine studies.

- SW Wisconsin: 247 busses, 17 detailed models, ZIP and CLOD loads
- **Electranet detailed model: 862 busses, 45 detailed models, simple loads**
- **AEMO NEM: 3700 busses, 140 detailed models, ZIP loads**
- **Oahu Island: 271 busses, 190 detailed models, simple loads**
- ERCOT Valley Region SSCI: 500 busses, 15 detailed models, ZIP loads
- **ISONE Western Mass. DER Cluster: 485 busses, 94 detailed models, ZIP loads**
- ISONE routine interconnection study: 300 busses, 10 detailed models, ZIP loads

For reference: Eastern Interconnect transient stability case has approximately 84,000 busses, 7,600 plants (mostly not including DER), 44,000 loads...

New focus on EMT as our grid changes ...requires renewed focus on IBR modelling

- IBR Model requirements must include:
 - **Accuracy**: Is it detailed and correct? Validated?
 - **Usability**: Does it function within a study context?
 - **Site-specific**: Does it represent the equipment being used?
 - **Performance**: Is the plant likely to conform with basic performance needs for the system? (Note that usually a full study is the final arbiter of “acceptable performance”)
- System models and study processes are relatively mature, but also must advance!

Key messages!

- Although EMT is not new, the **renewable transition is driving a wave of new requirements for EMT studies** to keep the grid reliable.
- EMT models need to be detailed and correct, or the studies become much less useful.
- EMT models are a fact of life in our future!
 - Invest in simulation hardware and software
 - Invest in people
 - Invest in knowledge
 - Get started on processes
 - Start collecting models immediately if you haven't already

Questions?

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Questions and Answers After All Presentations



Overview of FPL's IBR Special Studies

NERC Inverter-Based Resources Webinar Series

Andrew Arana – Director of Transmission Planning, Real Zero

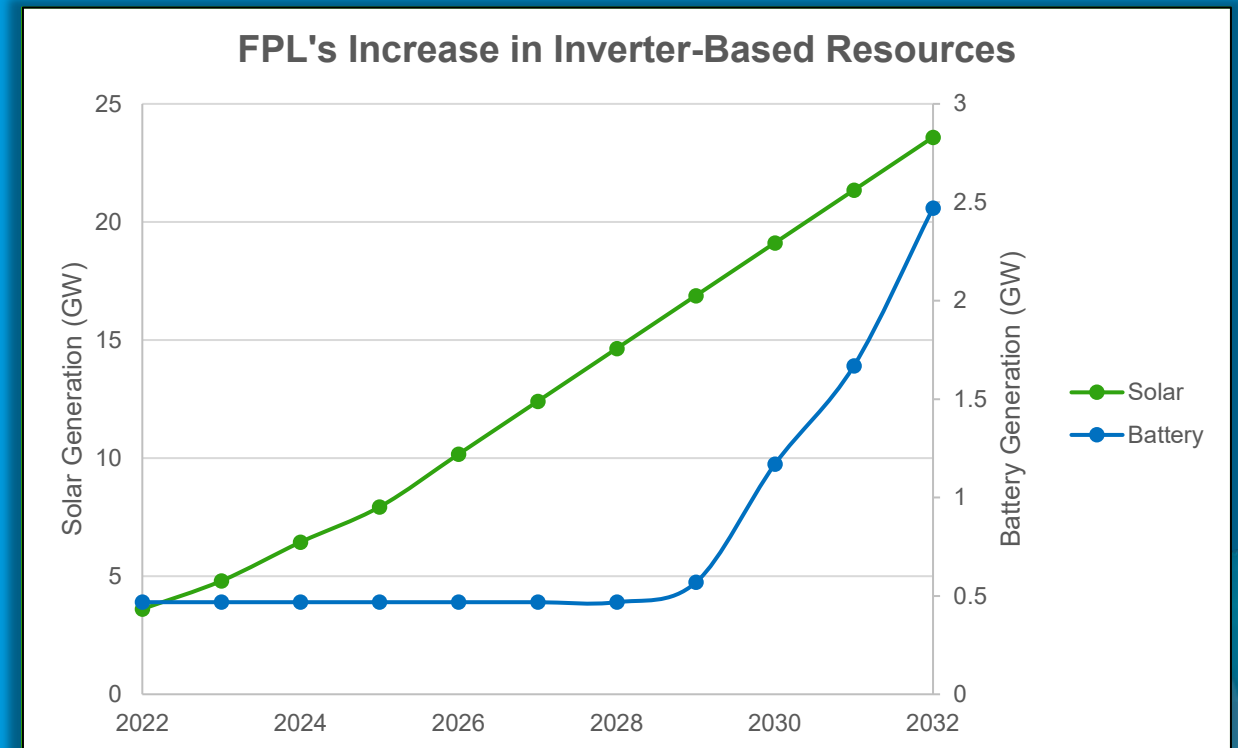
Power Delivery, Florida Power & Light Company

June 27, 2023

Detailed studies are required to ensure that inverter-based resources (IBR) are integrated reliably and cost-effectively

FPL's Decarbonization Opportunity

- ▶ FPL plans to integrate 20GW of solar and 2GW of batteries
- ▶ Solar plants are being sited in more remote areas
- ▶ New T&D devices and increased electrification also presents potential challenges
- ▶ Implementation of NERC recommendations



Special studies address phenomena that are not addressed by interconnection studies and annual planning assessments

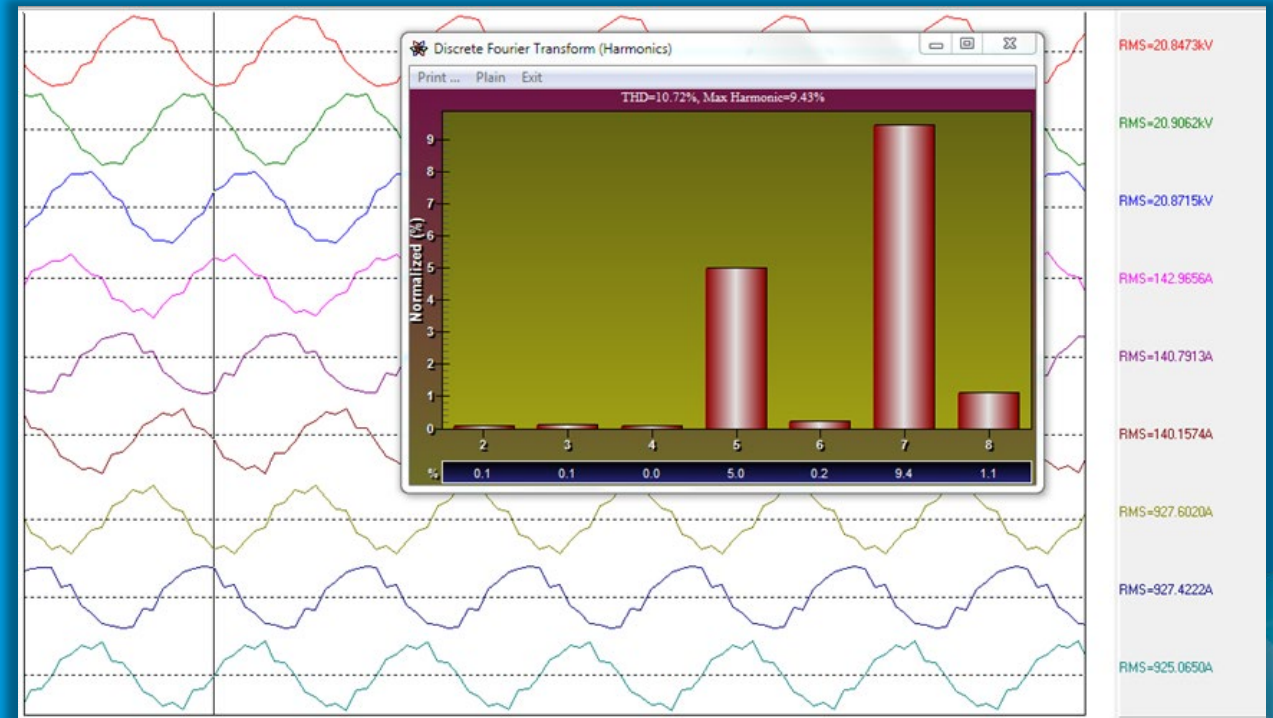
The Need for IBR Special Studies

- ▶ **Interconnection processes require EMT analysis when $WSCR < 3$ or if there is an elevated risk of controller interactions**
- ▶ **Recreation of power quality issues or reliability events**
 - » We need to be able to model these issues to get ahead of them
- ▶ **Changes to facility interconnection requirements**
- ▶ **Development of novel solutions**
- ▶ **Settings modifications to existing plants and protection and control systems**
 - » Impacts of lower system inertia and fault currents

Harmonics and flickers occurred near a newly commissioned PV plant when a transmission line was taken out of service for maintenance

Power Quality Impacts at FPL PV Sites

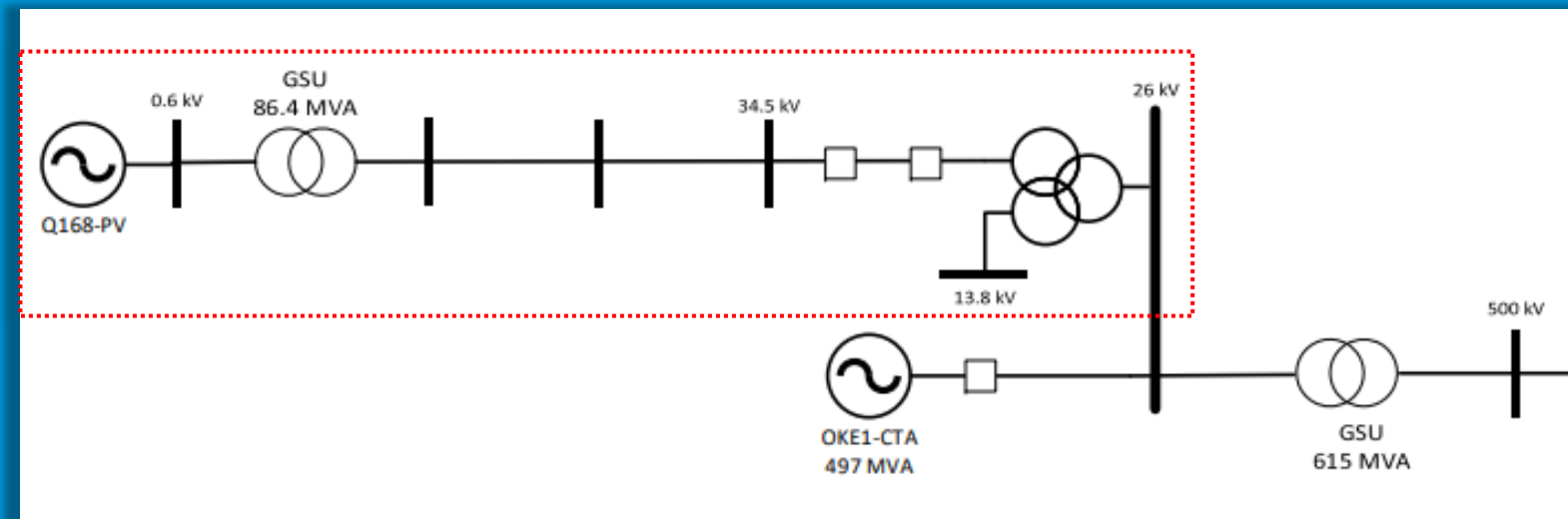
- ▶ All performance events must be investigated
- ▶ This phenomena can be modeled in offline studies
- ▶ Tools were implemented to identify this event in real time



Planning studies were used to recreate this event and develop both operating mitigations and design changes to prevent future occurrences

Review the dynamic performance and interactions of proposed PV plants with the existing combined cycle plant

Assess Risks to Nearby Synchronous Generators



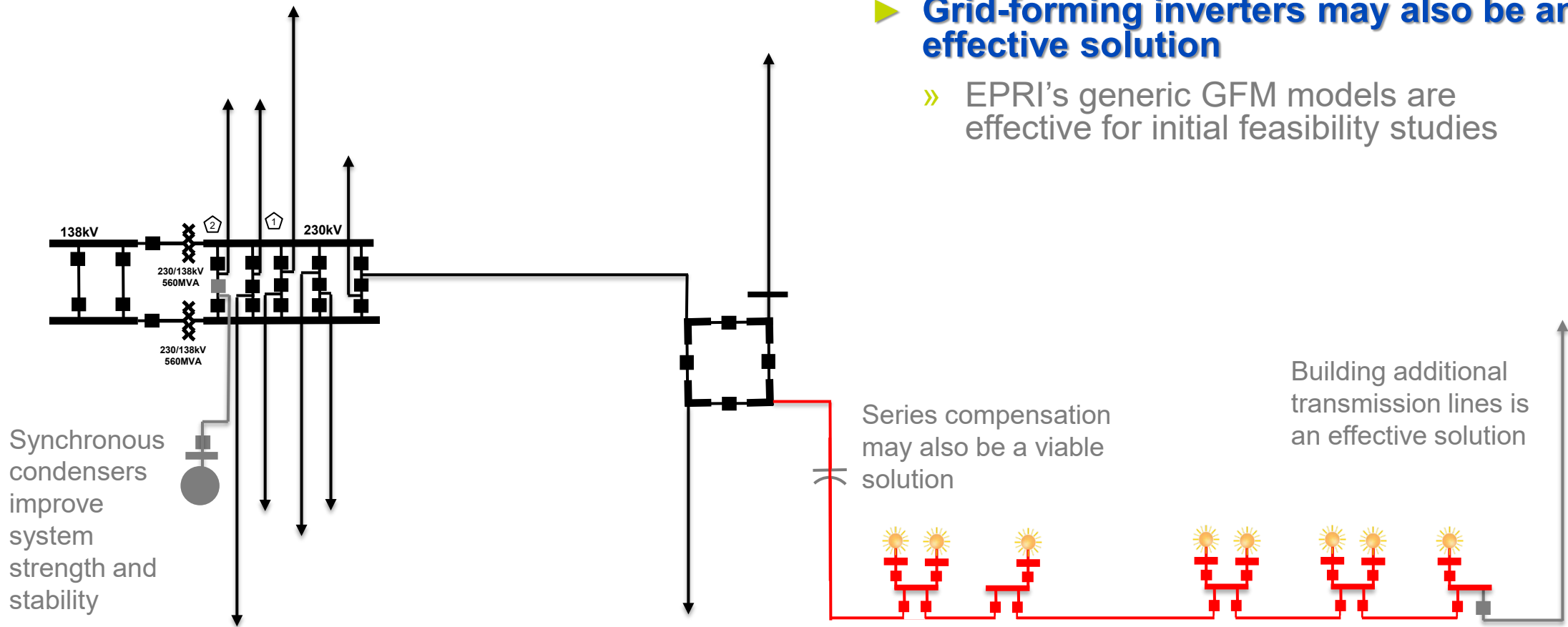
- ▶ PSCAD and PSSE inverter model benchmarking
- ▶ PSSE and PSCAD dynamic performance analysis
- ▶ Sub-synchronous torsional interaction (SSTI) analysis

Special studies are required to evaluate novel solutions to IBR performance challenges

Solar on Long Radial Transmission Lines

► **Grid-forming inverters may also be an effective solution**

- » EPRI's generic GFM models are effective for initial feasibility studies



Questions?

A map of North America, including the United States, Canada, and Mexico, is shown in a light blue color. A darker blue gradient overlay covers the central and eastern parts of the map, where the title text is located.

Questions and Answers After All Presentations

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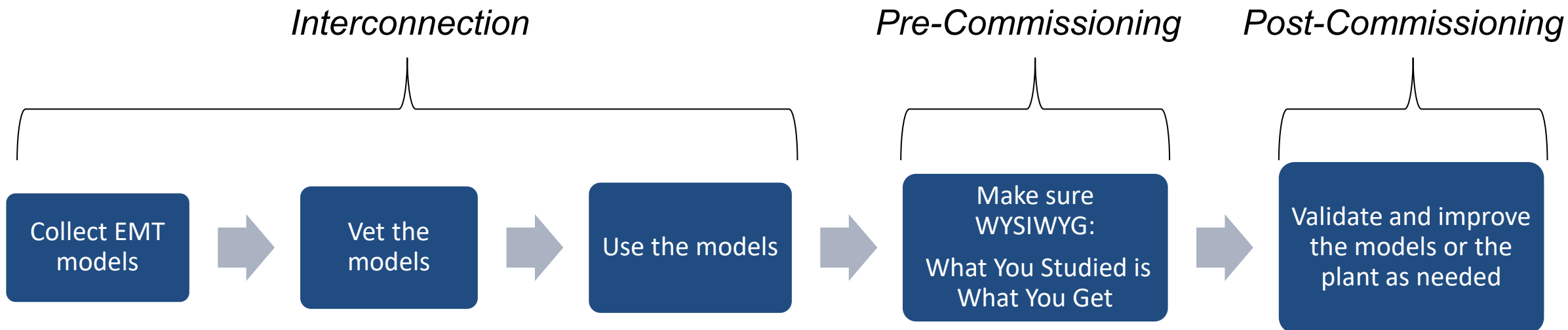
Reliability Guideline

Electromagnetic Transient Modeling for BPS-Connected Inverter-Based Resources
— Recommended Model Requirements and Verification Practices

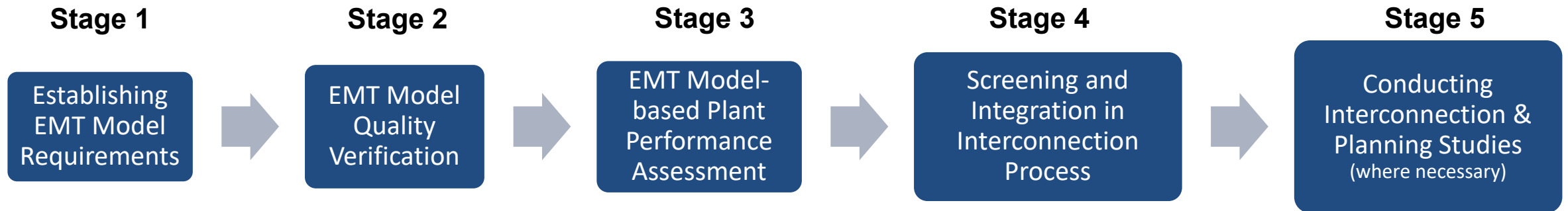
Aung Thant, Senior Engineer, NERC EMTTF Coordinator

IBR Webinar Series – Session 7

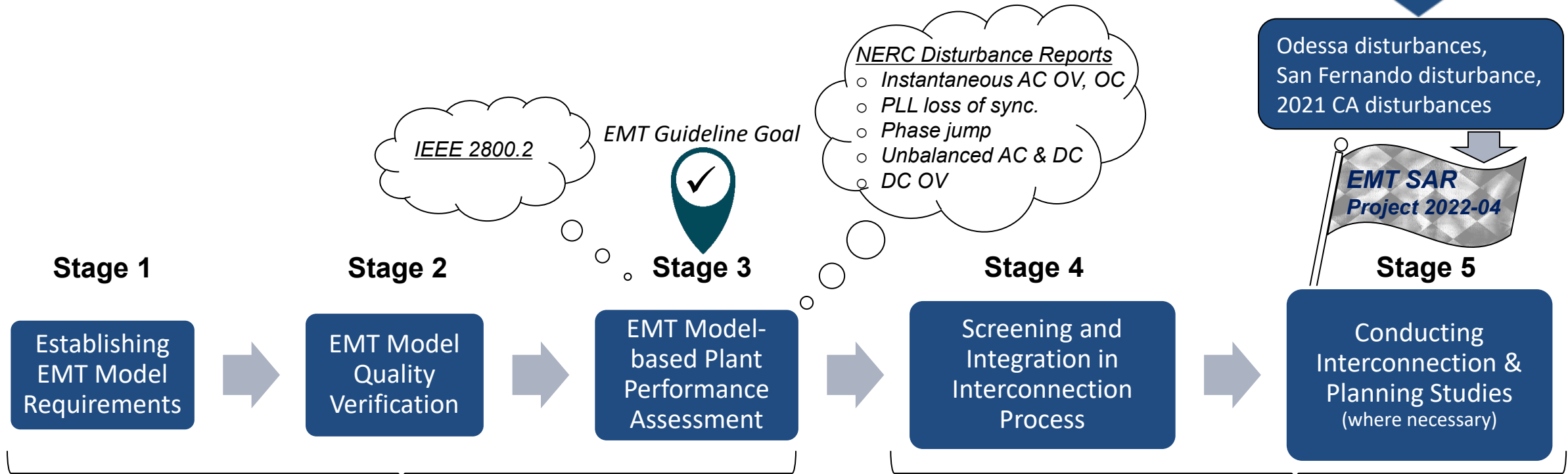
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EMT Modeling Adoption Visualized in Stages



EMT Modeling Adoption Visualized in Stages

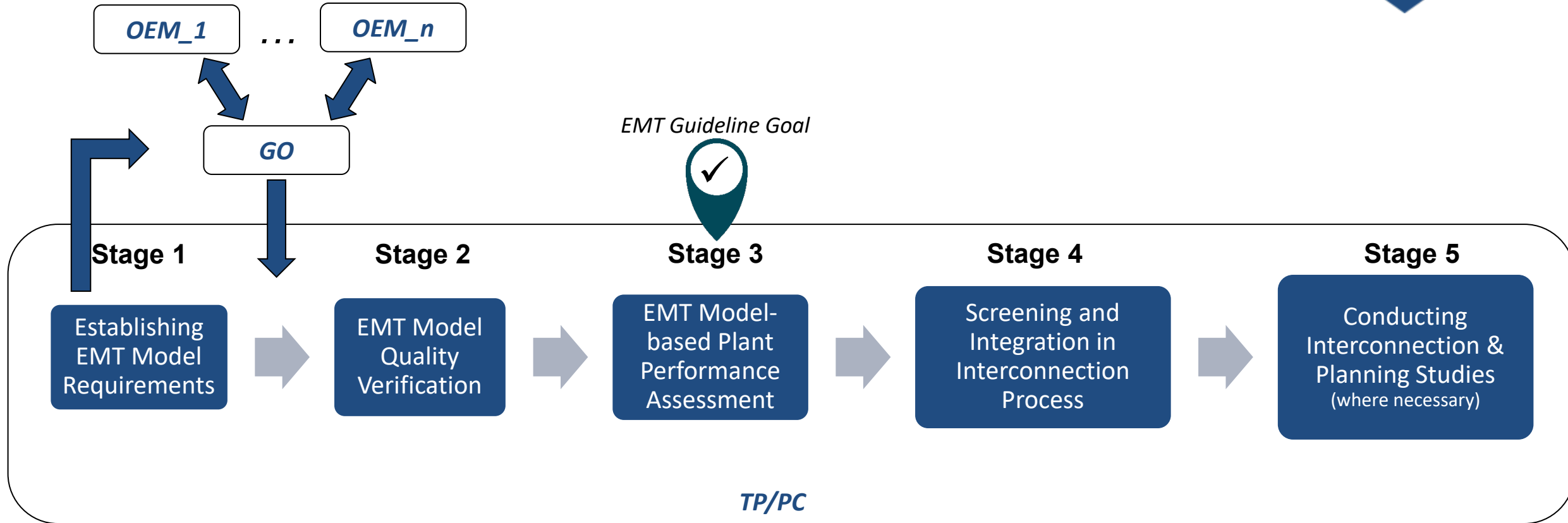


Published EMT Guideline Scope

- | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 |
|--|--|--|---|
| <ul style="list-style-type: none"> Recommended EMT Model Requirements Sample Checklist | <ul style="list-style-type: none"> Principles of Model Quality Verification Processes Attestations – unit models & plant model Unit Model Validation | <ul style="list-style-type: none"> Model Adequacy Tests Functional Tests Disturbance Ride-through Performance Tests | <ul style="list-style-type: none"> EMT Study Use Cases Common situations needing an EMT study |

New EMT Guideline Scope (Work item 2 of NERC EMTTF)

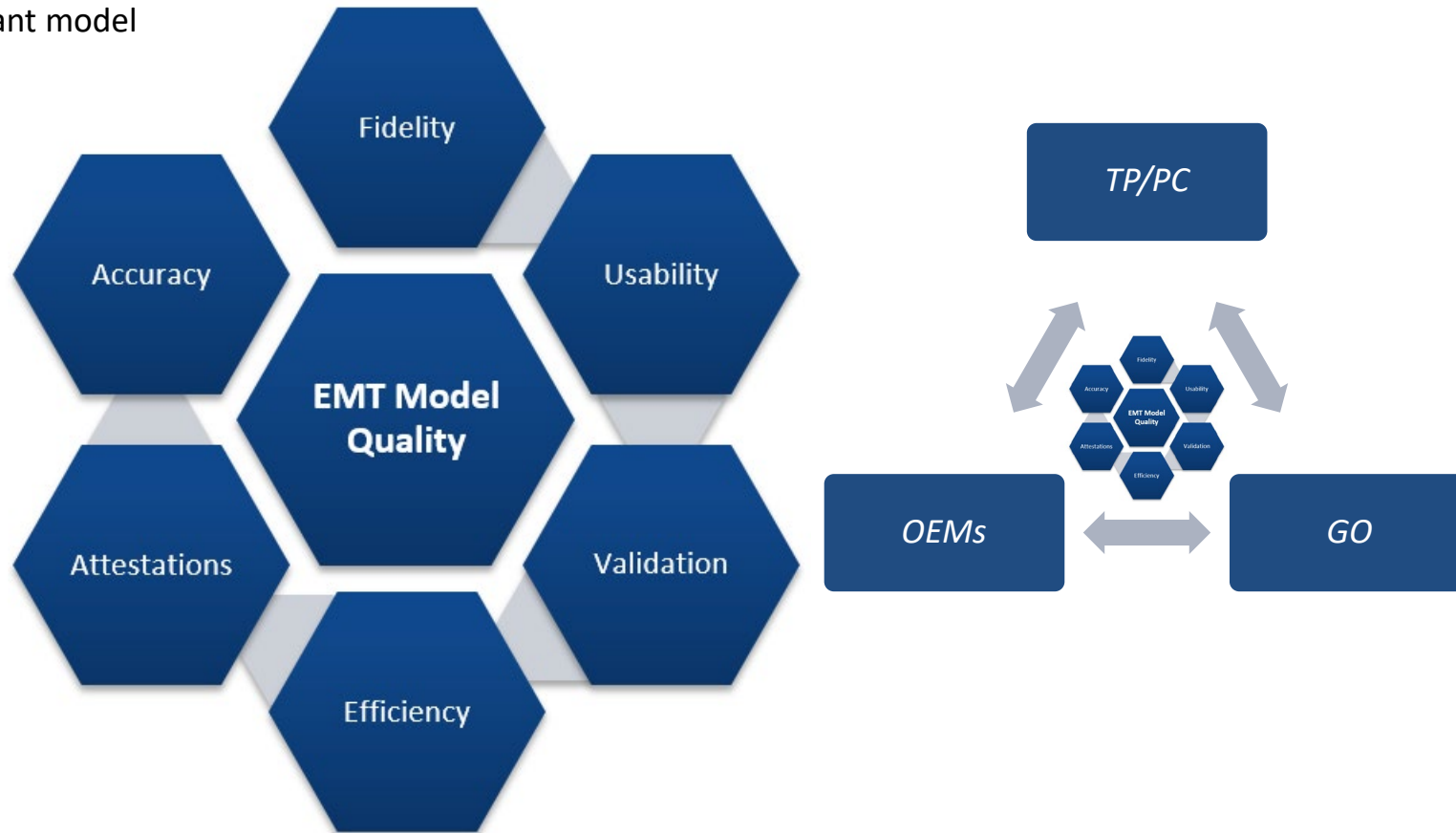
EMT Modeling Visualized by Functional Entities



- Establish EMT modeling requirements per FAC-002 for all new IBR resources
- Create a “checklist” of EMT model requirements for GO and equipment manufacturers
- Require high quality EMT models as a prerequisite of interconnection
- Require the EMT models accurately represents all pertinent controls, and protections that could affect the electrical output of the facility during and after grid disturbances
- Require all submitted EMT models include
 - Attestations by the equipment manufacturers and
 - Attestations by GO that aggregate model represents the entire plant and includes site-specific models, settings, protections, and controls
- Include change management requirements and protocols regarding how changes should be reflected in EMT models by the GO
- Clearly define the purview and duration of EMT simulations

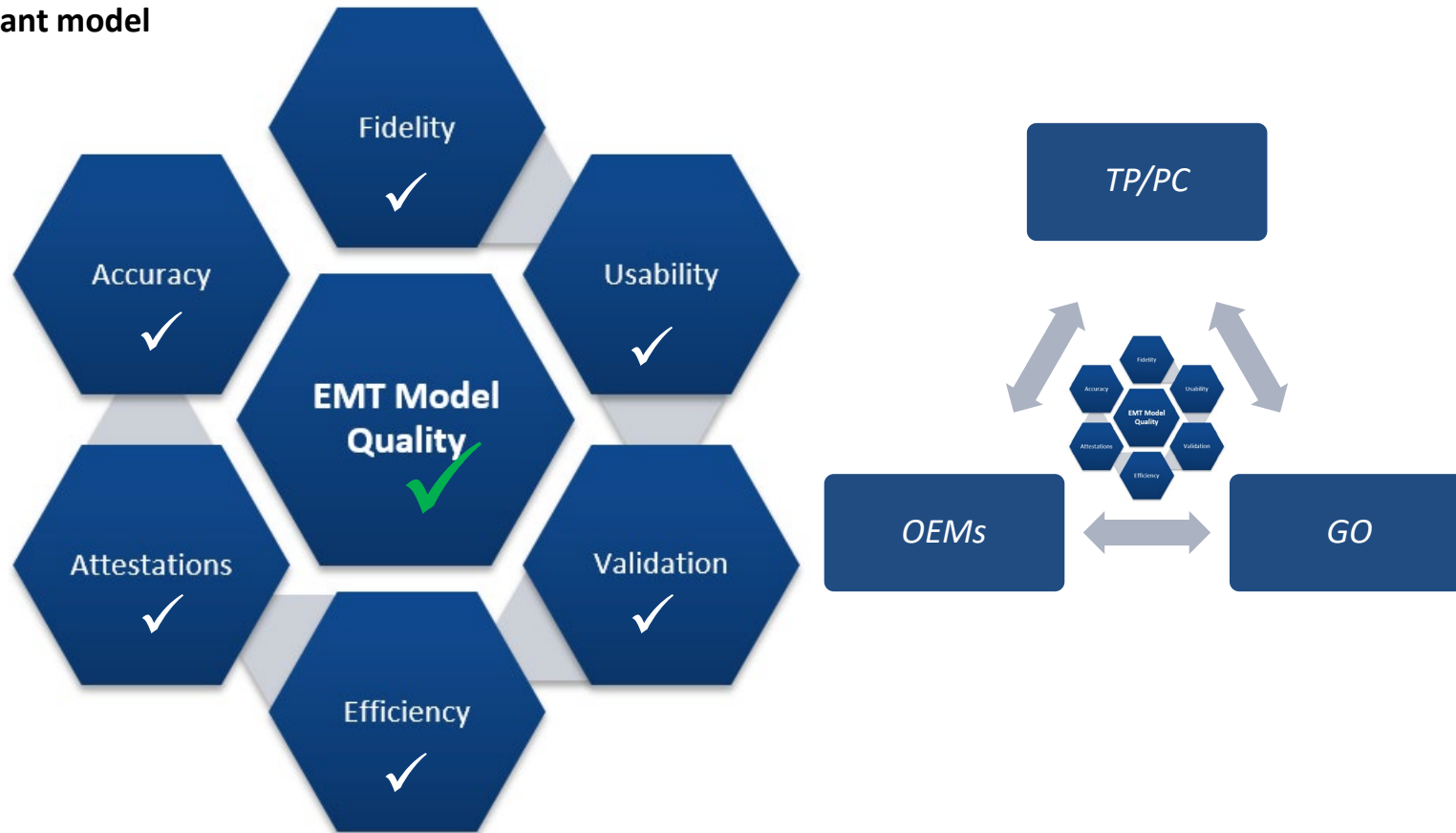
Chapter 2

- **Principles of Model Quality**
- Verification Processes
- Attestations – unit models & plant model
- Unit Model Validation



Chapter 2

- Principles of Model Quality
- **Verification Processes**
- **Attestations – unit models & plant model**
- **Unit Model Validation**



Chapter 2: Model Quality Verification Processes

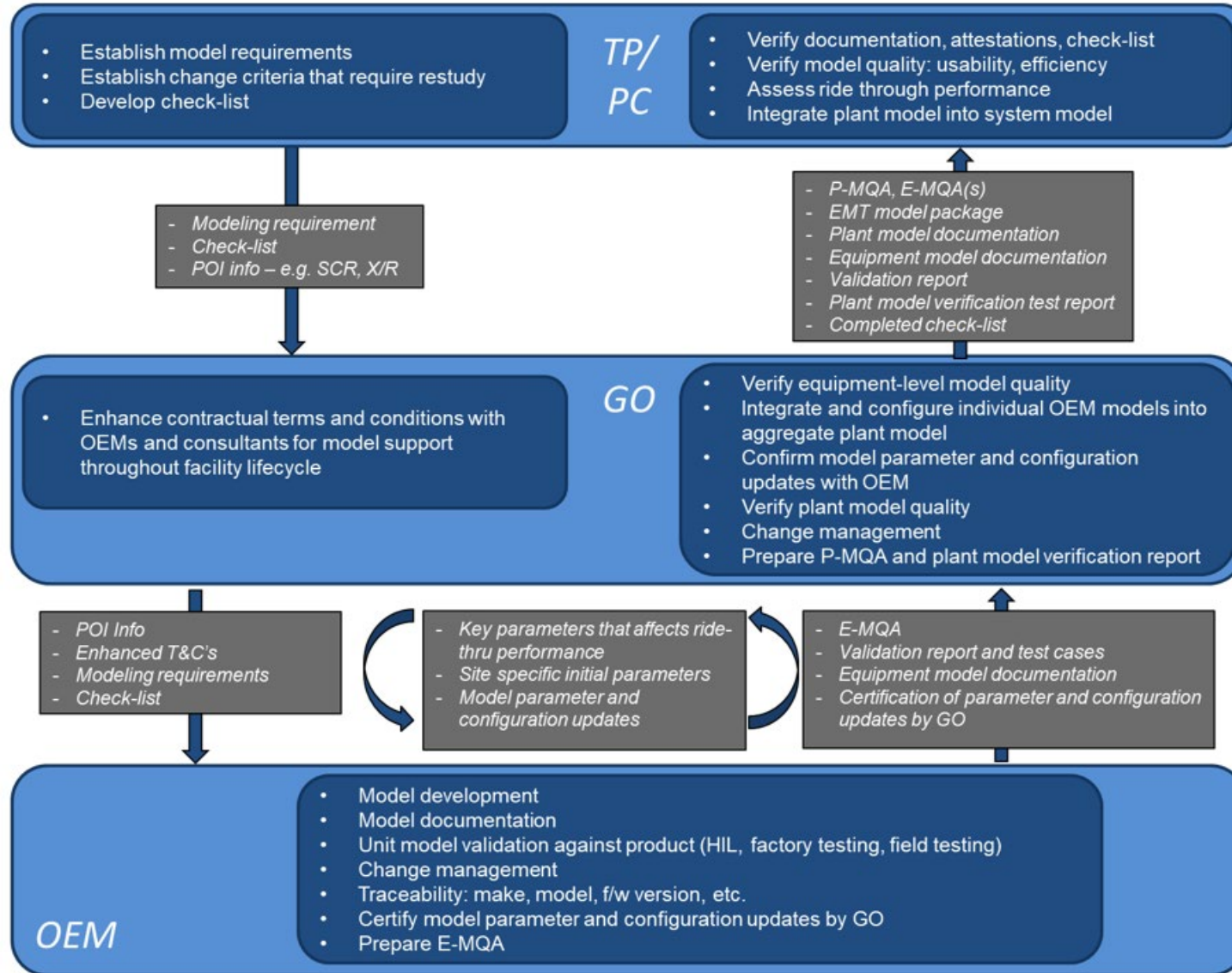
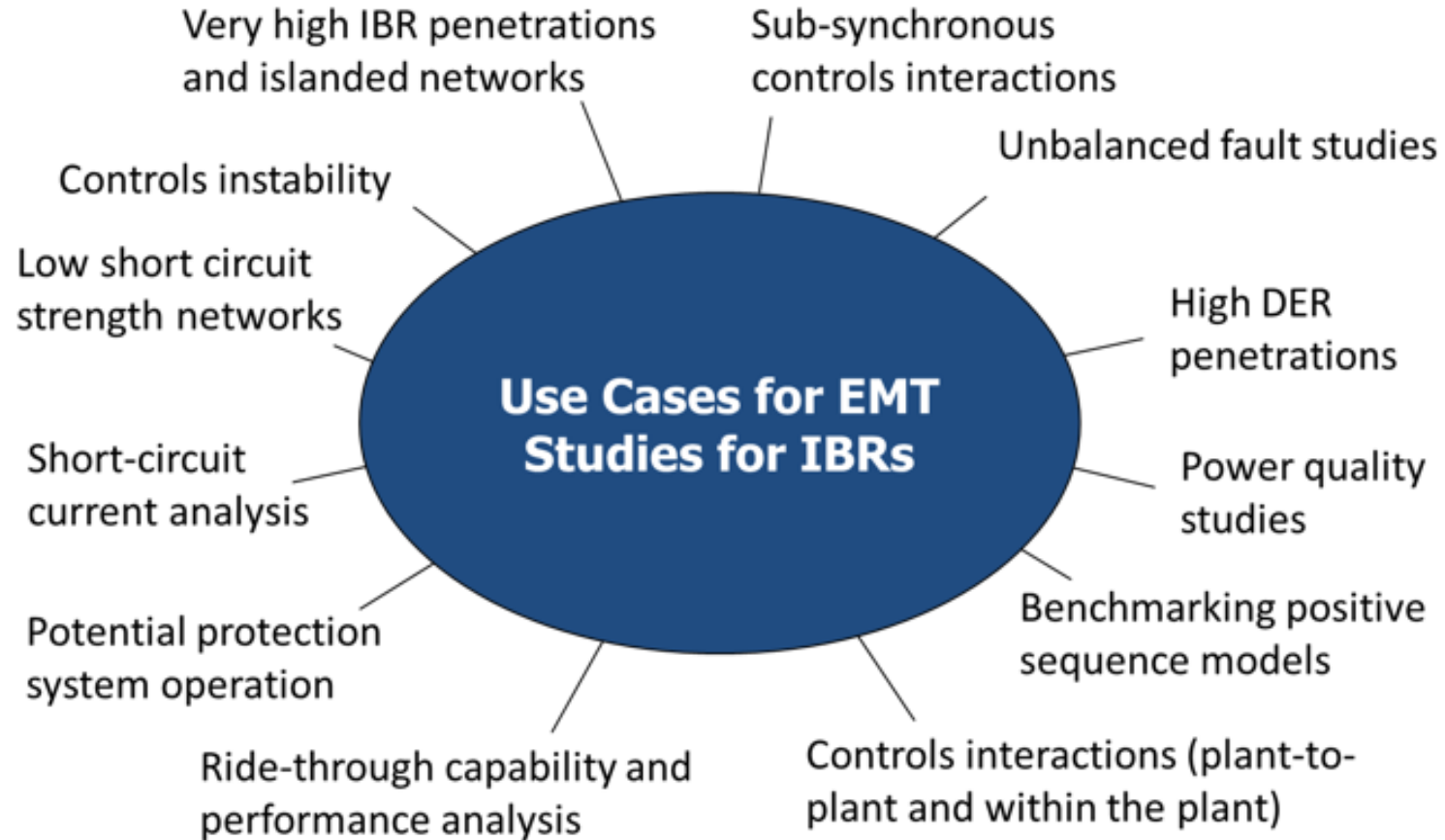
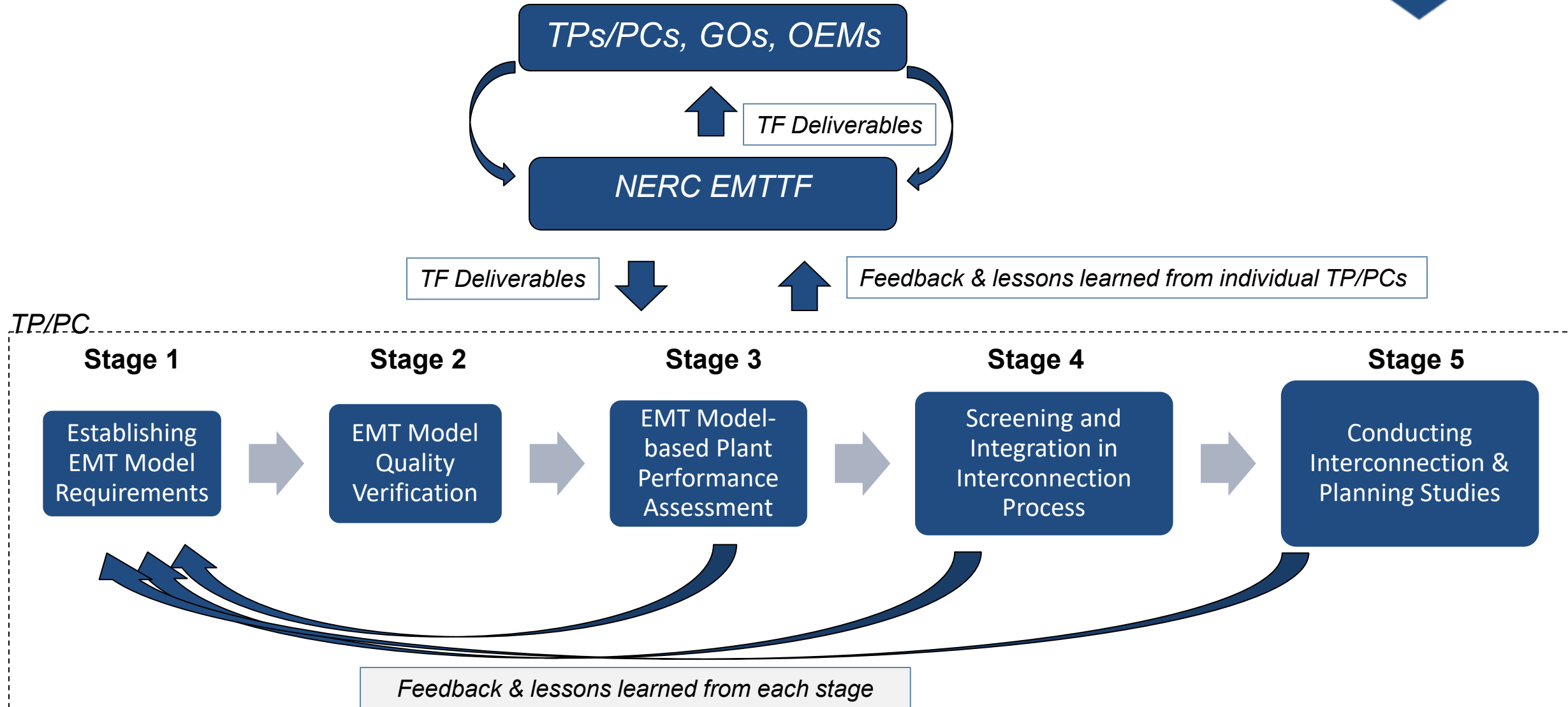


Figure 2.2: Model Quality Verification Processes, pg. 18



- Chapter 5: Other Relevant Topics
 - **Benchmarking Positive Sequence Dynamic Models against the EMT Model**
 - Resourcing for Future EMT Study Needs
 - Applicability and Use of IEEE 2800 Guidance
- Appendix A: EMT Model Terminology
 - Generic versus Equipment Specific Models
 - Equipment-Specific **Model Types**
 - Transparent EMT Models
 - “Black Box” EMT Models
 - “Real Code” EMT Models
 - Detailed and Aggregate EMT Modeling
- Appendix B: **References for EMT Model Requirements**

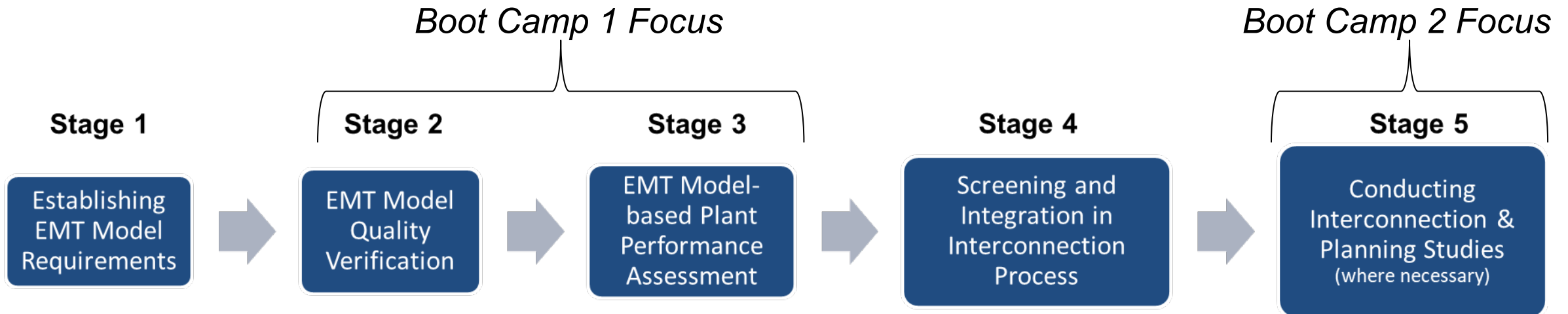
- Help industry close EMT modeling knowledge gaps
- Provide a foundation of knowledge for new modeling requirements and practices
- Guidance to make quality-vetted EMT models available to TPs and PCs for the purposes of reliability studies – interconnection studies per FAC-002 and planning assessments per TPL-001
- Help industry close current gaps between interconnection studies and installed equipment



- EMT Modeling Boot Camps (Virtual)

- co-hosted by U.S. Department of Energy Interconnection Innovation e-Xchange (i2X) and NERC

Date	Time	Session
July 27, 2023	1 – 3 pm Eastern	Pre-session
August 3, 2023	1 – 5 pm Eastern	Boot Camp 1: Individual IBR Plant Performance Assessment
September 14, 2023	1 – 5 pm Eastern	Boot Camp 2: System Impact Assessment





Questions and Answers

*Feel free to reach out to us if
interested in participating in the NERC
IRPS or EMTTF!*