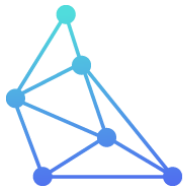
EMT Inverter-Based Resource Plant Modeling

How Consultants, Developers, OEMs, and Grid Operators Can Create Best Practices Together

Kelsey Ciemny, Senior Power Systems Engineer



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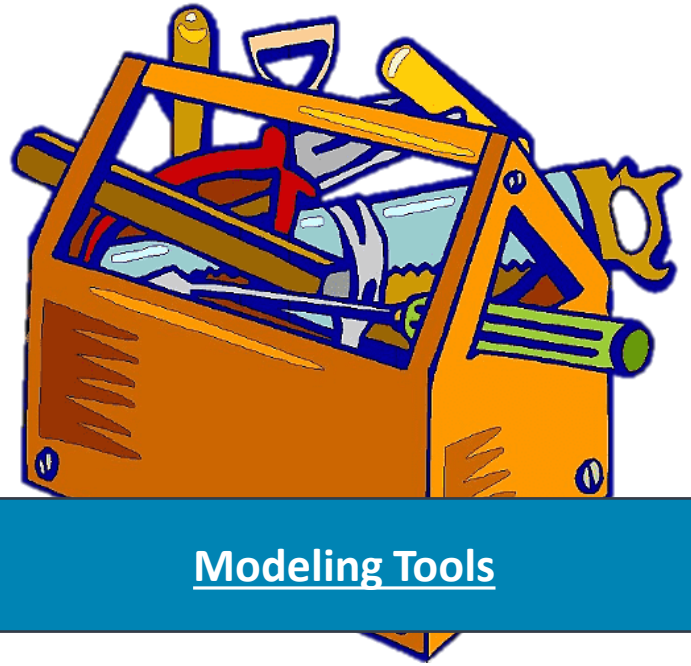
Agenda

- Our Modeling Toolbox and How EMT Fits
- Using EMT Models
- Relevant Standards and Requirements
- Challenges
- Parting Thoughts

IBR Modeling Toolbox



Modeling Tools

Steady State Tools
-TARA
-PSSE
-PSLF
-PowerWorld

Positive Sequence Tools
-PSSE
-PSLF
-PowerFactory
-TSAT
-PowerWorld

Electromagnetic Transient (EMT) Tools
-PSCAD
-EMTP
-PowerFactory

IBR Modeling Toolbox

	Time-step	Product to Model Relationship	Detail
Positive Sequence Tools -PSSE -PSLF -PowerFactory -TSAT -PowerWorld	Milli-second time-steps	Reduced Order: user defined model or generic	Simplified and/or omitted equipment details
Electromagnetic Transient (EMT) Tools -PSCAD -EMTP -PowerFactory	Micro-second time-steps	Closely aligned: “real code”, blackbox	Highly detailed; Complex software & compiler

Modeling Tools

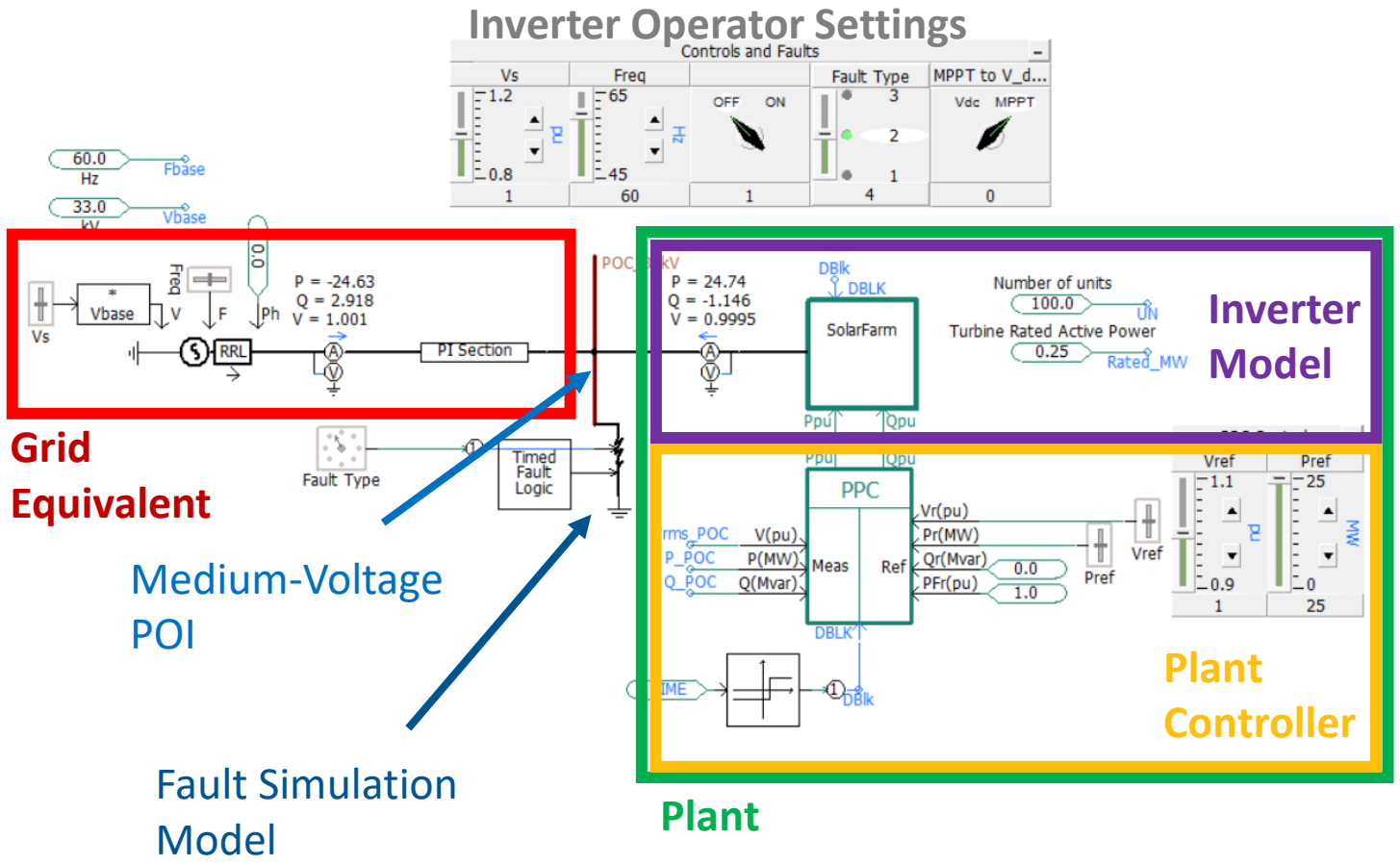
EMT Models- What are they used for?

Interconnection Applications	Complex Interactions and Study Work for Grid Compliance	Validation and Studying Grid Events	Research and Academia
- What's going to happen when we connect this new IBR to the grid?	- Weak grid - Sub-synchronous oscillations - Evaluating areas with multiple IBRs	- Does the model match how the plant performs? -Regularly keeping models up to date - Replicating and understanding grid events, with mitigation opportunities	- New technology development (example GFM) -Generic EMT models - Understanding events and potential mitigations

Typical EMT Model Structure

PSCAD's simple solar farm example

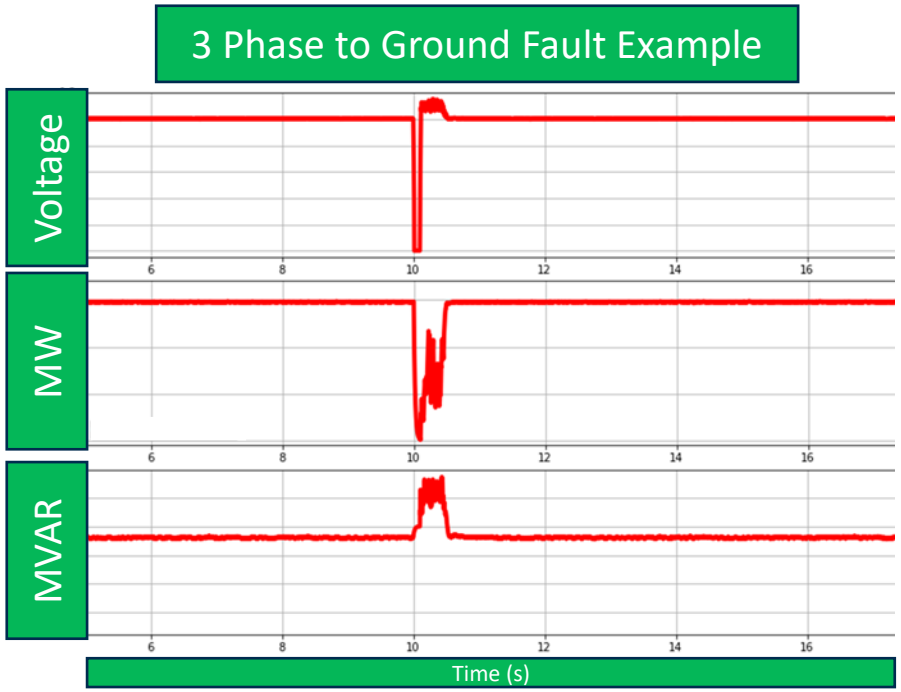
- Power plant controller (PPC)
- PV Array
- Boost converter
- DC-AC inverter
- Scaling Component



Using the EMT Model- Test Systems

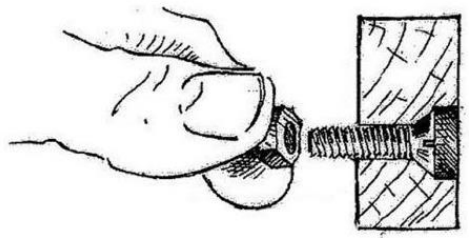
- We've seen grid operators using test systems to ensure that the EMT models respond as anticipated
- Open source (without black boxing) test systems are helpful for diagnosing assumptions and grid configuration

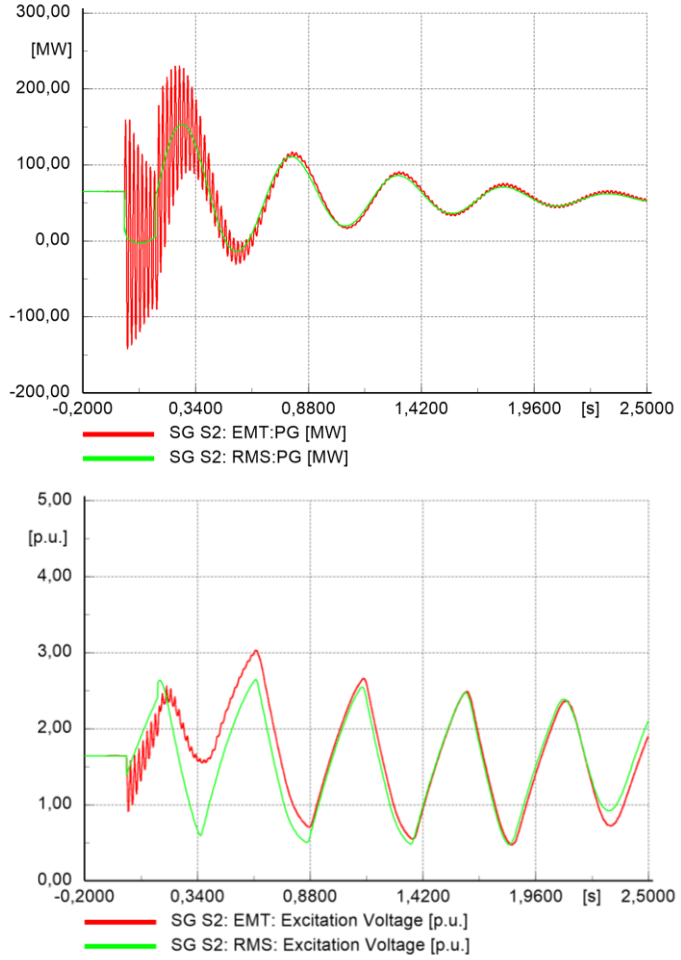
Flat Run	3 Phase Fault at 100% Power	Single Phase Fault at 100% Power
BESS Charging Case	NERC PRC-024	Voltage Step Response
Frequency Step Response	System Strength Test	Voltage Protection Test



EMT Modeling as a Tool

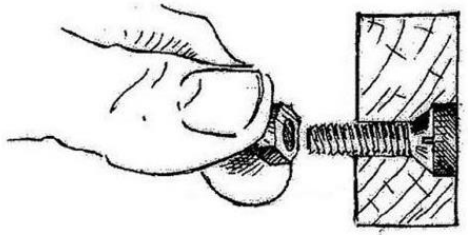
- EMT modeling isn't new but it is becoming more important as there is more IBR penetration on the grid
- Increased need for using EMT modeling during interconnection process to ensure reliability
- Updating models after project is built to ensure that the model reflects actual site performance





DIgSILENT RMS-EMT Model Benchmarking

What do we need and when?

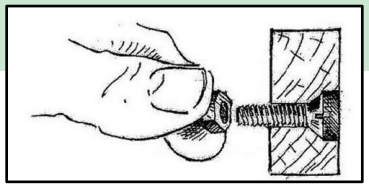


- Inverter and plant controller
- Reasonable plant design and equipment parameters
- Reasonable response to a generic equivalent grid
- Good model quality and initialization

- Exact plant design and equipment parameters
- Plant controller tuned gains for the specific interconnection

EMT Standards and Requirements- Today

Interconnection Application



- Model test controller systems
- EMT model development checklists

Commissioning of IBR Plant

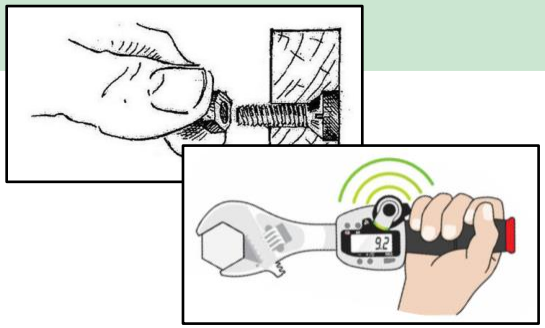
- ERCOT Model Quality Testing
- MOD-026

Lifetime of IBR Plant

- ERCOT Model Quality Testing
- MOD-026

EMT Standards and Requirements- Ongoing

Interconnection Application



- FERC Order 2023
- New IBR Requirements IEEE- 2800

Commissioning of IBR Plant

- ERCOT Model Quality Testing
- MOD-026-2

Lifetime of IBR Plant

- ERCOT Model Quality Testing
- MOD-026-2

A Linear Approach is Limiting

New IEEE 2800 requirements, need for validating new product hardware/software to the EMT model

They said we needed to decide on a specific product, have a validated model, and couldn't make any changes to our site design

EMT models used in the interconnection analysis match the plant exactly

OEM product development (time: 3-5+ years)	Developer Interconnection Process (time: 3-5+ years)	IBR in the ground and connected to grid (how long? 6-10+ years)

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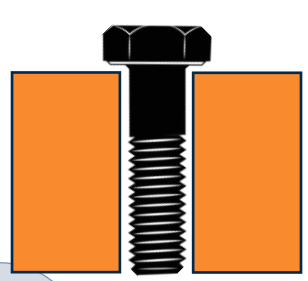

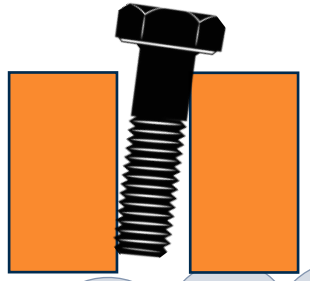

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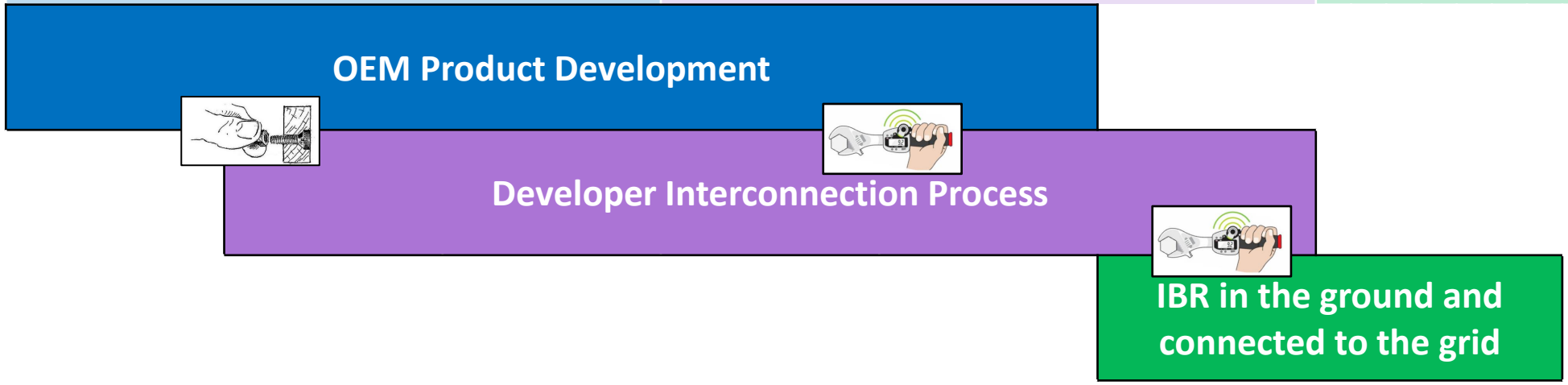
An Adjustment to the Approach

Let's design products with the ability to keep iterating to meet new codes and standards.

Let's iterate on the design of an IBR plant, making decisions about manufacturers, products, and features when it makes sense.

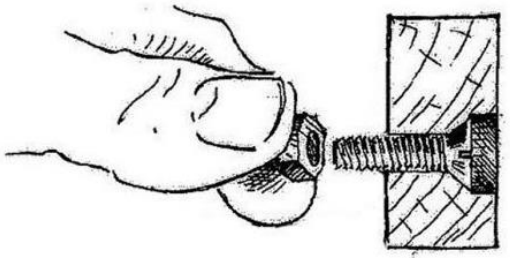
Interconnection Applications should take into account the challenges OEMs and developers face, without penalizing newer/better technology advances.

OEM product development	Developer Interconnection Process	IBR in the ground and connected to grid



The “What” and “When” Both Matter

- Remember to ask:
  - What are we trying to accomplish by using EMT models?
  - Is this the right tool for the job and is it the right time to use it?



Thank you!

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