NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

NERC Inverter-Based Resource (IBR) Webinar Nine:

Session 9: Commissioning

July 11, 2023

New Resource Commissioning

ISO New England Approaches and Lessons Learned

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DIRECTOR, TRANSMISSION SERVICES AND RESOURCE QUALIFICATION

Highlights

- ISO New England (ISO-NE) has various technical requirements for the commissioning of new resources, including Inverter-Based Resource (IBR) interconnections
- ISO-NE is expecting to expand these requirements as part of our adoption of IEEE 2800 (Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems)

ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

Grid Operation

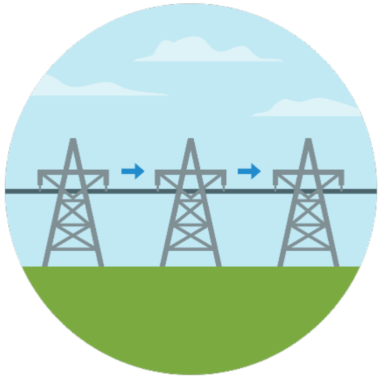
Coordinate and direct the flow of electricity over the region's high-voltage transmission system

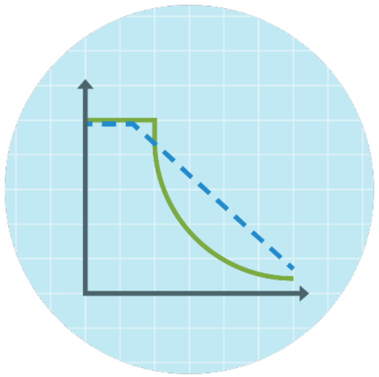
Market Administration

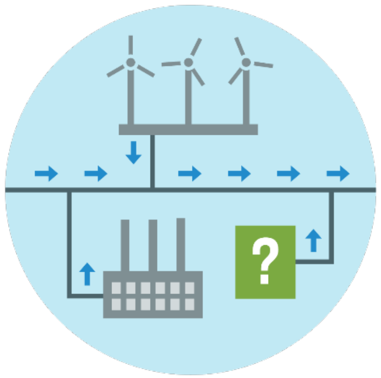
Design, run, and oversee the markets where wholesale electricity is bought and sold

Power System Planning

Study, analyze, and plan to make sure New England's electricity needs will be met over the next 10 years

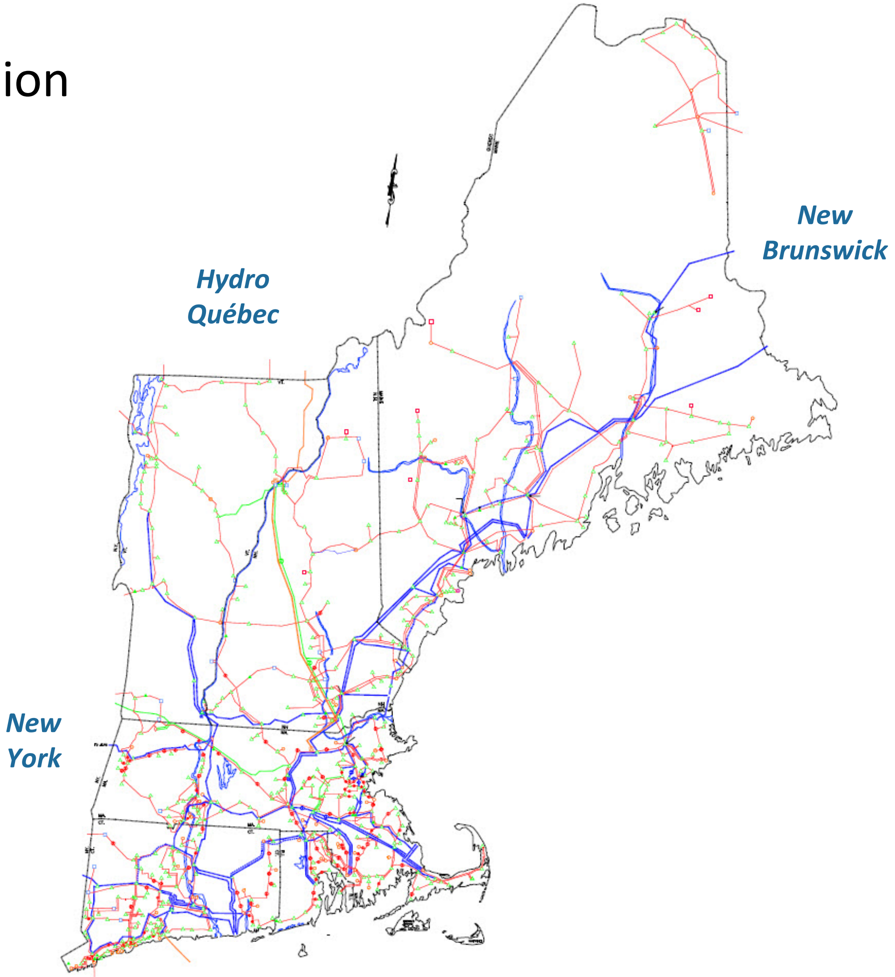






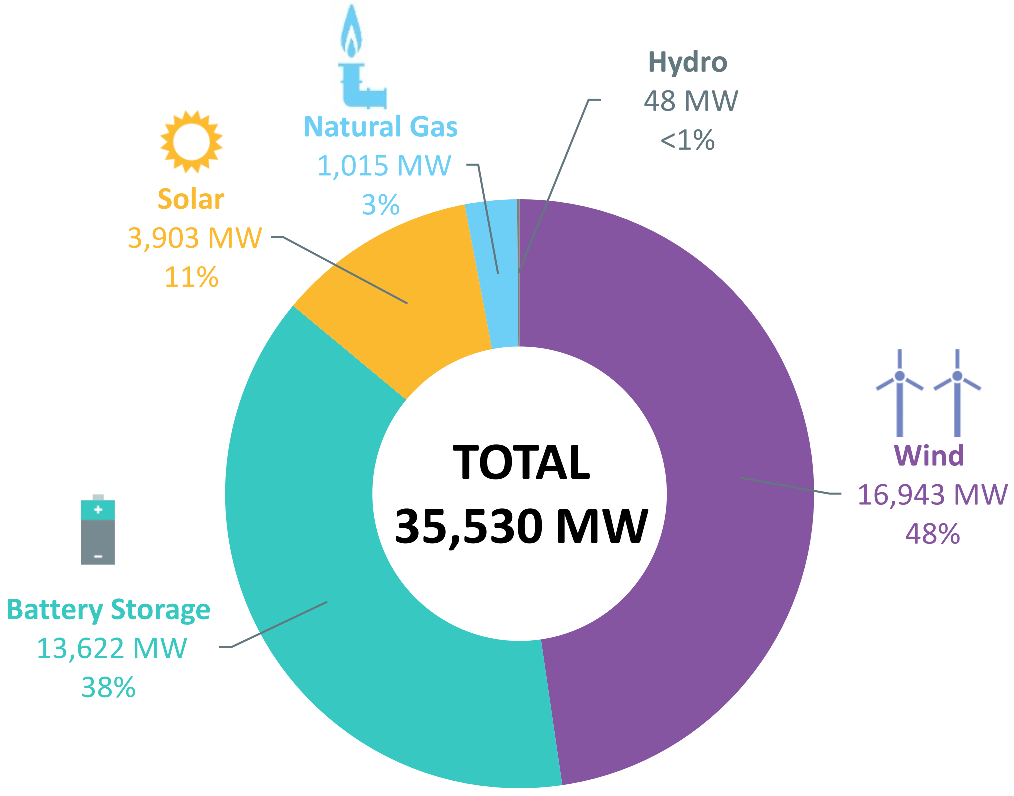
New England's Transmission Grid Is the Interstate Highway System for Electricity

- **9,000 miles** of high-voltage transmission lines (primarily 115 kV and 345 kV)
- **13 transmission interconnections** to power systems in New York and Eastern Canada
- **14%** of region's energy needs met by imports in 2022
- **$11.9 billion** invested to strengthen transmission system reliability since 2002; **$1.3 billion** planned
- Developers have proposed multiple transmission projects to access **non-carbon-emitting resources** inside and outside the region



IBRs Comprise Nearly All of New Resource Proposals in the ISO Interconnection Queue

All Proposed Resources



Source: ISO Generator Interconnection Queue (June 2023)
FERC Jurisdictional Proposals; Nameplate Capacity Ratings
Note: Some natural gas proposals include dual-fuel units (with oil backup).
Some natural gas, wind, and solar proposals include battery storage. Other includes hydro, biomass, fuel cells and nuclear uprate.

Proposals by State

(all proposed resources)

State	Megawatts (MW)
Massachusetts	19,700
Connecticut	7,125
Maine	5,461
Rhode Island	1,574
New Hampshire	1,295
Vermont	375
Total	**35,530**

Source: ISO Generator Interconnection Queue (June 2023)
FERC Jurisdictional Proposals

NEW RESOURCE COMMISSIONING

Data collection, model review & performance verification

Commissioning Process

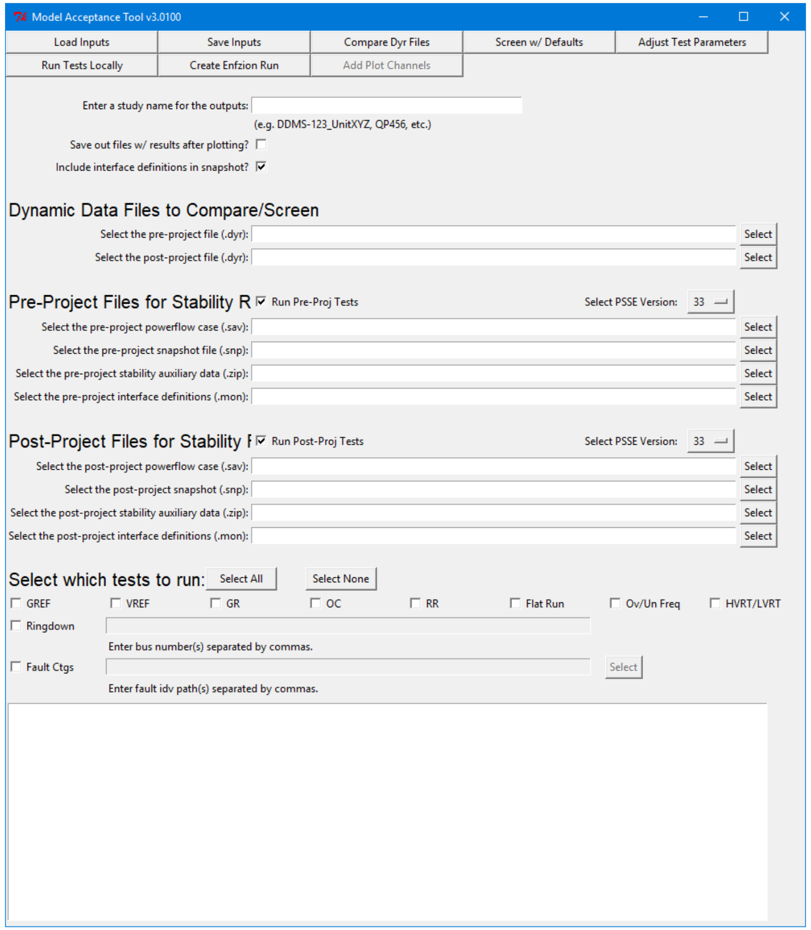
- The new resource registration process has numerous steps and requirements
  - Market registration and modeling
  - Communications and dispatch requirements
  - Technical submittals and demonstrations
- Here we will focus on specific technical requirements of interest to IBR commissioning
  - As-built model and data submittals
  - Power Factor demonstration
  - Voltage response demonstration
  - Frequency response demonstration

Model Submittal Sequence

- **As-Studied Data**
  - Initially submitted with the Interconnection Request
  - Must pass acceptance testing
  - Used for System Impact Study
  - Updated at end of study with any upgrades needed
- **As-Purchased Data**
  - Due At Least 180 Days prior to initial synchronization
  - Should be very similar to As-Studied Data
  - Must Pass Acceptance Testing again if different than As-Studied
- **As-Built Data (part of the commissioning process)**
  - Required prior to Commercial Operation
  - Should be very similar to As-Purchased Data
  - Must Pass Acceptance Testing
  - MOD-26/27 requires testing of this data within 1 year
    - MOD-26 Attachment 1 Row 3
    - MOD-27 Attachment 1 Row 4

Model Acceptance Tool

- Provides all testing requirements within one application
  - Reads in .dyr files
  - Can run parameter wise comparison between two .dyr's (useful for MOD-26/27 review)
  - Screens parameters to meet regional modeling requirements
  - Runs all checked tests on all defined units within .dyr
  - Parallel processing functionality



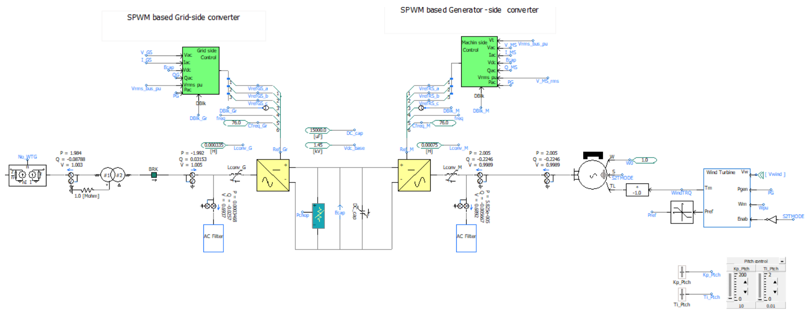
Dynamics Data Submittals Approval

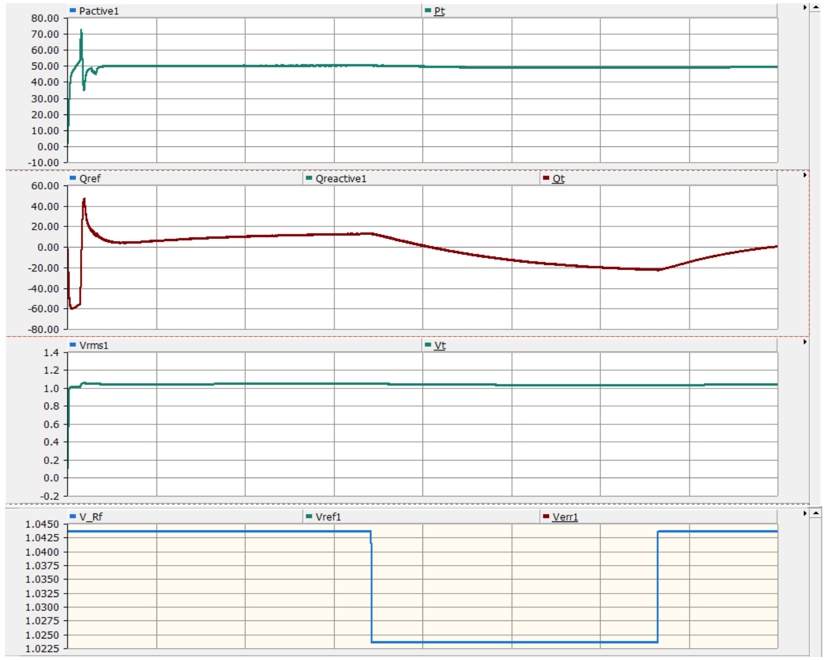
- For MOD-26/27 submittals, a checklist to show what was tested and what passed/failed is also provided

ISO New England - Transmission Planner –MOD-026/MOD-027 Review Summary		
Test	Pass/Fail	Comments
Summary of results	Pass	Results acceptable overall
Model Provided in proper format	Pass	
Test report documentation provided	Pass	
Model initialization results (MOD-026 R6.1 and MOD-027 R5.1)	Pass	
No disturbance results (MOD-026 R6.2 and MOD-027 R5.2)	Pass	
Exciter response (MOD-026 R6.3)	Pass	
Exciter response ratio (MOD-026 R6.3)	Pass	
Vref (i.e. Qgen) change results (MOD-026 R6.3)	NA	
Governor response (MOD-027 R5.3)	Pass	
Gref (i.e. Pgen) change results (MOD-027 R5.3)	NA	
SLG fault test result (MOD-026 R6.3 and MOD-027 R5.3)	NA	
LL fault test result (MOD-026 R6.3 and MOD-027 R5.3)	NA	
LLG fault test result (MOD-026 R6.3 and MOD-027 R5.3)	NA	
3PH fault test result (MOD-026 R6.3 and MOD-027 R5.3)	Pass	

PSCAD Models – Model Requirements

- Models are required to be provided as part of the interconnection of all IBRs
- Models are vetted for accuracy, useability, and efficiency as part of the interconnection
  request review process
  - Benchmarking
  - Single Machine infinite bus
  - Playback Testing





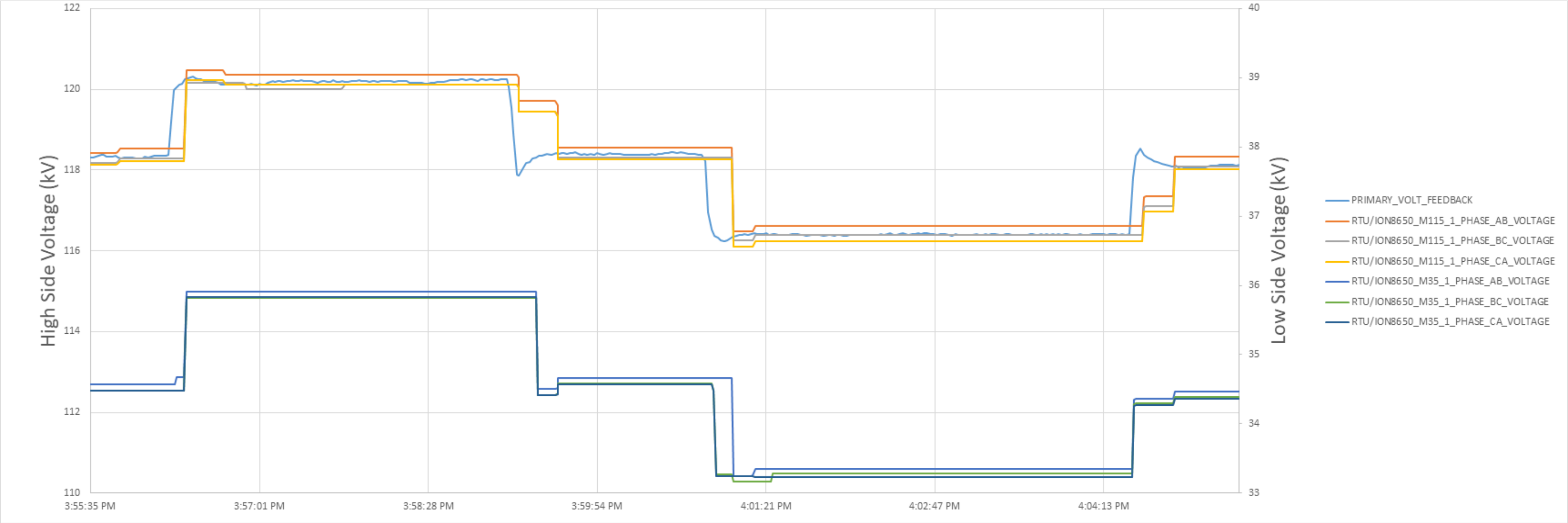
Power Factor Demonstration

- During the Reactive Capability Audit, the Reactive Resource shall absorb or produce the maximum reactive power of the Reactive Resource such that the Reactive Resource reaches a defined limit, given the current conditions and limitations, for the entire audit duration
  - This limit may be internal to the Reactive Resource (e.g., maximum excitation limiters (MEL), under excitation limiters (UEL), volts/hertz limiters, terminal voltage, procedural) or external to the Reactive Resource (e.g., transmission bus voltage)
- In the event that reactive equipment or elements that may limit reactive capability (e.g., transformers, feeders, etc.) are shared between multiple Reactive Resources (e.g., pseudo-combined cycle assets, wind, co-located solar and storage facilities), those Reactive Resources may be required to test at the same time in order to determine limitations

Voltage Regulator Testing

- Test requirements:
  - Automatic voltage regulator on and in voltage control mode
  - Five percent change in Large Generating Facility terminal voltage initiated by a change in the voltage regulators reference voltage
- Interconnection Customer shall provide validated test recordings showing the responses of Large Generating Facility terminal and field voltages

Voltage Regulator Testing - Example

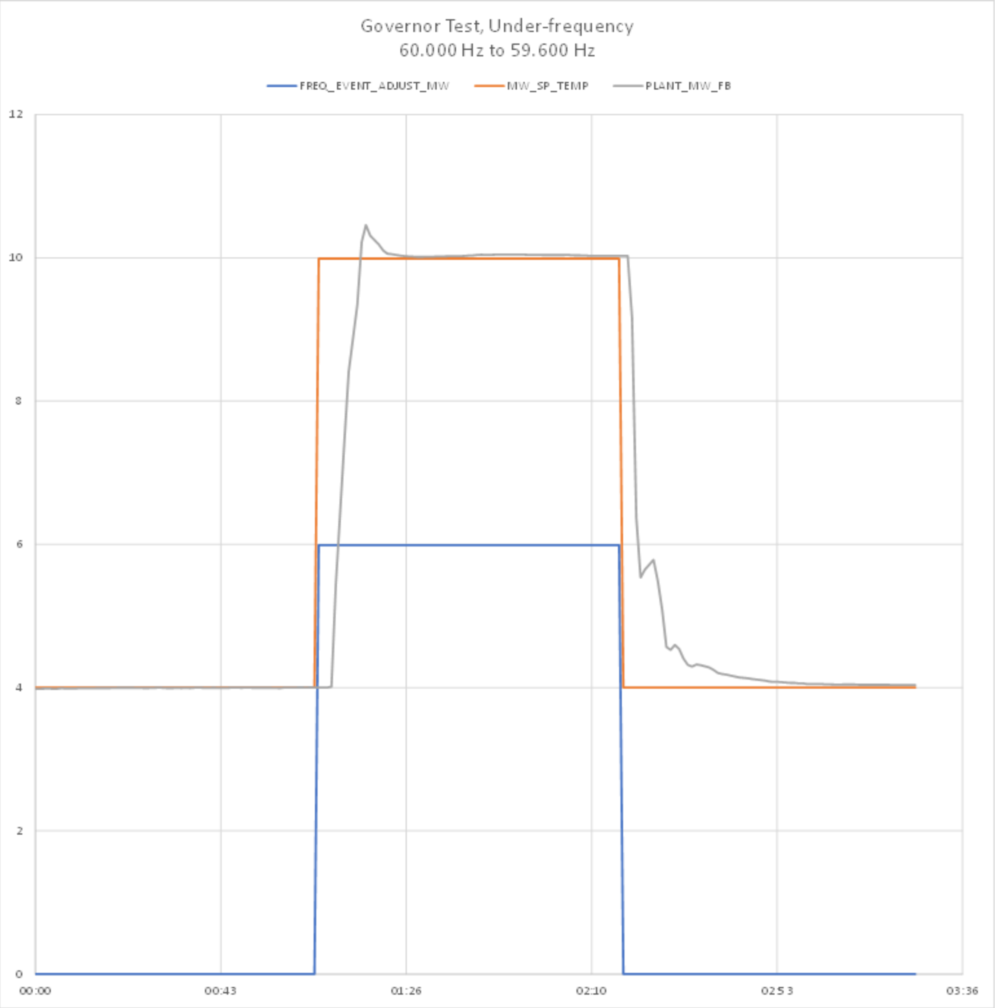


Frequency Response Testing

- Performance requirements
  - Droop based on nameplate capability set between a minimum of four percent (4%) and a maximum of five percent (5%);
  - Frequency response deadband of no greater than 59.964-60.036 Hz; and
  - Real power response is not inhibited by effects of outer loop controls (such as operator set point controls and load control but excluding AGC) that would override the governor response (including blocked or nonfunctioning governors or modes of operating that limit Frequency Response)
- Testing conditions
  - Under the on-line condition, measure and record the MW output (for a period of certain length with sampling rate of sufficient precision) of the applicable unit by injecting a step change of the speed reference with the following requirements met:
    - Variant sizes of the step change (in both directions, i.e. over-speed and under-speed) should be tested;
    - The step size is no less than 50mHz;
    - The test shall be repeated under different loading conditions of the applicable unit;
    - If there exists an outer-loop load control that is enabled in the normal operating mode of the unit, such a control loop shall be placed in-service during the governor testing.

Example of Additional Tuning Resulting from Frequency Response Testing (initial sluggish response)

Example of Additional Tuning Resulting from Frequency Response Testing (improved as-built response)



Future changes

- More formal adoption of the requirements associated with IEEE 2800 (Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems)
- Development of verification requirements to follow in conjunction, or after, publication of IEEE P2800.2
  - Interim approach may be to accept developer provided verification/validation in conjunction with conformity assessment performed by ISO-NE

Questions

Questions and Answers After All Presentations

Traversing the Commissioning Process

Katie Iversen,
Generator Modeling Manager
AES Clean Energy

Introduction – Why do settings matter & how did I get here?

Inverter/turbine settings govern **important** aspects of plant behavior. They are **key elements** of power flow models.

Settings Background

Types of settings:

- Ride-Through
- Grid Support
- Normal Operation
- Communication & Restarts
- Monitoring & Logging
- Security

Overall, settings are loaded in finality at **“hot commissioning”.**

Lessons Learned

1. Collaboration & Communication is Key
2. Be Curious
3. Document and Verify

Collaboration & Communication is Key

"A single leaf working alone provides no shade." – Chuck Page

→ The commissioning team must have settings to commission

- Requires **collaboration** and communication between **multiple parties** ***across*** and ***within*** companies
  - Equipment Manufacturer ("OEM")
  - Developer/Generator Owner, including hired consultants or contractors
  - ISOs/RTOs/Utilities

Be Curious

“I have no special talent. I am only passionately curious.” – Albert Einstein

→ Ask Questions

- **Check** on communication and collaboration across parties
- **Deliverables** and **consistency**
- Seek **understanding** of **overlap effects**
  - If X is studied, commission based on X
  - If Y is studied, commission based on Y

Document and Verify

"Trust, but verify." – Ronald Reagan

→ **QA/QC**

→ **Verify** commissioned settings

- Manufacturer verification
- Developer/owner verification

→ Retain **documentation** of **settings** and **notes** within databases

Margaret Hamilton standing next to the navigation software that she and her MIT team produced for the Apollo Project. (Draper Laboratory)

Where to go from here?

“Making things easy is hard.” – Ted Nelson

- → **Learn** from each other across **functions** and **organizations**
- → **Consistency** in process and application
- → **Clear** documentation, including settings and properties of interest
- → **Tools** & **Automation**

Recap

- Settings matter!
- Lessons learned
  1. Collaboration & Communication is Key
  2. Be Curious
  3. Document and Verify
- Future

Questions or Comments

Katie Iversen
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Questions and Answers After All Presentations

NERC – Commissioning

OEM Perspectives

August 28, 2023
Chris Chuah P.E., CEng
Commissioning Manager

Process Overview

Grid Studies

- OEM inputs
  - UL1741
  - Type test data (varies)
- Outputs
  - Protection & Coordination, Short Circuit, Load Flow, Overvoltage

Settings

- Relay Protections
- Over Voltage (OV)/ Under Voltage (UV) / Frequency Ride Through (FRT)
- Grid Loss/ Recovery times

Commissioning (Cx)

- Cold Cx – Configuration & Verify Settings
- Grid Operator (GO) Witness testing
- Hot Cx – Import/ Export & Performance Testing

At Commissioning

- OEM involvement depends on scope
  - Equipment Packages – Commission the equipment
  - Engineering Procurement & Construction – Turnkey – Do everything
  - ….but we have no direct contract with the GO. Must go through our customers.

- At Commissioning (Cx)
  - Cold Cx – Verify Settings – Prepare for Energization
  - Energization – Witness test by GO
  - Hot Cx – Verify equipment and System operation

Issues

- GO Parameters vs Contract
  - What we are obligated to provide to our Customers is often restricted by the GO
  - Example Ramp Rate; Technology & Contract align with msec response time. GO wants minute responses
- Witness Testing
  - Scheduling & Scope varies wildly
  - Scheduling witness tests can push projects by months
  - Some GOs require 1st energization at witness test, others will do witness test in stages.
  - No Energization – No Cx. A limited exception during Cx across GOs would help…even if import/export limited

Observation

- Performance Testing Not Well Defined
  - US: Primarily. WECC & GO dictated. Subjective on criteria.
    - Step tests, ramp rate, grid loss/recovery
    - Write a report
  - EU: G99. Very Prescriptive; Voltage, Frequency, Active & Reactive Power
    - Model
    - Test
    - Submit Report & Results
    - Feedback

- Grid Loss/ Recovery Time
  - Only seeing this in the US
  - Islanding is understood but minutes to recover seems long.

Questions and Answers

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