May 24, 2023

Inverter-Based Resources: Challenges & Opportunities

Power Electronics Grid Interface (PEGI) Workshop

Disclaimer

Perspective

Research Needs

- → Broaden ride-through capabilities for IBR’s in GFM
- → When and how much GFM capacity will be needed?
- → Characteristics of IBR that introduce oscillations
- → How to predict grid impacts of IBRs with less intensive modeling
- → Common data models for inverter parameter settings
- → Inverter performance data and solutions for high performance in challenging environmental conditions

Ride-through in Grid Forming Mode

→Grid needs

- At high penetrations of IBR, IBR will be (or are) increasingly relied upon for grid forming mode (GFM) capability.
- Ride-through requirements for plants can be very wide, especially in island grids.
- GFM IBRs need to be online to form the grid when synchronous machines are no longer operating.

Ride-through in Grid Forming Mode

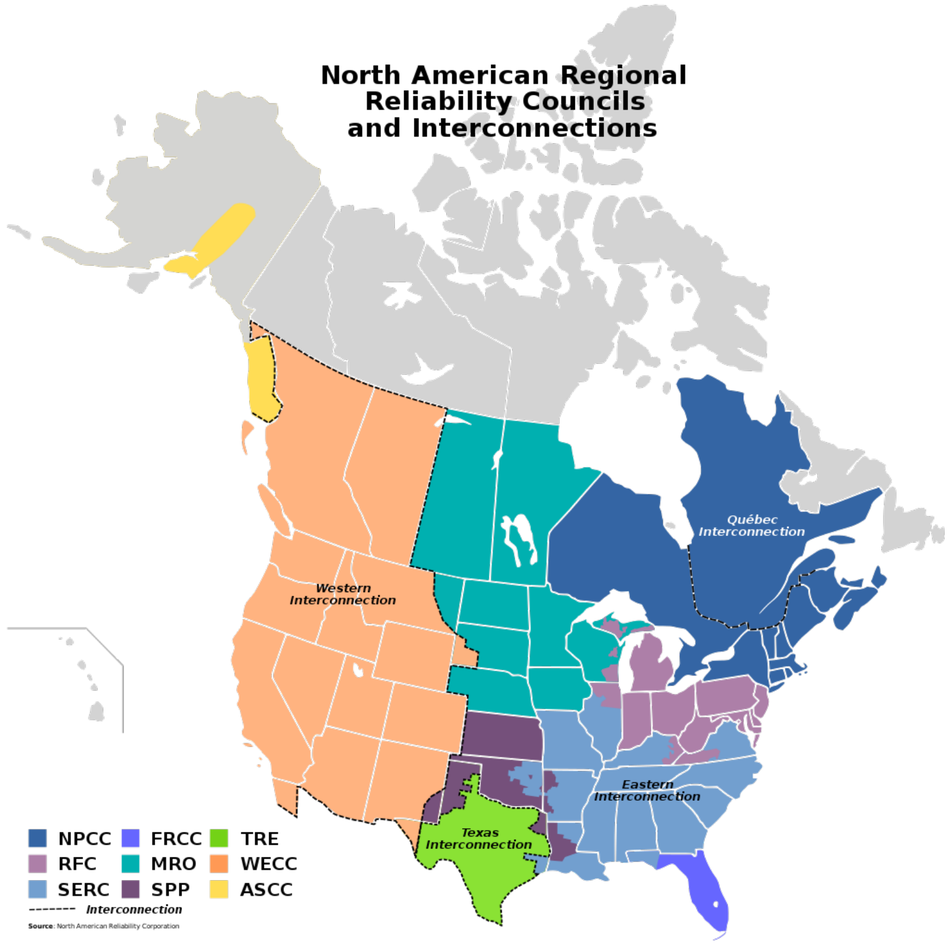
Challenges

- Not many inverter companies are well-positioned to address these wide ride-through curves in GFM.
- Challenges with robust ride-through from different IBR manufacturers, particularly either low-voltage fault or frequency ride-through.
- Limited research is available on how IBRs respond to faults in GFM, especially asymmetrical faults.

Opportunities

- Collaborate with IBR vendors on research to address these challenges.
- Analyze and publish fault data to inform probabilities of encountering different fault scenarios and inform ride-through curve requirements.

When and where will we need GFM capacity?



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GFM is new, required for some projects in Hawaii.

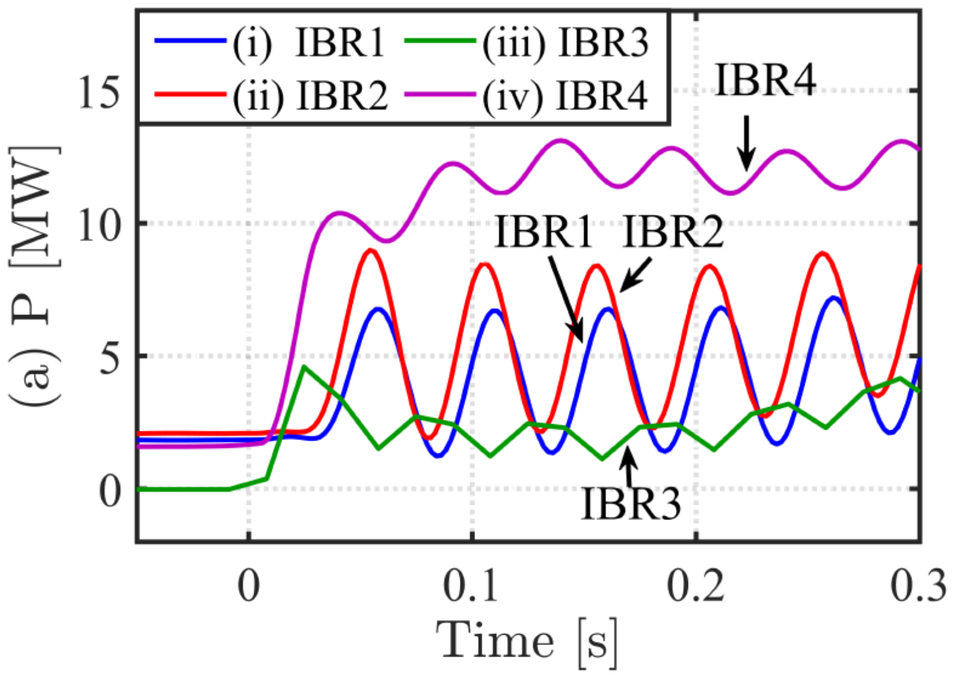
Each grid has different needs in terms of GFM performance.

Not all inverter suppliers are ready to provide GFM capabilities.

It is not currently well understood when and how much GFM capacity from IBRs will be needed in different regions. **Research to determine this would be valuable.**

Have seen the grid can be stabilized with GFL up to high penetrations with reduction in P-f droop slope and/or tuning of converter PPL parameters.

What Causes Oscillations to be Introduced into the Grid by IBRs?



IBRs can introduce oscillatory modes into the grid.

The grid may still be stable if these are well-damped. But…

What inverter characteristics introduce oscillations on different grid types?

How do we mitigate oscillations?

- Mitigation options for GFL and GFM controls

How do inverter and plant response times affect oscillations and system stability?

Analysis of November 21, 2021, Kaua‘i Island Power System 18–20 Hz Oscillations. 2023. https://arxiv.org/pdf/2301.05781.pdf

Predicting Impacts with Simpler or No Modeling?

- Models do not always capture all possible events.
- Version control issues with models as firmware rapidly evolves.
- Modeling resources (people & computational) and expertise can be limited.
- Research on ways to predict possible grid impacts of IBRs with less intensive or even no detailed models/modeling required would be valuable.

Common Data Models for Inverter Parameter Settings

Manufacturers do not present or share the same parameters or settings from the inverter and/or power plant controller (PPC).

These parameters are critical for performance and tracking them important for ensuring consistent performance and in root cause analysis.

A SunSpec/MESA type common data model could help improve parameter sharing and tracking.

Understanding & Improving Inverter Performance in Challenging Environmental Conditions

Not the environment inverters are in

Environmental conditions that plants operate in can cause challenges for inverters and other power electronics:

- Mud/silt or dirt intake through cooling systems
- High humidity environments, marine environments
- Increasing temperatures over time could result in inverters operating at a de-rate or less efficiently

Vendors and system owners are doing a lot of work here, but additional research could provide value:

- How different environmental conditions affect inverters, and/or
- Ways to predict potential failures, and/or
- Increasing efficiency of power electronics in high temperature environments.

Thank you

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