Improving Flexibility to Improve System Stability

Operational and planning solutions

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Background

- Changing needs and services for grids with the increased use of inverter-based resources (IBRs)
- A system in transition requires different types of flexibility solutions
- Provision of flexibility should also be accompanied by guarantee on stability

Evolving system needs expected from Inverter Based Resources (IBRs)

Power System	System needs from IBR
Past: SG dominated system	Unity power factor, minimal fault ride-through …
Present: Increased penetration of IBRs	Automatic voltage control, frequency response, V/F ride-through …
Future: IBR dominated system	Without relying on SGs, provide the above services and more (fast frequency response, maintain system stability…)

Moving toward an inverter dominated power system, IBRs will gradually substitute synchronous generators (SGs) in providing grid services and ensuring grid reliability

Terminology note:
IBR can represent both transmission and distribution device
DER represents only distribution device

Example projection of IBR growth…

AEMO 10 year IBR Growth

Summary Table: NEM Scheduled, Semi-scheduled & Non-scheduled Generation (MW) - Existing and New Developments by Fuel-Technology Category

Summary Status	Fuel - Technology Category										
	Coal	CCGT	OCGT	Gas other	Solar*	Wind	Water	Biomass	Battery Storage	Other	Total
Existing	21,255	2,985	7,314	1,945	9,103	11,125	7,999	542	1,605	224	64,097
Announced Withdrawal	2,880	180	158	800	-	-	-	-	-	-	4,018
Existing less Announced Withdrawal	18,375	2,805	7,157	1,145	9,103	11,125	7,999	542	1,605	224	60,079
Upgrade / Expansion	-	-	-	-	-	-	-	-	-	-	-
Committed	-	-	750	-	2,514	3,167	2,450	-	3,659	-	12,540
Anticipated	-	-	204	-	1,899	486	1,998	-	4,846	-	9,433
Proposed	990	207	2,864	1,687	48,379	130,363	20,271	333	80,847	4,286	290,227
Withdrawn	-	-	-	-	-	-	-	-	-	-	-

Notes:

"Existing" summary status includes "Announced Withdrawal".

"Committed" summary status includes "Committed*".

"Solar*" Fuel-Technology category excludes Rooftop PV installations.

Projects with "TBA" Dispatch Type are not included in the Summary Table.

Projects with "Confidential" FuelBucketSummary are not included in the Summary Table.

*Figures source: https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information

Example projection of IBR Growth…

ERCOT Facts and IBR Growth

Wind, Solar & Energy Storage by the numbers

40,739 MW
of installed wind capacity as of March 2026, the most of any state in the nation

29,011 MW
Generation Record (May 18, 2026)

69.15%
Penetration Record (April 10, 2022)

38,608 MW
of utility-scale installed solar capacity as of March 2026

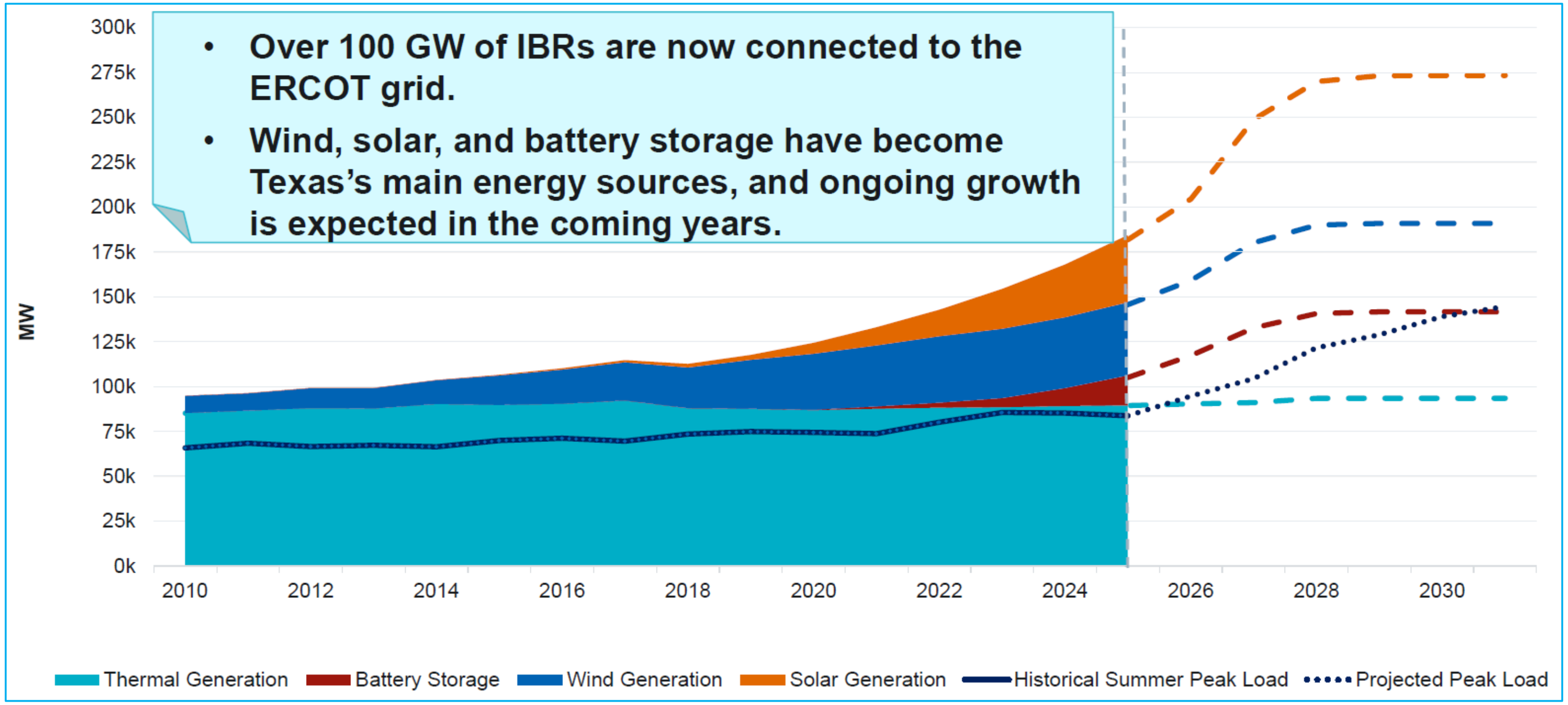
34,498 MW
Generation Record (May 13, 2026)

72.74%
Penetration Record (May 2, 2026)

+ **86.77%** Penetration Record (March 18, 2026)

19,693 MW of installed energy storage capacity as of March 2026

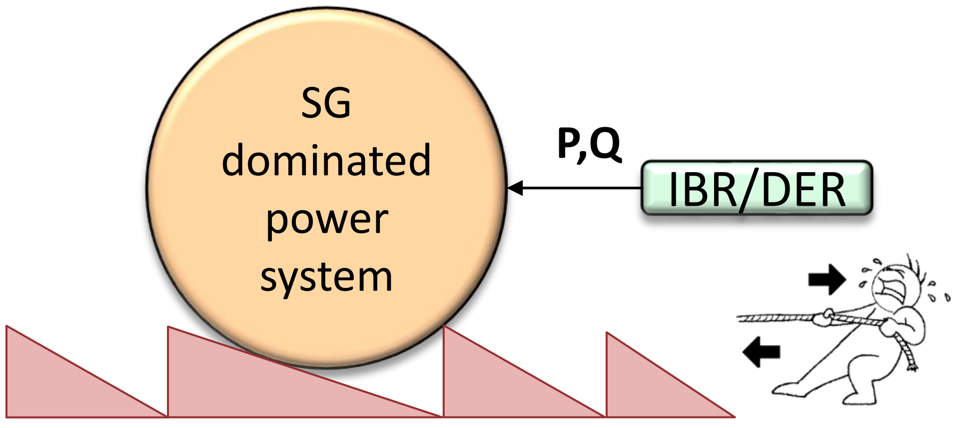
10,515 MW
Energy Storage Generation Record (March 13, 2026)

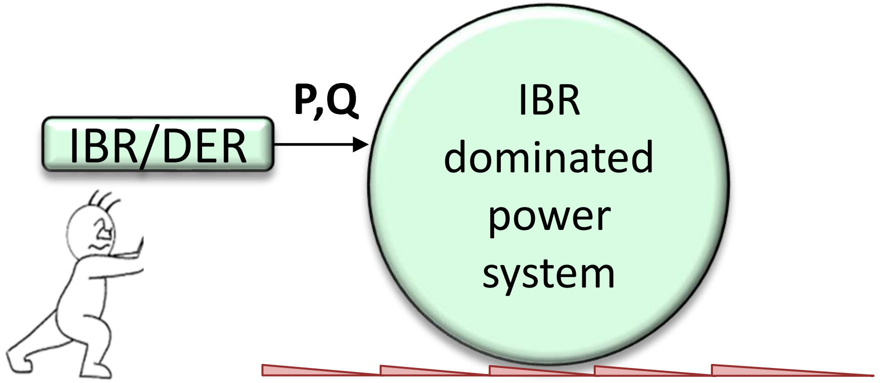


*Figures source: Fred Huang, "ERCOT Advanced Grid Support Summary and Recent Update," UNIFI General Meeting 2026, Golden CO

Power system is changing

SG: Synchronous Generator
IBR: Inverter Based Resource
DER: Distributed Energy Resource



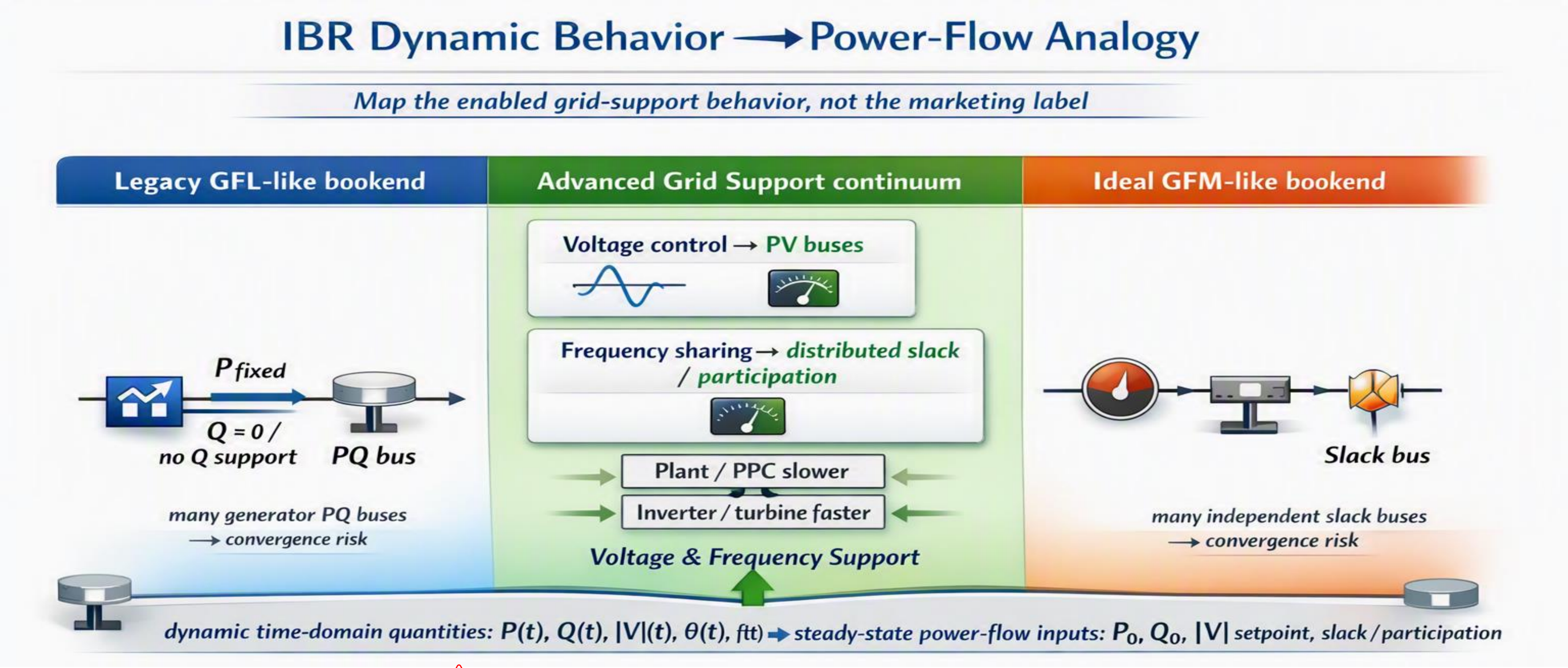


- Majority of today's IBR/DER control is designed to work in a stiff system
  - Changes in IBR injected current do not 'move' the stiff system
  - Changes in system cause IBR to 'move' in tandem

- In IBR dominated power system with few or no SG:
  - Increased elasticity in the grid
  - Changes in IBR injected current will 'move' the system
  - This movement in system will itself cause IBR to 'move' in tandem

Increased elasticity of the grid requires sources to provide increased stiffness, but at the same time, be flexible

Understanding need for dynamic flexibility from the context of power flow



⚠ Bookends are limiting cases; practical operation lives in the continuum

Infographic generated by Co-pilot using material from:
Deepak Ramasubramanian, "Leveraging advanced grid support capability from inverter–based resources," *Power in Mind Magazine*, Opal-RT Technologies, vol. 10, no. 4, 2025
https://www.opal-rt.com/power-in-mind/volume-10/article-4/

Voltage

Reactive power is generated/absorbed to increase/decrease voltage magnitude

Short-circuit capacity is power available to be fed into the grid during a short-circuit fault to maintain voltage stability

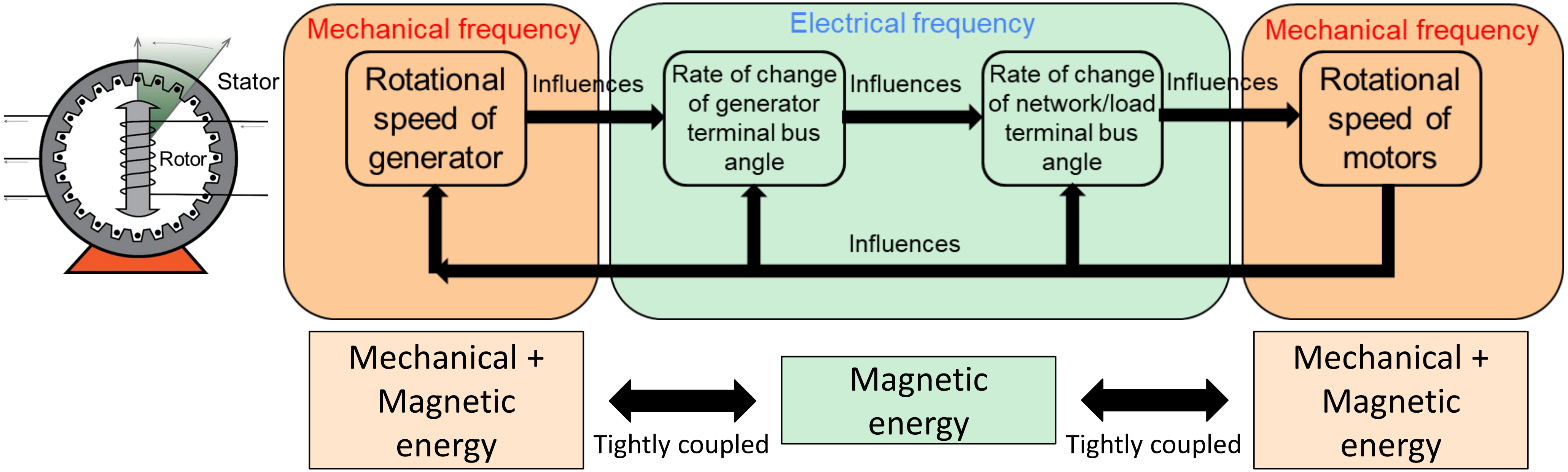
Grid Stability

Frequency

Inertia maintains stability by opposing/slowing down changes in frequency, both in normal operation and during disturbances

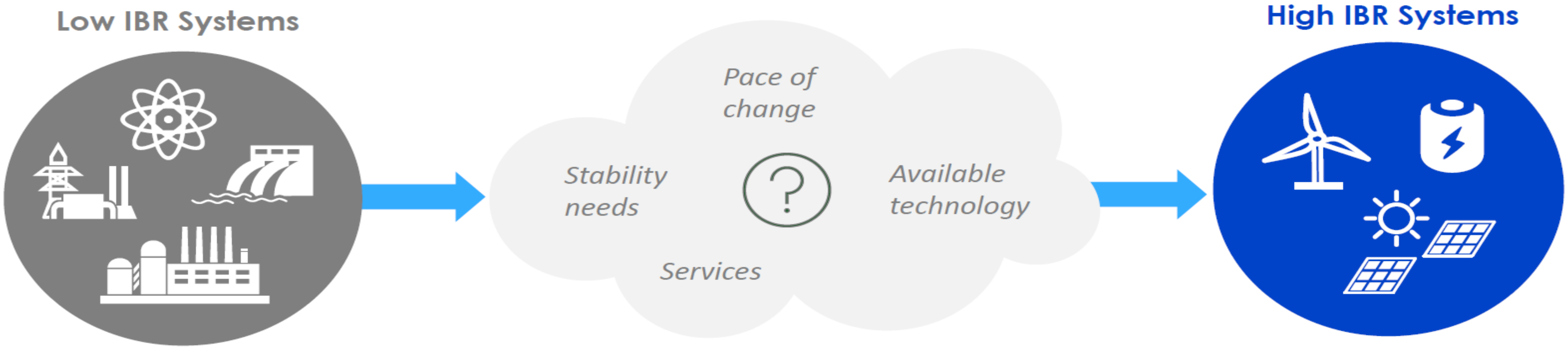
Mechanics of operation of a conventional synchronous machine

- Electromagnetic properties of the network and machines lock their behavior to be in sync
- A change in load is automatically/naturally reflected in change in speed of rotation of the machine
- System frequency is governed by speed and mass of rotating machines



Inherent tight coupling through laws of electromagnetism allow for seamless delivery of services from machines

Transition of the system brings about inherent risk

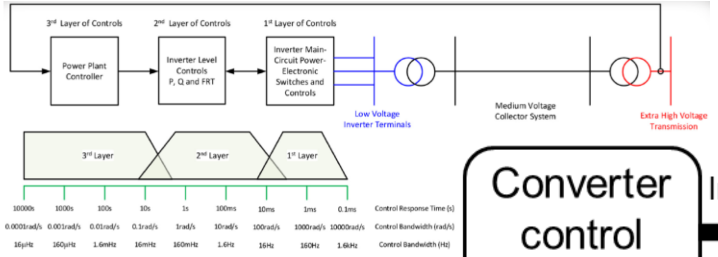


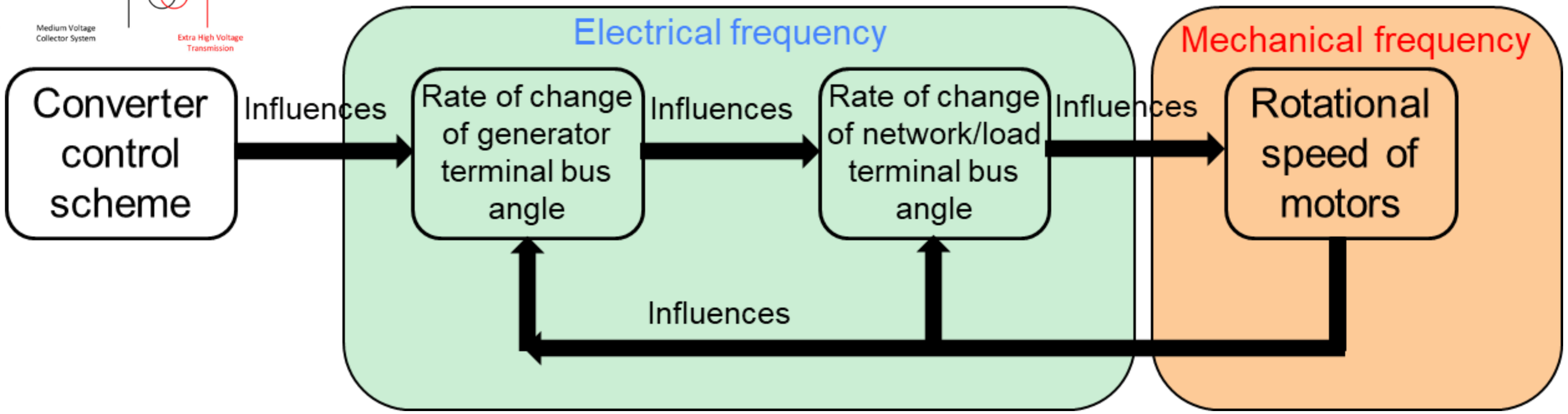
L. Lederman, et. al, "System Analysis Framework to Enable Transition to NET-zero (SAFE-T NET)", NERC IRPS Presentation, August 2025

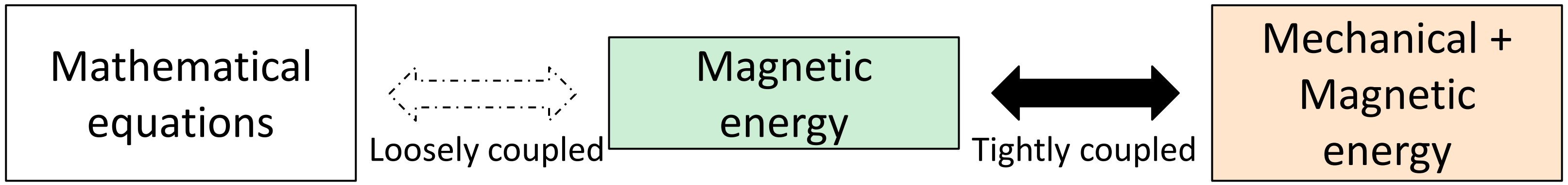
- Assessment and comparison of future scenarios in terms of stability and resilience requires multiple risk assessment frameworks, with assessment of services being critical
- Quantifying services from generation sources becomes a critical piece of these risk assessment framework

Mechanics of operation of an inverter based resource

- Break in the link between source and network
  - Some form of a mathematical synchronization controller has to be involved.
- A change in load does not automatically/naturally reflect in change of power output
- More specific definitions and requirements of services are needed.

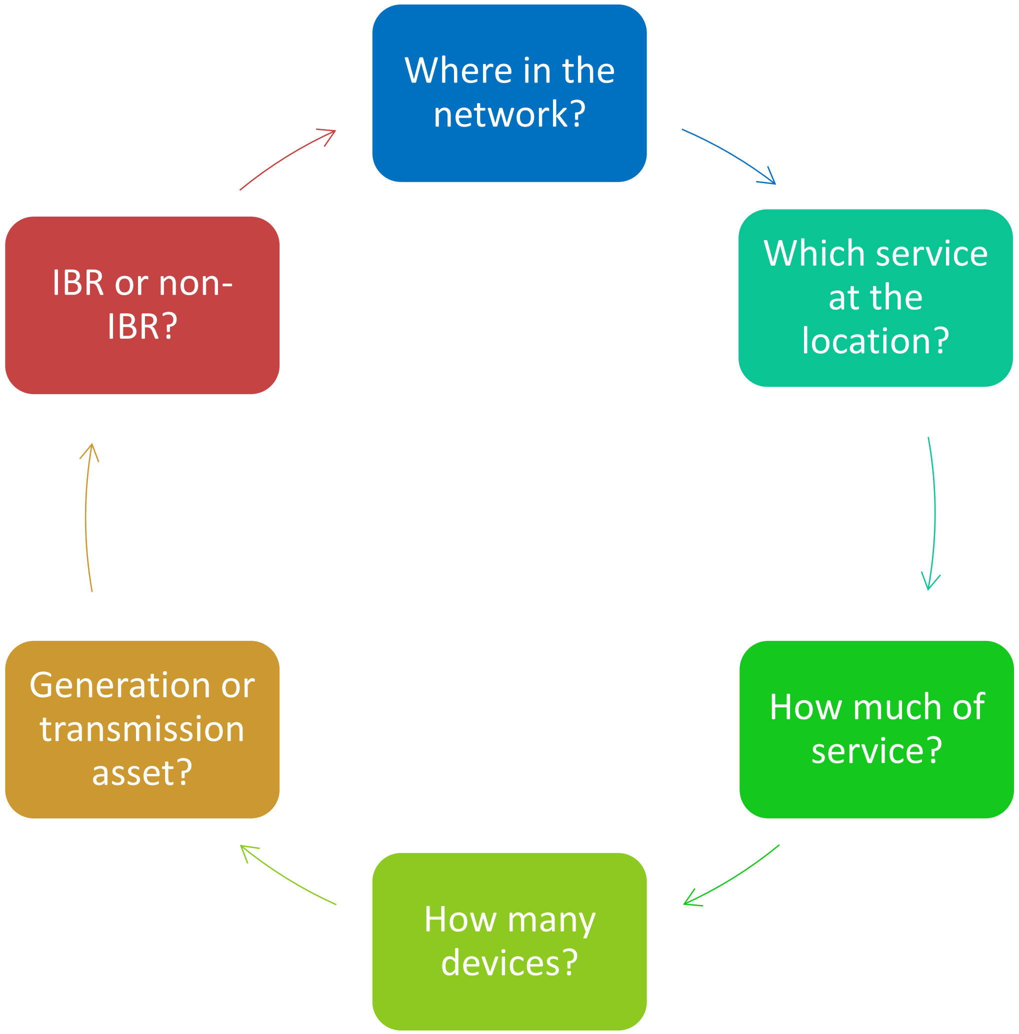






Delivery of services from the inverter will depend on (i) robustness, (ii) objectives, & (iii) structure of control system

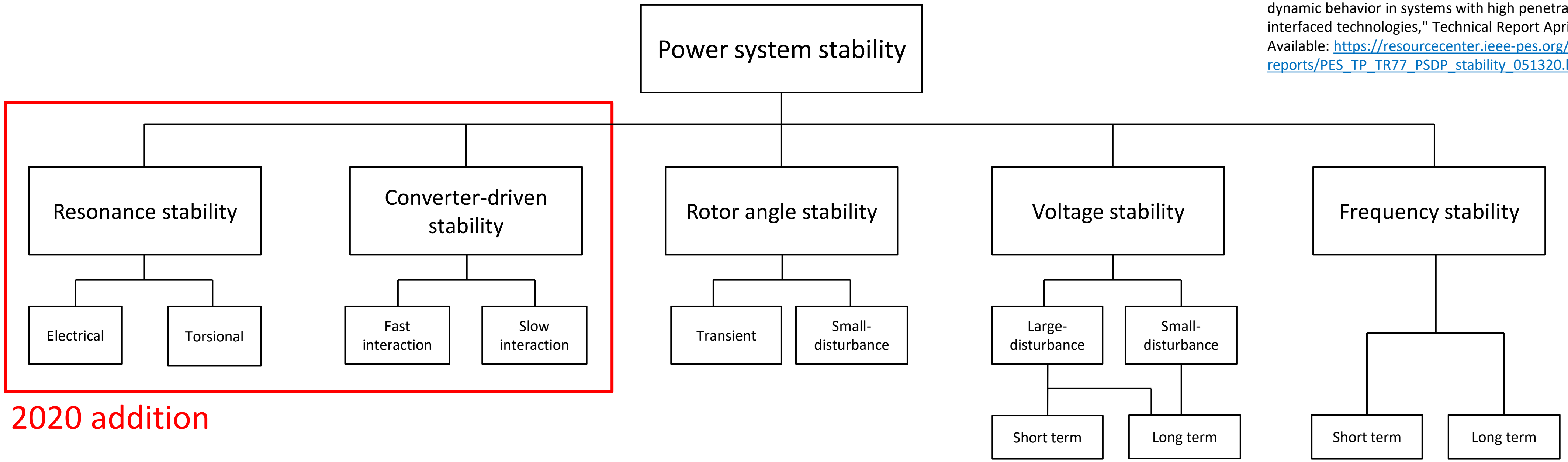
Questions that are to be asked when determining how should flexibility be provided



Planning and operation of a system with high IBRs requires an evaluation of capability and deliverability of performance from various devices in the network

Classification of power system stability expanded to reflect increase in IBR

Figure from: PES-TR77, "Stability definitions and characterization of dynamic behavior in systems with high penetration of power electronic interfaced technologies," Technical Report April, 2020. [Online]. Available: https://resourcecenter.ieee-pes.org/publications/technical-reports/PES_TP_TR77_PSDP_stability_051320.html



Resonance stability	Torsional	➢ SSR: interactions between series compensation and torsional models of the turbine-generator mechanical shaft ➢ SSTI/DDSSO: interaction of PE controls with mechanical torsional models of turbine-generator shaft
	Electrical	SSCI: Resonance between the effective inductance of an induction generator and a series capacitor
Converter-driven stability	Slow interaction	< ~10 Hz: Examples include interactions between the control of power electronic-based devices and electromechanical dynamics of synchronous machines, synchronous machine control, or network. Low frequency oscillations due to power electronic-based device control and system strength are included in this classification.
	Fast interaction	> ~10 Hz up to kHz: Examples include interactions between the control of power electronic-based devices and the network, or other PE-based devices

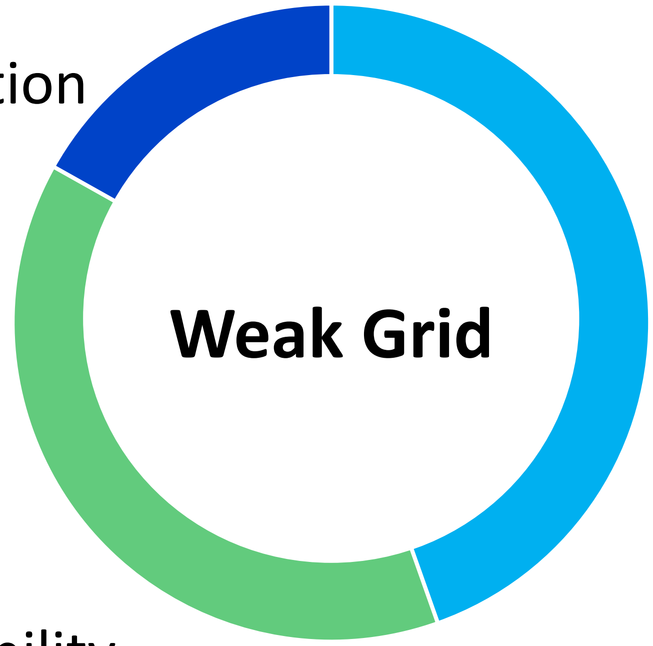
Voltage stability and system strength

Small disturbance and short term

What does weak grid mean?

Low short circuit MVA

- Challenges system protection



High $\frac{\Delta V}{\Delta I}$

high sensitivity of IBR terminal voltage to its current injection

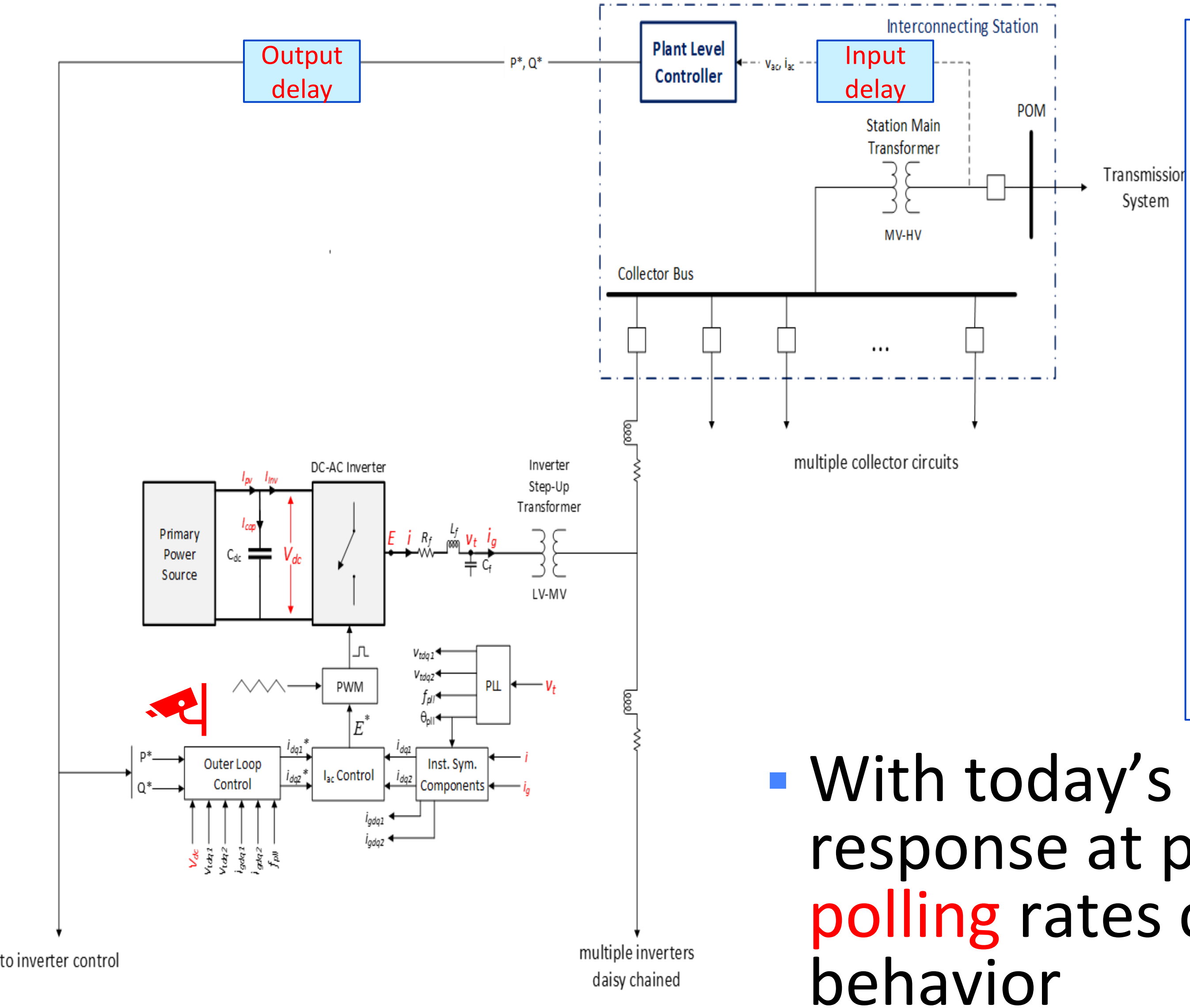
- Challenges stable operation of conventional IBR

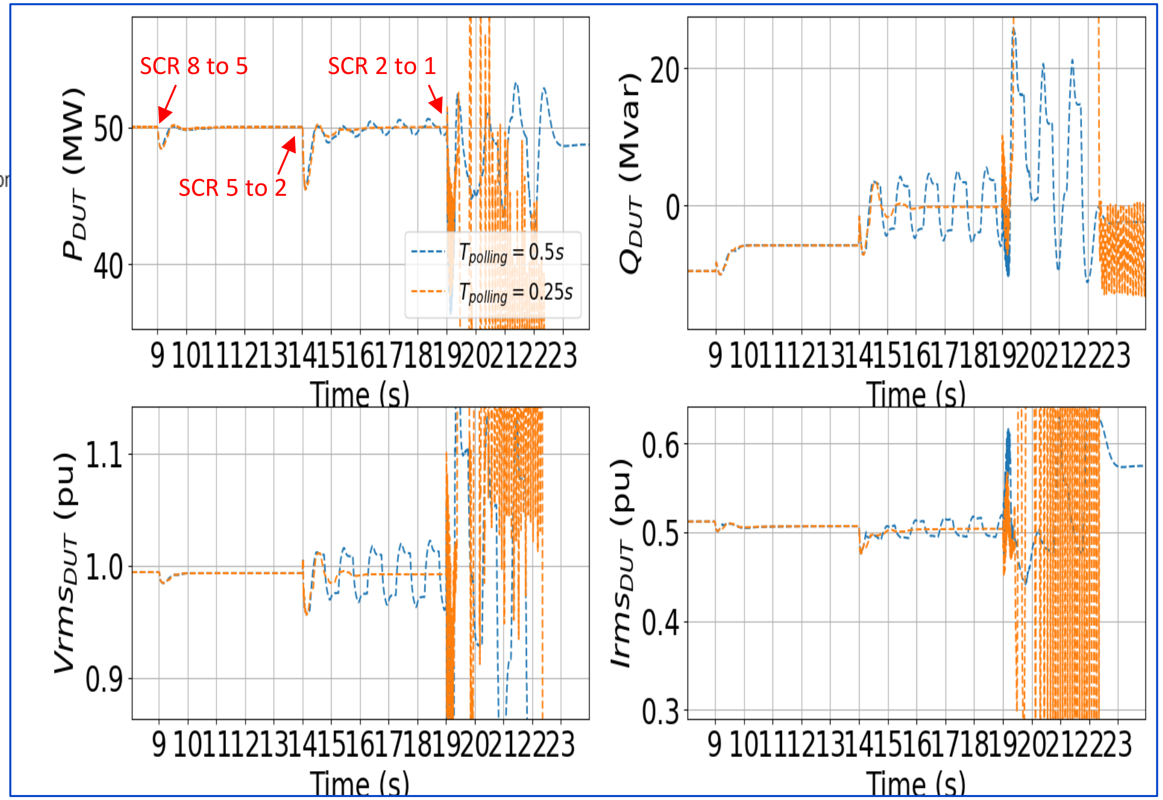
High $\frac{\Delta f}{\Delta t}$

low system inertia

- Challenges frequency stability of power system

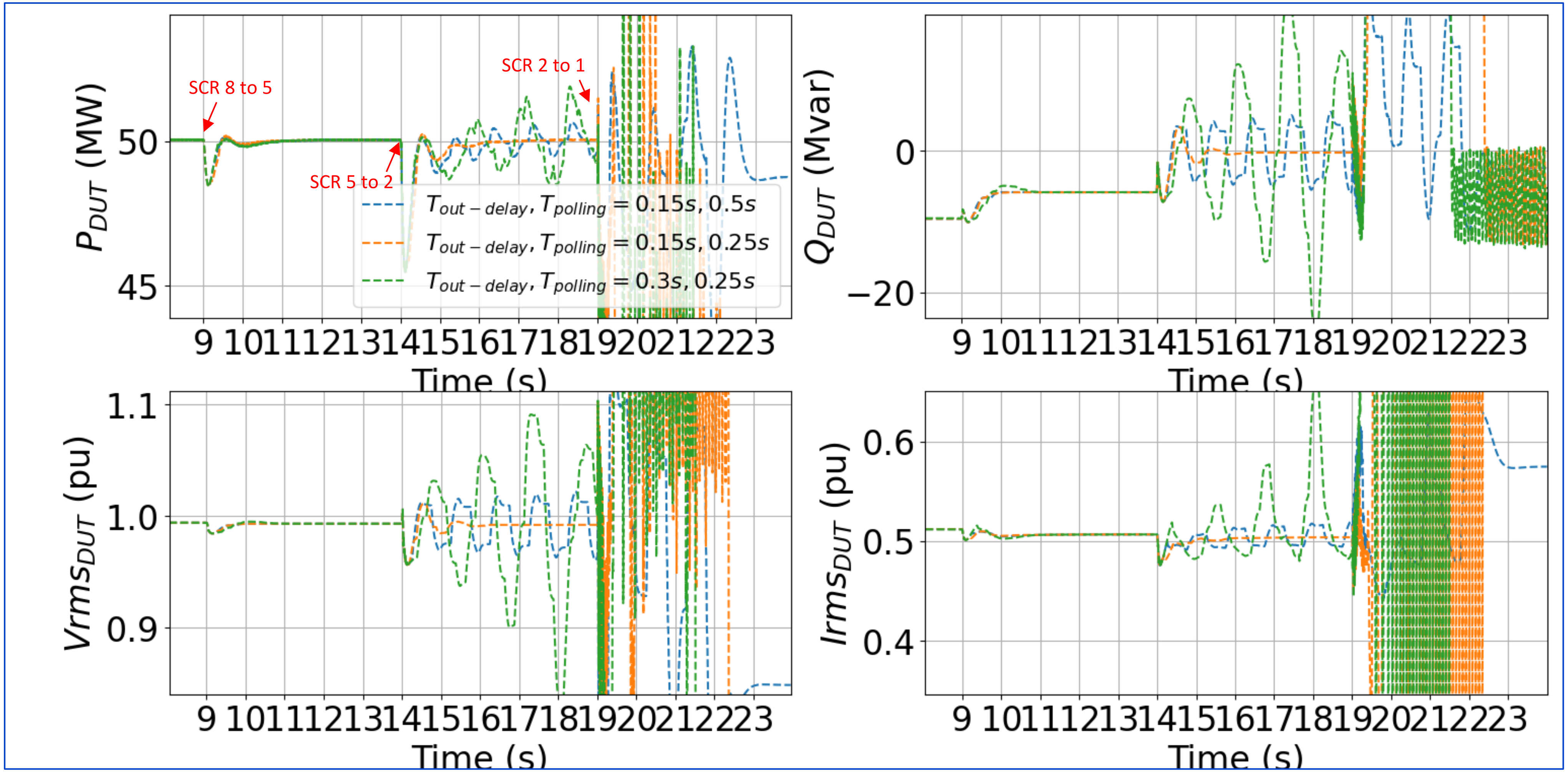
IBR plants being the cause of voltage instability





- With today's IBR plants having voltage response at plant level, differences in inverter's polling rates could introduce oscillatory behavior

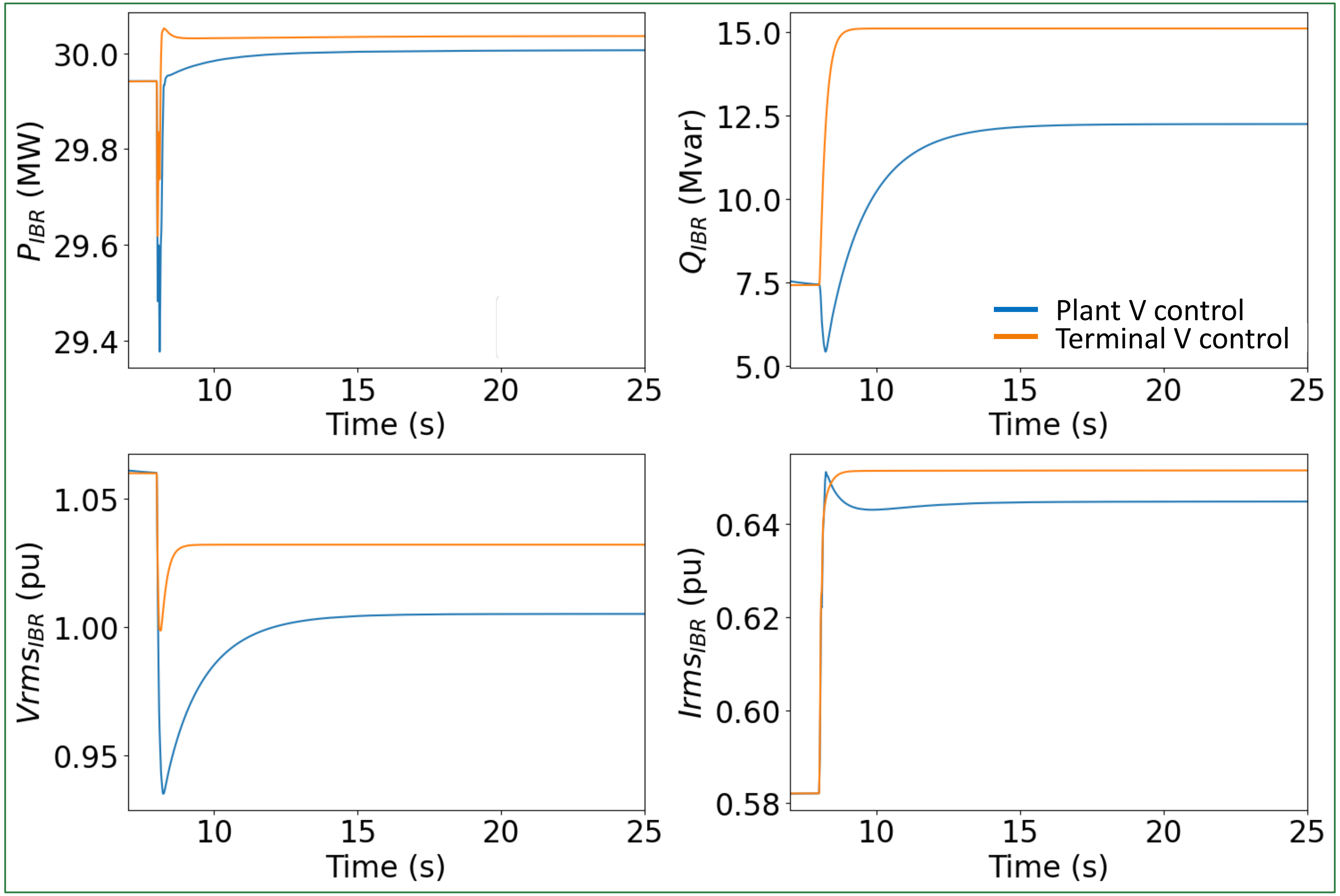
IBR plants being the cause of voltage instability



- With today's IBR plants having voltage response at plant level, differences in communication links could introduce oscillatory behavior

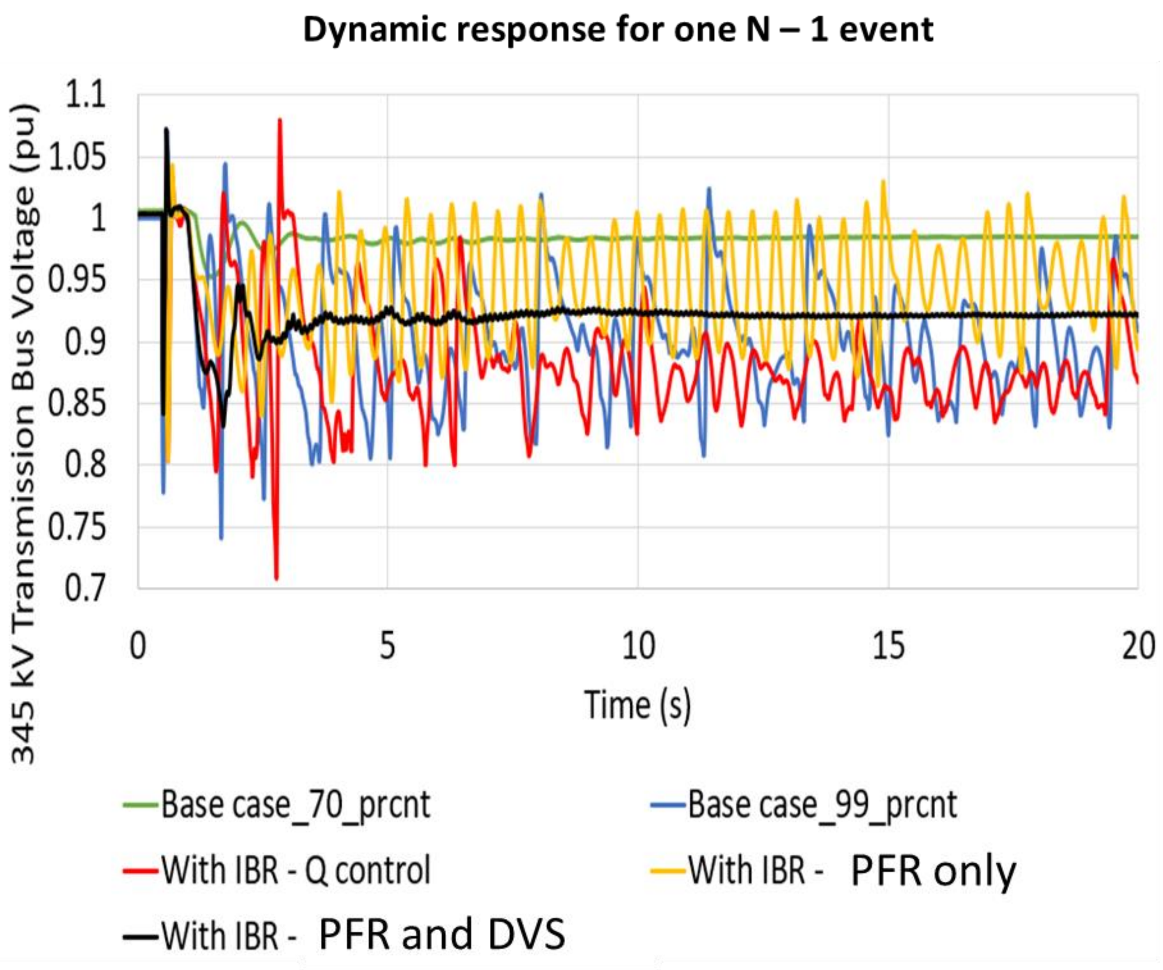
Flexibility provision from IBR

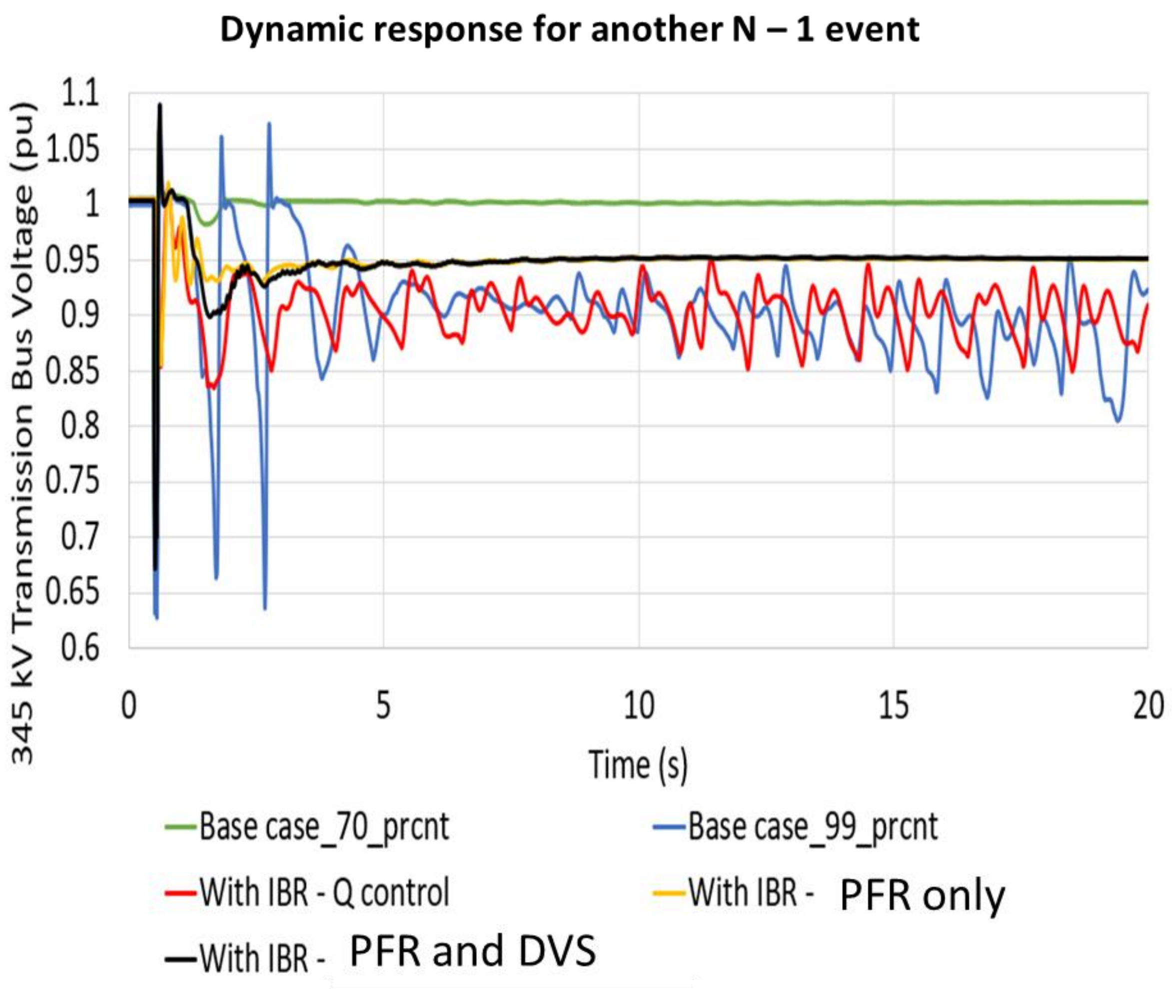
Terminal V control



- Plant level voltage control can be augmented with inverter level voltage control
- Could provide improved benefit with high IBR systems

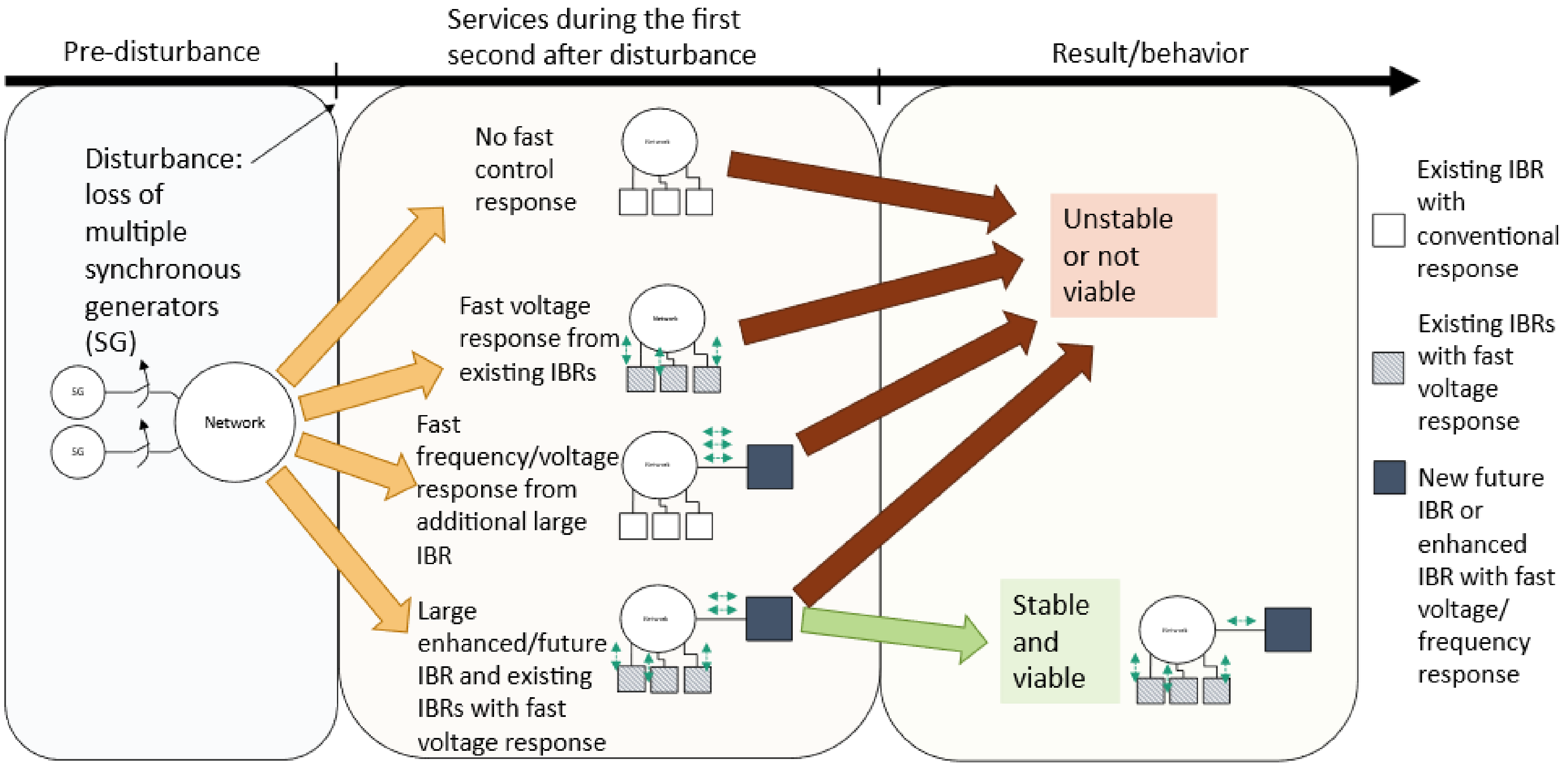
Potential application in South Texas to increase export of wind





With the inclusion of BESS providing fast voltage, wind export could be increased by 1 GW

Impact of voltage support services from IBRs

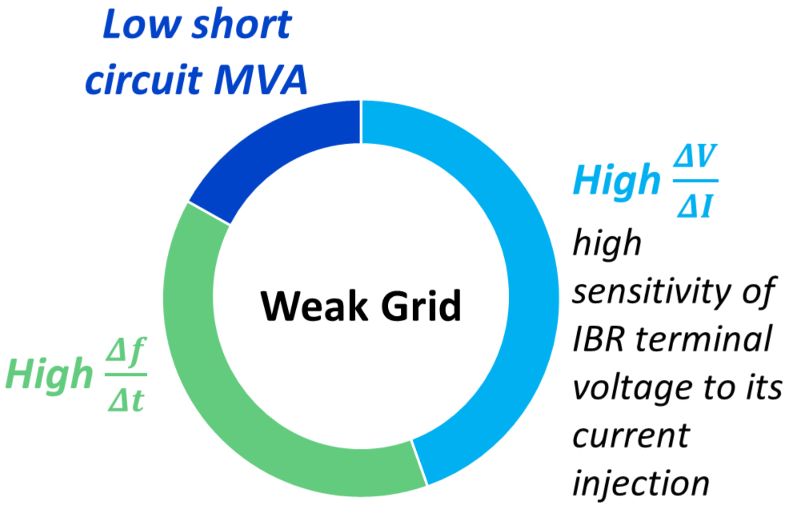


Voltage response: single large inverter may provide fast response, or the burden can be shared among multiple inverters

* Stable/unstable conditions based on the limited number of simulations conducted, and may not necessarily be generalizable to all systems and conditions/ disturbances

Energy Systems Integration Group. 2024. “Assessment of Inverter-Based Resources' Ability to Provide Voltage and Frequency Services: Phase I Results Summary.” Reston, VA
https://www.esig.energy/wp-content/uploads/2024/10/ESIG-Reliability-services-voltage-frequency-phase-I-2024a.pdf

Takeaways associated with IBR – weak grid

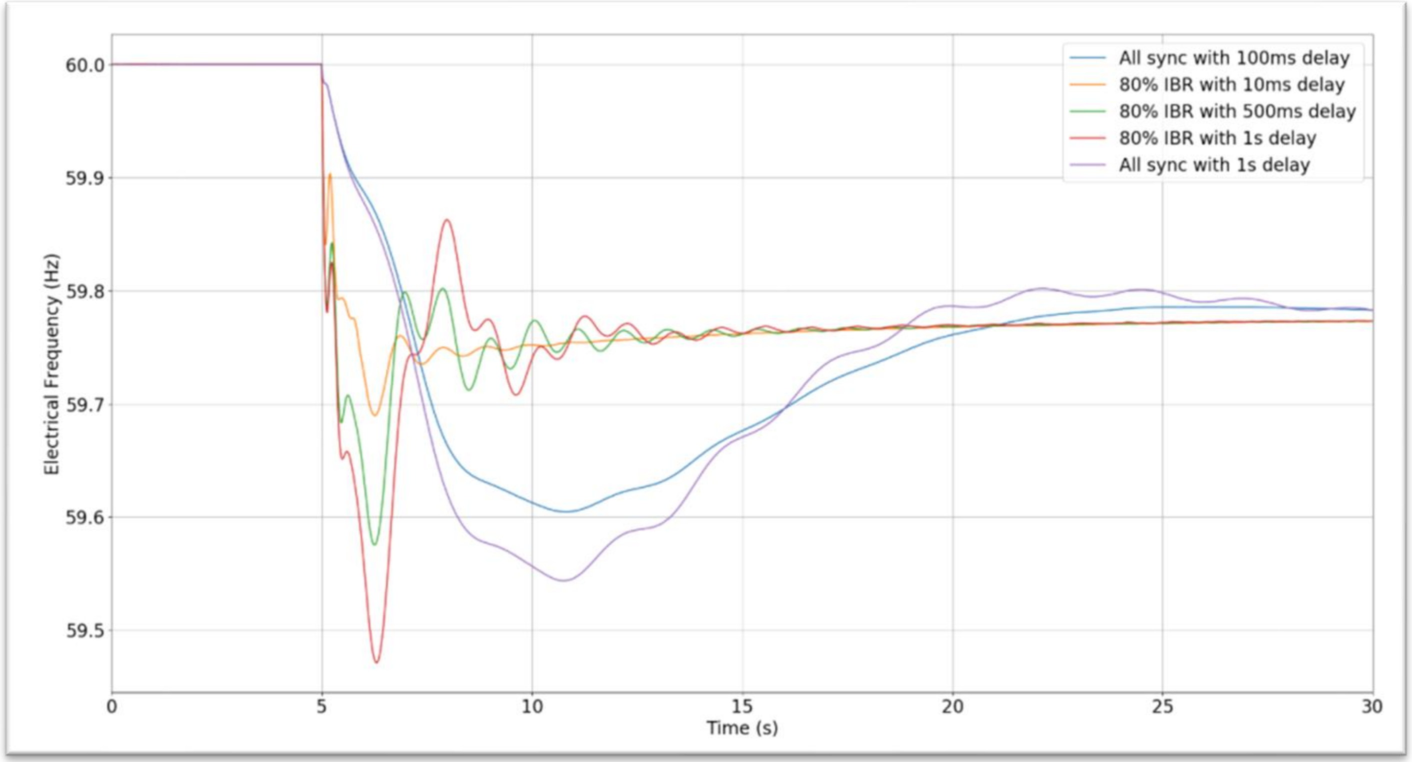


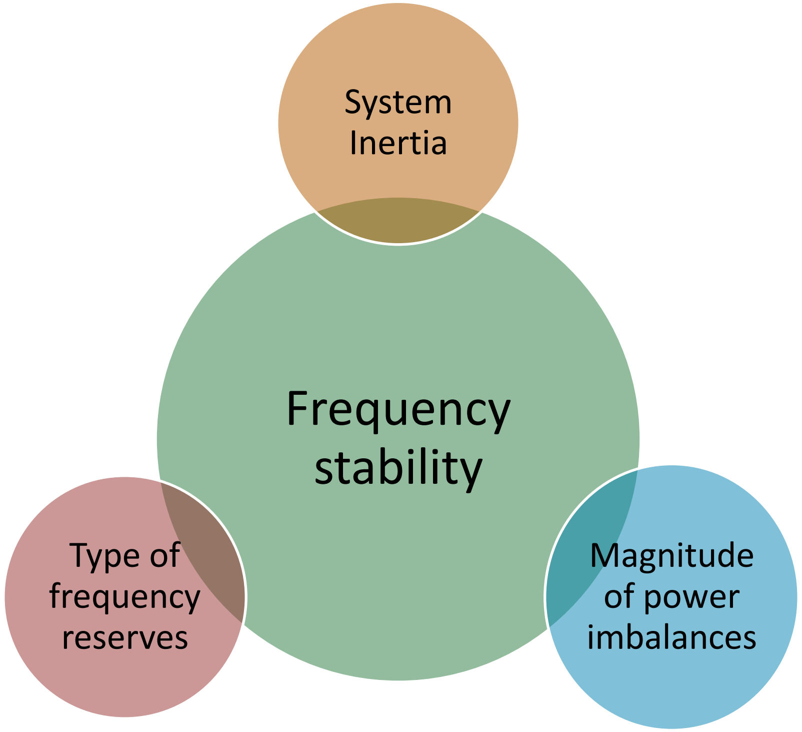
- **Challenges**
  - Protection and stability issues
  - Conventional IBRs struggle
  - Increased oscillations and inverter instability
- **Mitigation Options**
  - Strengthen transmission (increase SCR)
  - Add synchronous condensers
  - Re-tune IBR controls
  - **Adopt Advanced Grid Support (AGS/GFM) IBRs**

- **Transmission-Level AGS/GFM**
  - Stabilizes weak areas under contingencies
  - Reduces renewable curtailment and improves transfer capability
  - Helps maintain stability during outages and high IBR penetration
- **Distribution-Level AGS/GFM DER**
  - Strengthens local feeders with multiple DERs
  - Reduces size and burden on Tx-connected AGS/GFM BESS
  - Prevents DER tripping under IEEE 1547-2018 settings
- **System-Wide Benefits**
  - Improves damping of oscillations under high IBR penetration
  - Enhances resilience during faults

Frequency stability

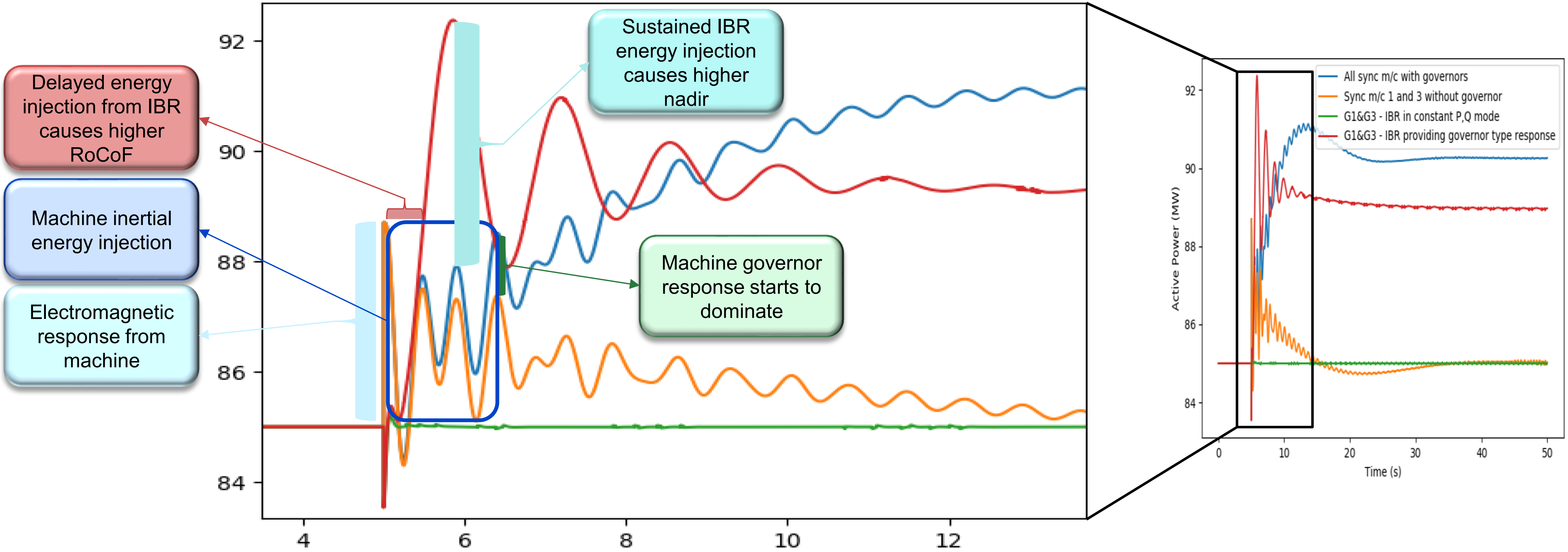
Factors affecting frequency stability





- Less commitment of synchronous generation reduces **system inertia** which leads to higher ROCOFs
- Power injection provided from **fast frequency reserves** can reduce the maximum frequency deviation
- Fast frequency response can compensate for the reduced system inertia
  - Less inertia devices need to be online

Inertial energy injection from synchronous machine compared to energy injection from IBR

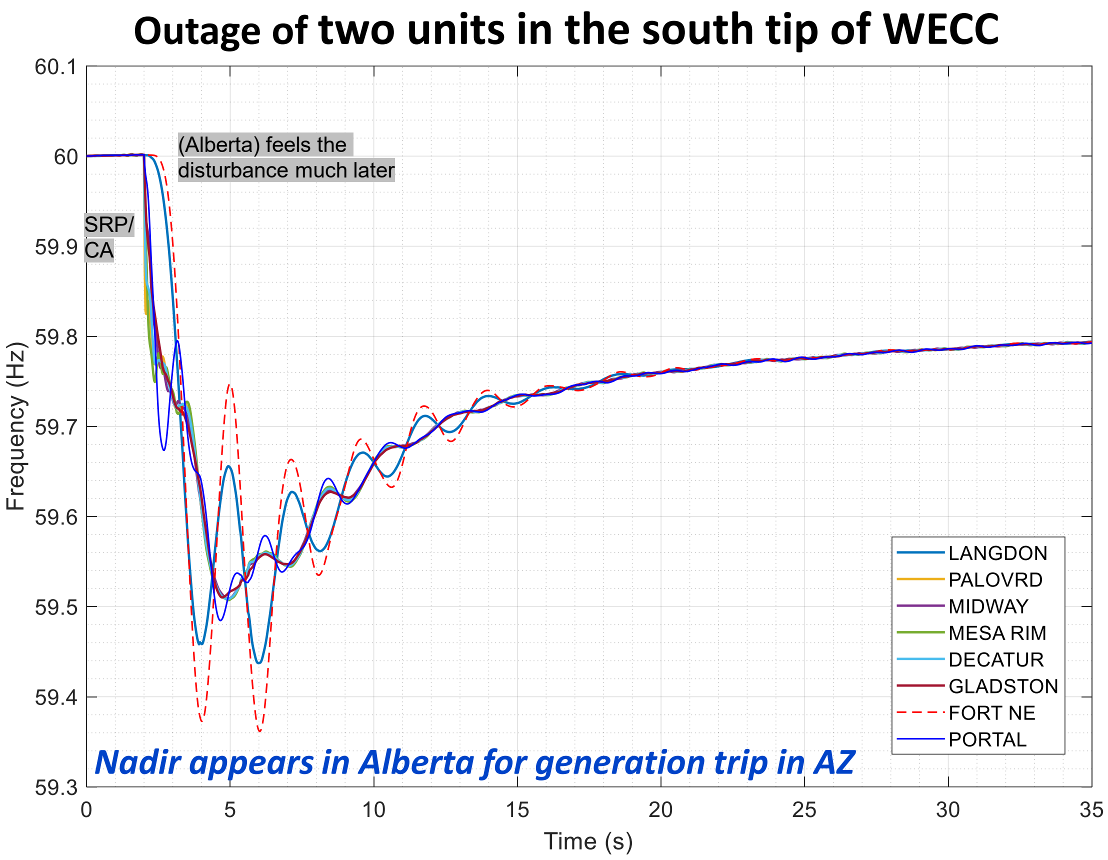


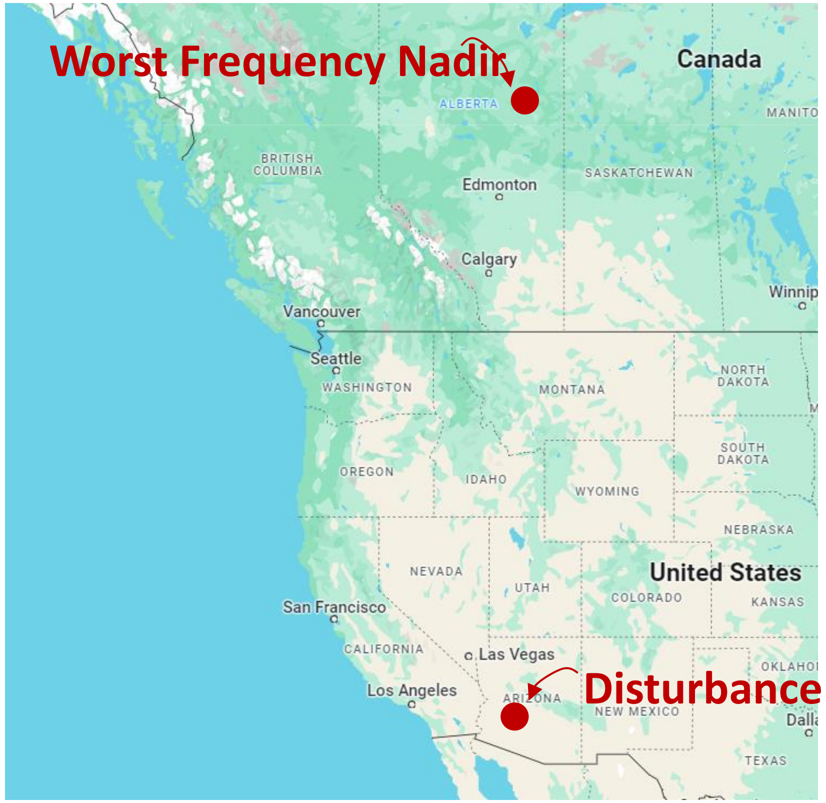
- IBR energy injection delayed by around 500ms
- But subsequent continued energy injection from IBR results in higher nadir

Reference: Frequency Response Primer: A Review of Frequency Response with Increased Deployment of Variable Energy Resources, EPRI Palo Alto 2018 3002014361

Regional Aspect of Frequency Dynamics

➢ **Simulation results from an EPRI-SRP inertia and frequency study project**



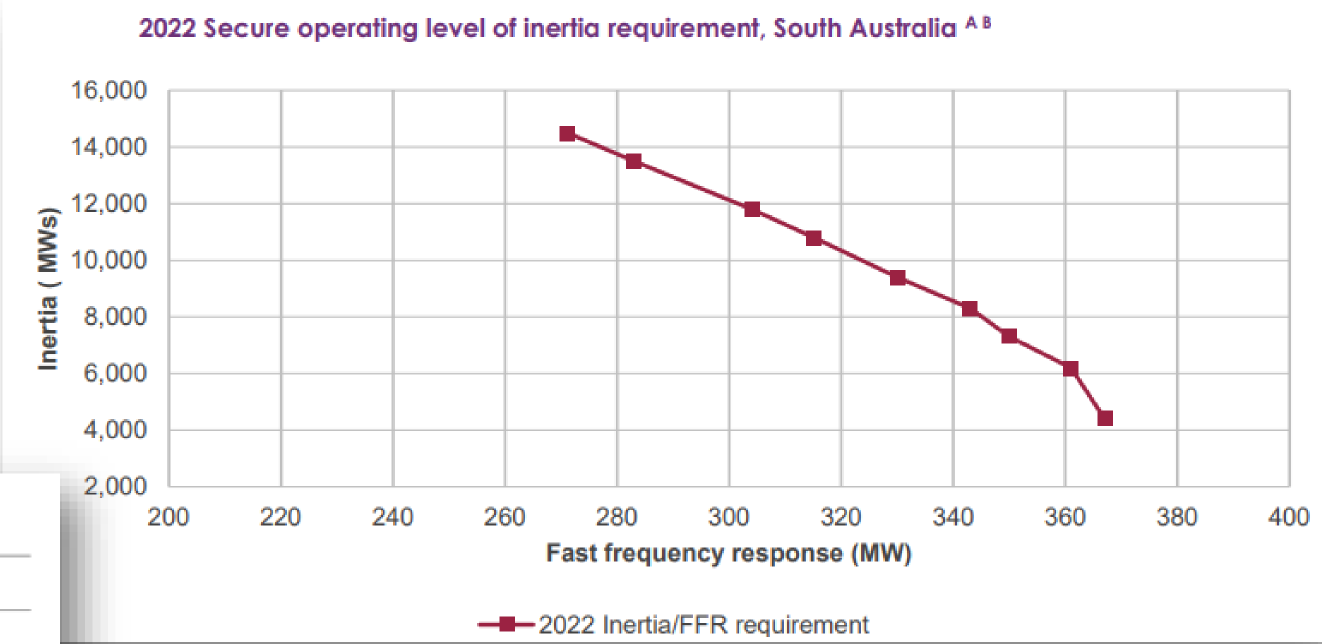


➢ **Frequency dynamics in certain regions** can deviate from the rest of the system due to their **regional inertia levels** and their **weak connections** to the rest of the system.

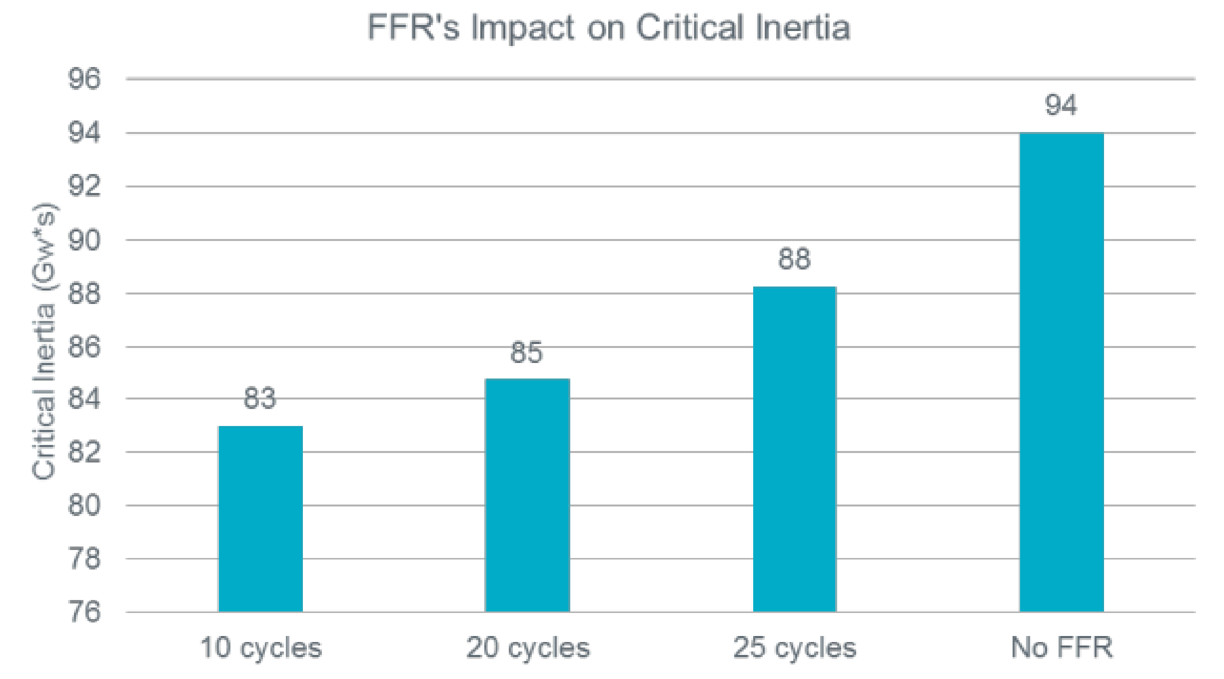
C. Zhang, P. Mitra, D. Ramasubramanian, V. Singhvi, M. Rhodes, B. Gong, S. Anderson, "Frequency Performance and Regional Inertia Analysis in High IBR Penetration Systems – An SRP Case Study on WECC System," *CIGRÉ Science & Engineering*, vol. 41, Jun 2026, pp. 1-16, https://cse.cigre.org/cse-n041/frequency-performance-and-regional-inertia-analysis-in-high-ibr-penetration-systems-an-srp-case-study-on-wecc-system.html

Fast Frequency Response (FFR)

Increasing level of FFR reduces minimum level of inertia required (17)



Source: AEMO, Australian Energy Market Operator (17)



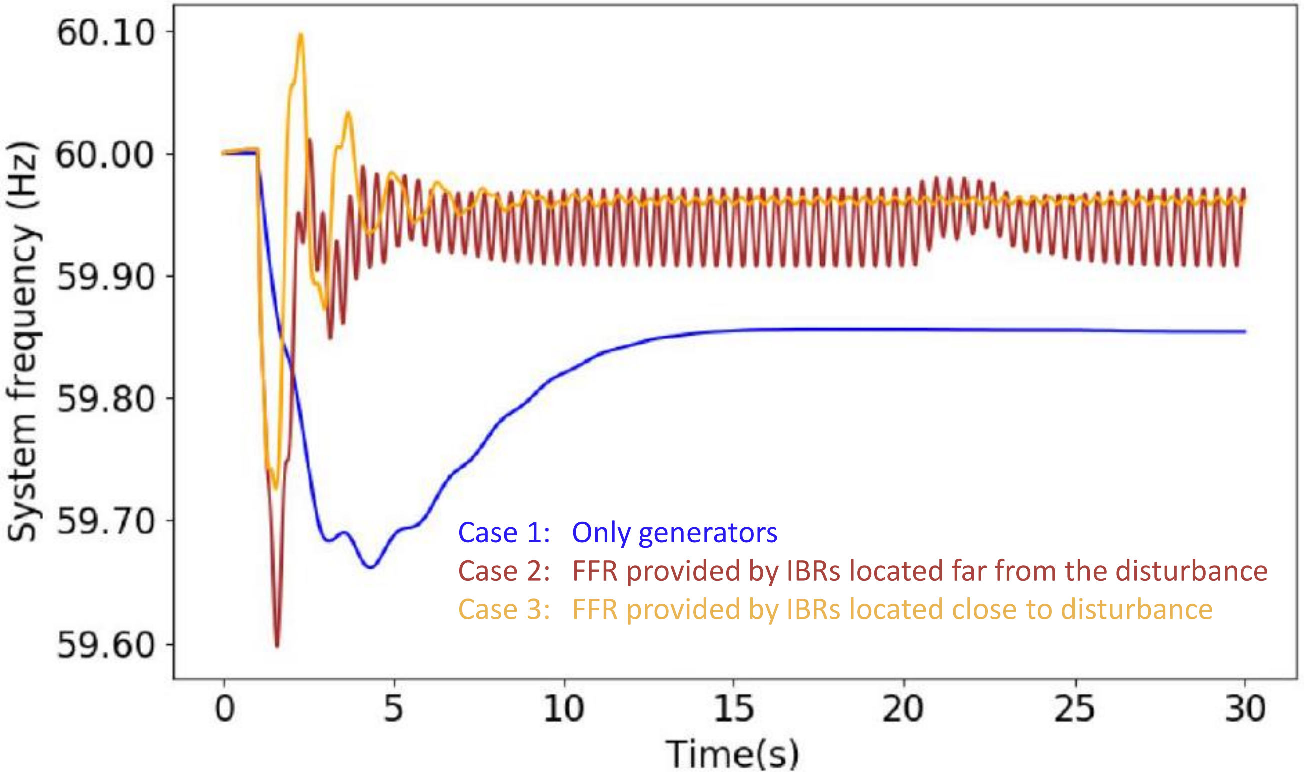
Source: ERCOT, Electric Reliability Council of Texas (18)

Decreasing FFR response time reduces minimum level of inertia required (18)

Further Reading: N. Miller et. al., "Technology Capabilities for Fast Frequency Response," GE Energy Consulting, 09 March 2017. [Online].

Fast response is not always good for the network

- Location of fast frequency reserves with regards to disturbance location also plays a role
- Fast Frequency Reserves (FFR) located far from the disturbance location can have adverse effect on system stability (Case 2)
  - Network structure can prevent delivery of stable fast response
  - FFR can deteriorate the system damping
- Same amount of frequency response leads to higher frequency nadir when reserves are located closer to the disturbance location (Case 3)
  - No adverse effect on system stability



Source: D. Ramasubramanian, P. Mitra, P. Dattaray, M. Bello, and V. Singhvi, "Delivery of primary frequency response over weak electrical paths," in 2021 IEEE Madrid PowerTech, 2021, pp. 1–6

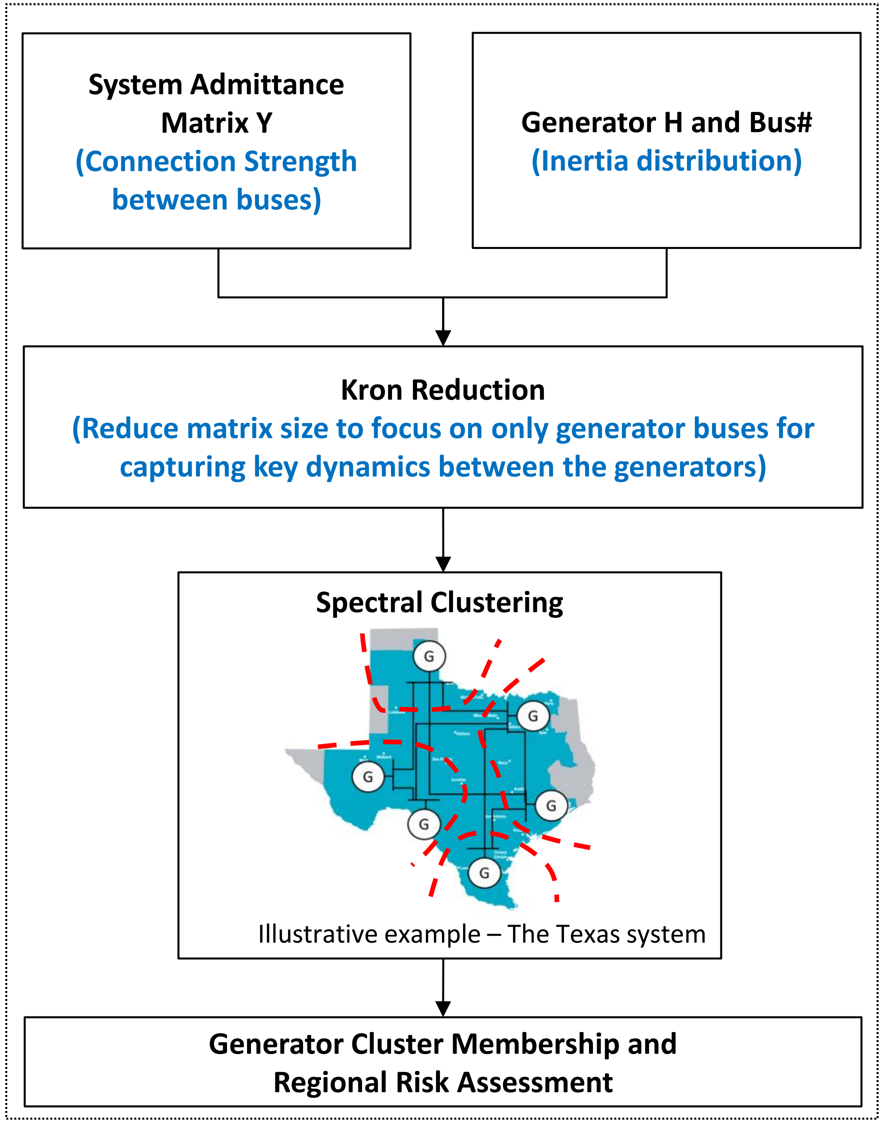
BESS can give FFR, but location of delivery is important

Inertia Regionalization and Risk Identification

- Integration of more IBRs **decreases *H*** and **increases the risk of regional inertia issues**.
- Traditional interconnection-wide frequency studies may overlook these regional frequency dynamics – **regionalization of the inertia** helps **identify risky areas** and **informs necessary mitigation measures**.

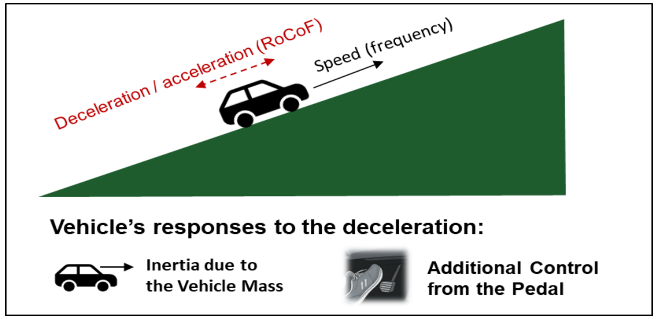
- A **spectral clustering approach** is used to group generators based on basic system information.
- **Inputs**
  - ✓ **Basic Network Data** (Connection strength between generators)
  - ✓ **Generator dispatch and inertia constants** (distribution of inertia)
- **Outputs**
  - ✓ **Clustering** results of generators
  - ✓ Metrics for **identifying risky regions**

**Does not require time-domain simulations*



Reference: EPRI Technical Report, "Inertia Estimation and Monitoring: Algorithm and Case Studies"

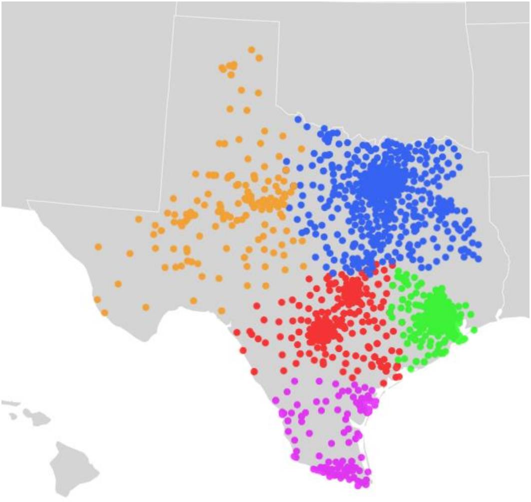
Takeaways IBR – frequency response



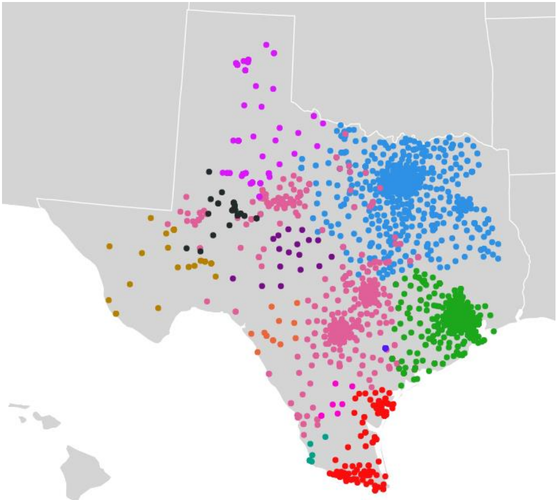
- **Challenges**
  - High IBR → low inertial time frame energy → faster frequency changes
  - Increased UFLS and cascading outage risk
- **Response Dynamics**
  - **Sync machines**: instant inertial energy
  - **AGS/GFM IBRs**: near-instant response, lower RoCoF
  - **GFL IBRs + FFR**: effective but few cycles initial delay
- **Observations**
  - First few cycles matter for RoCoF; energy injection equalizes after ~1s
  - Adequate headroom is critical for fast response
- **Controls & Limits**
  - GFL with FFR usually sufficient for frequency nadir
  - GFM adds stability and improved RoCoF benefits
  - Power/current limits and energy source characteristics affect performance
- **System Insights**
  - Aggressive Freq-Watt or GFM improves nadir in high-DER grids
  - Similar to conventional IBRs, some forms of GFM could give very fast response but may need tuning to avoid oscillations

Multi-Perspective Remedial Action for Regionalized Issues

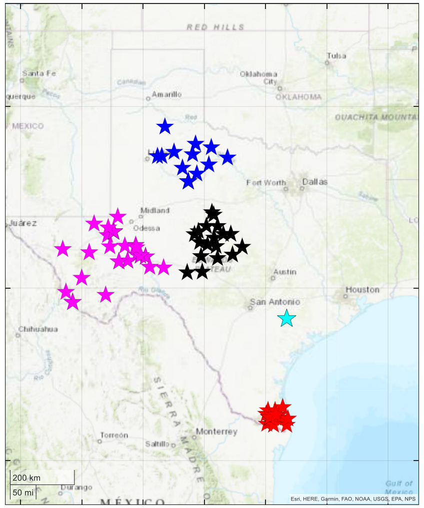
- Bus/Generator clustering methods are utilized in **inertia**, **voltage**, and **grid strength** analyses.
- They are based on either **admittance-matrix-based spectral clustering** or **sensitivity analyses**.
- Overlaying multiple clustering results from these aspects has the potential to **identify locations for optimal remedial decisions** that take **all these perspectives** into consideration.
- This leads to most **efficient remedial actions** that attend to all aspects and **avoids deterioration** in other aspects when placing resources for a certain purpose.



Inertia Regionalization



Voltage Control Areas

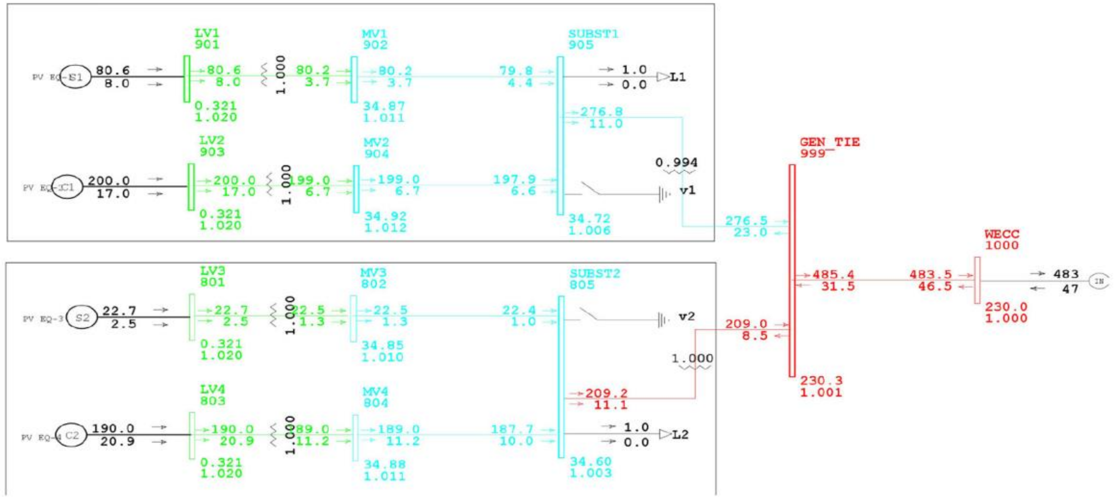


Grid Strength Assessment

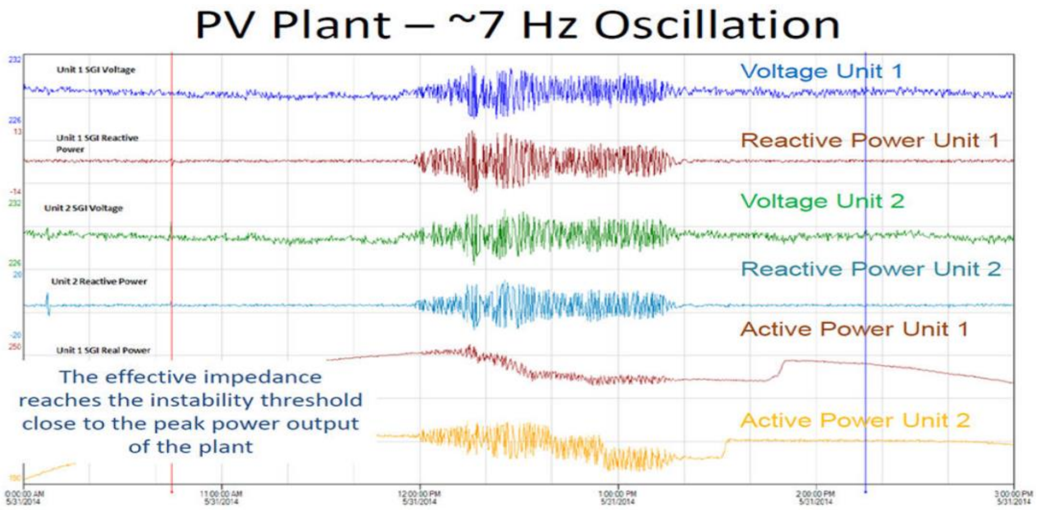
Inertia Regionalization: Identify inertia clusters and assess regional inertia risks. Link to EPRI Technical Report.
Voltage Control Area (VCA): Determine voltage control areas and assessment of reactive power reserve for transmission systems. Link to VCA.
Grid Strength Assessment (GSAT): Evaluate system strength under various network and topology conditions. Link to GSAT.

Oscillatory Stability

Oscillations Due to Weak Grid Conditions

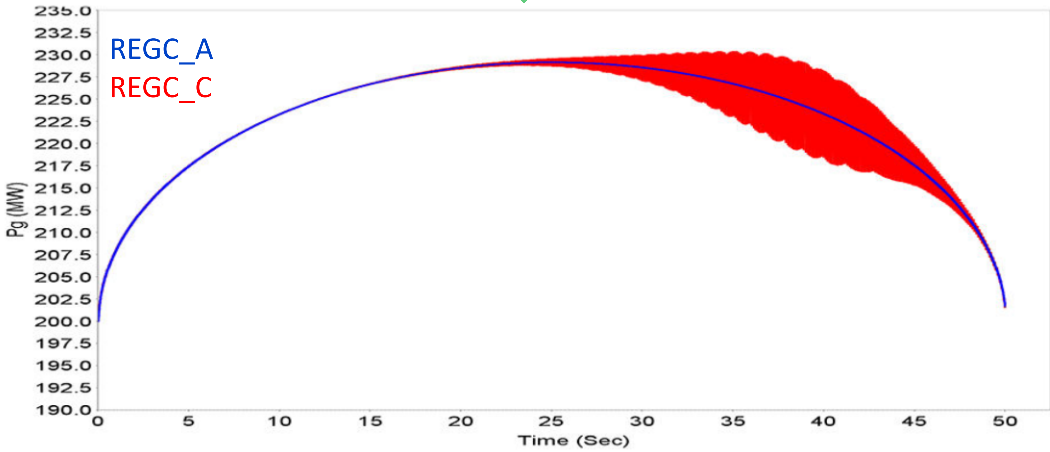


Oscillation occurred as plant output ramps up to maximum



First Solar Inc.: 'Deploying utility-scale PV power plants in weak grids,' 2017 IEEE Power & Energy Society General Meeting, July 2017

Recreated in simulation



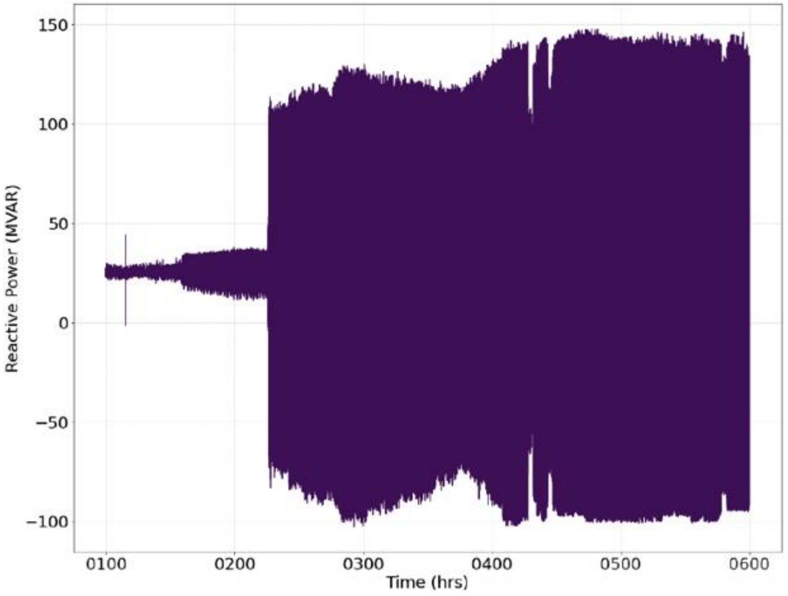
- Use of improved robust positive sequence models to re-create low short circuit events
  - ~ 7 Hz oscillation observed in SCADA measurement
  - ~ 9 Hz oscillation observed in simulation
- Simulation time scale is for computation efficiency

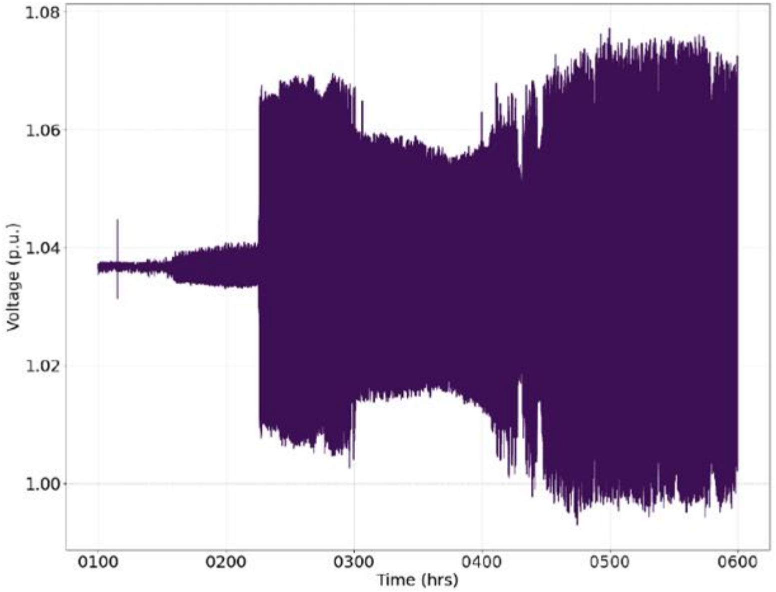
Reference: D. Ramasubramanian *et al*., "Positive sequence voltage source converter mathematical model for use in low short circuit systems," in *IET Generation, Transmission & Distribution*, vol. 14, no. 1, pp. 87-97, 17 1 2020 (link)

In collaboration with PEACE, PLLC. and First Solar

South Australian Oscillation – 2022

- prolonged oscillatory event characterized by voltage and reactive power oscillations
- classified as a plant-originated control-system oscillation involving voltage and reactive power control

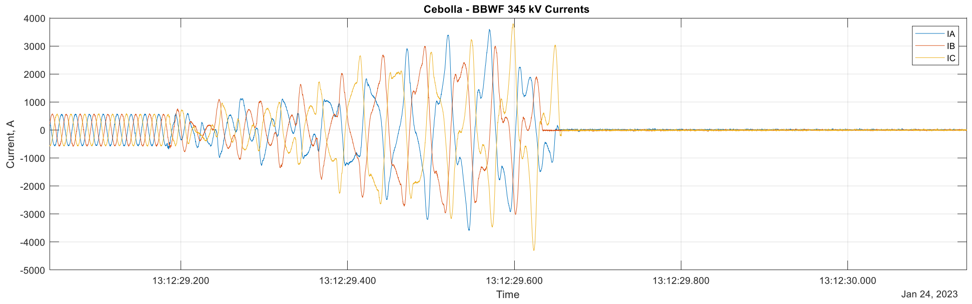


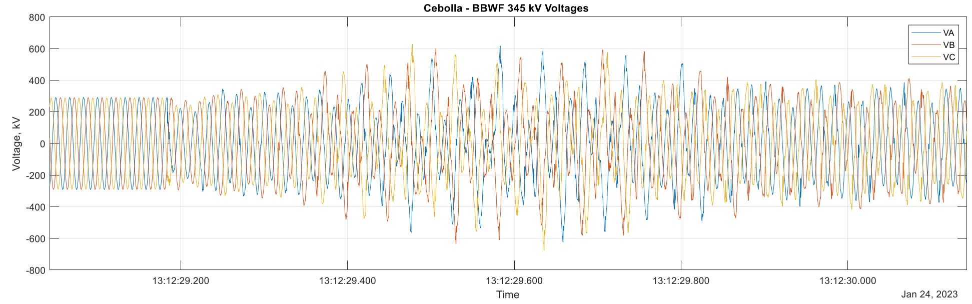


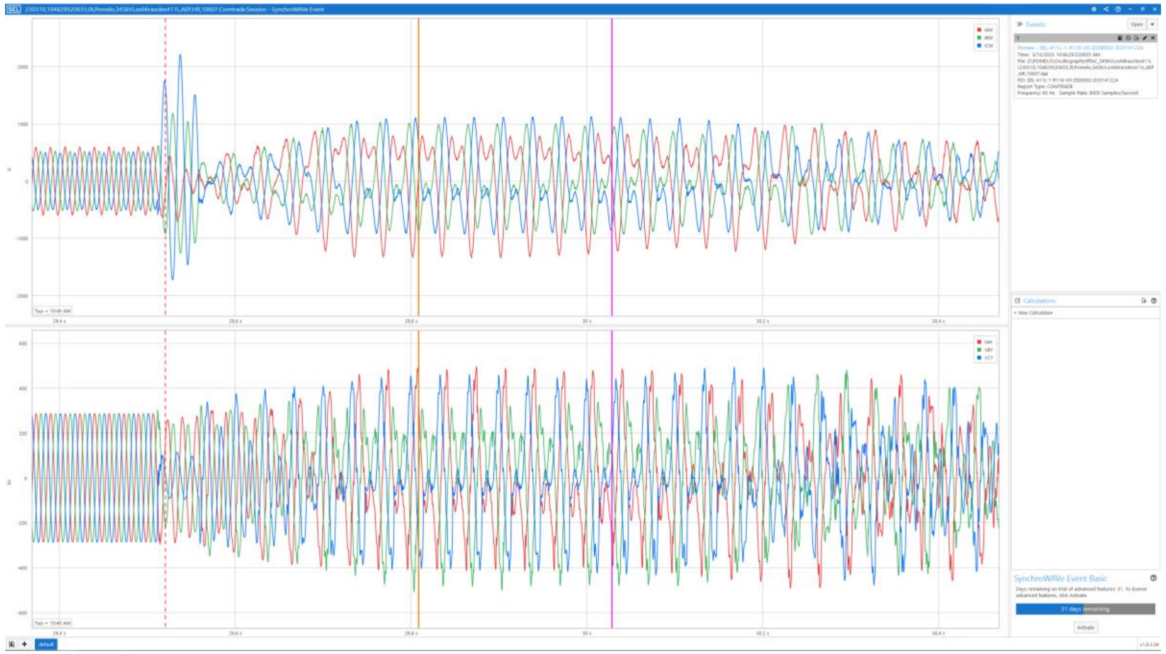
https://www.aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2022/south-australia-power-system-oscillations.pdf?la=en

SSO Events in 2023

- 228 MW WF interconnecting to middle of a 345 kV line series compensated at one end, WF generating near its MW capacity
- Four WFs totaling 937 MW capacity interconnecting toward one end of a (different) 345 kV line series compensated at two locations







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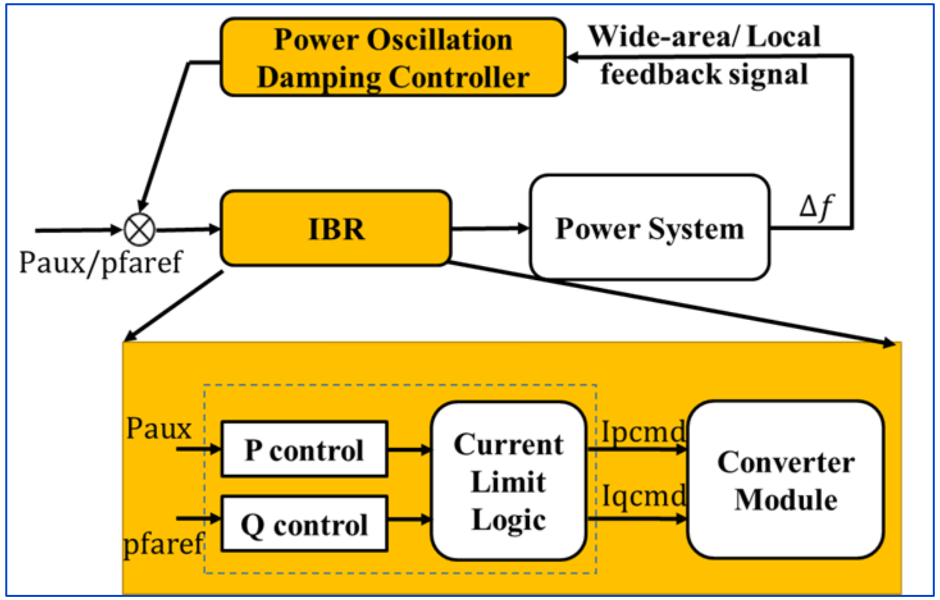
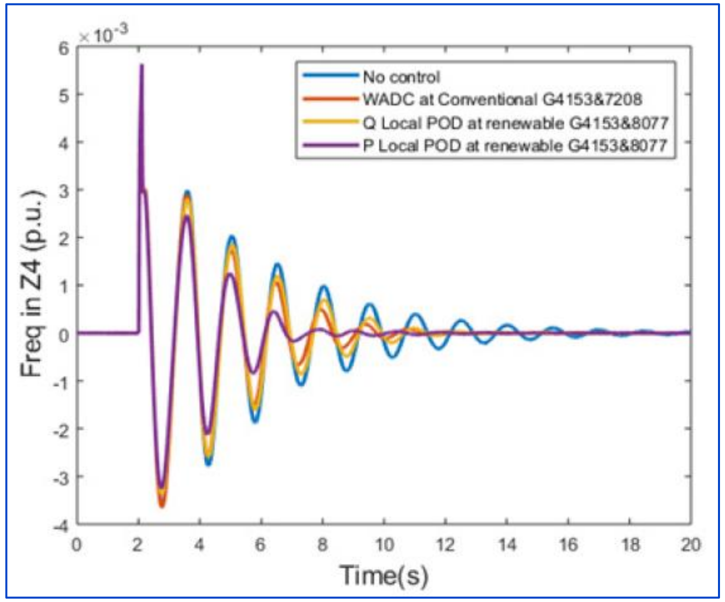
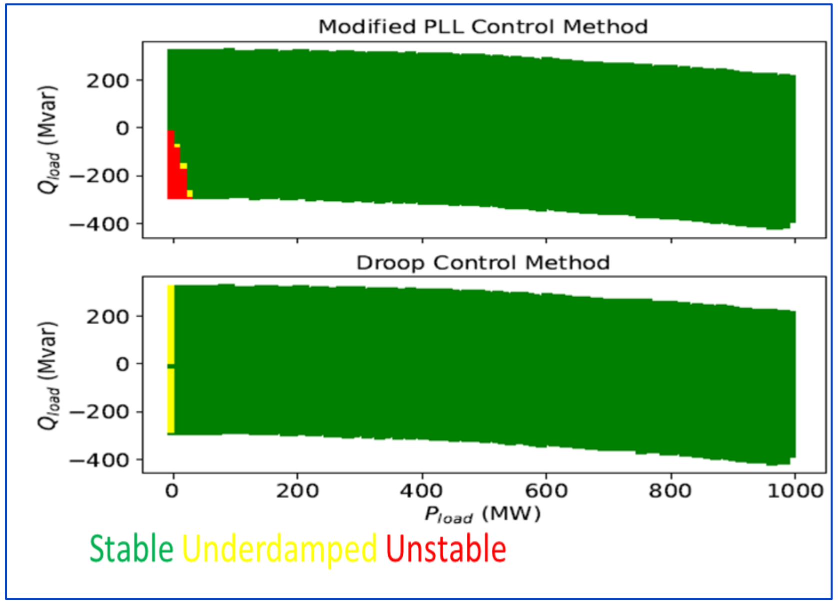
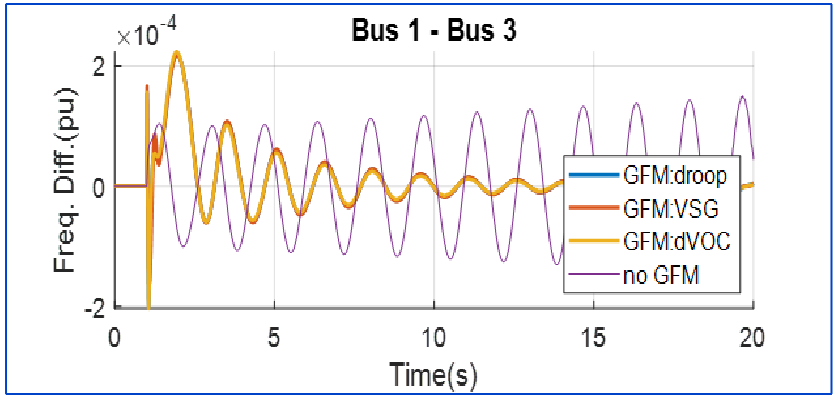
Power oscillation damping (POD) in inverter-based resources







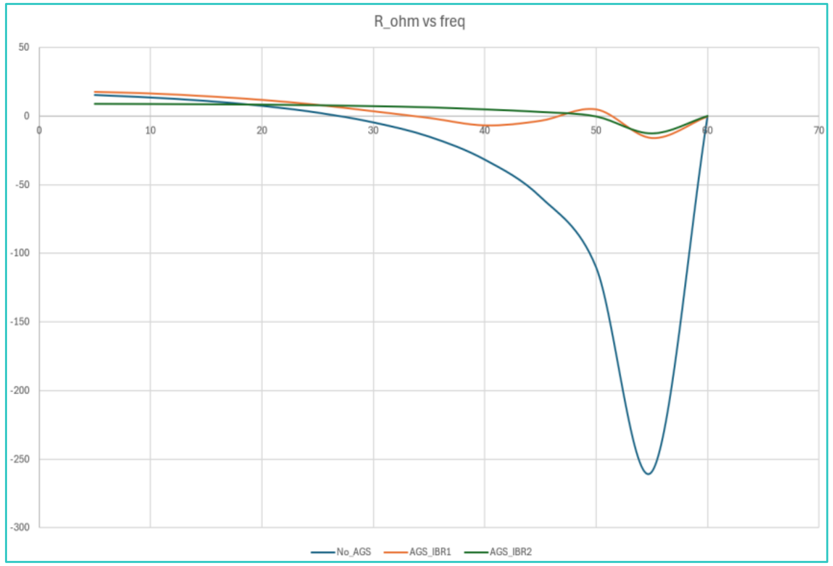
- Power oscillation damper can be used similar to power system stabilizers
- Some inverter controls may have inherent capability for damping
- With IBRs, there either active power or reactive power can be modulated
- Source constraints/limits have to be kept in mind

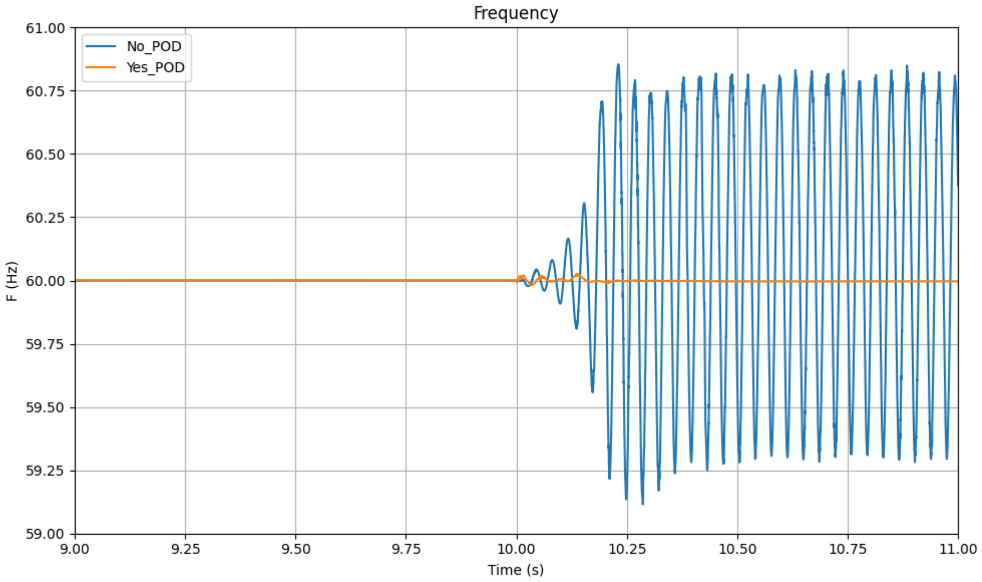


IBR with POD could provide sub-synchronous damping

- Comparing three different OEM IBRs
  - Without AGS – potentially large negative damping
  - AGS_IBR1 – improved damping
  - AGS_IBR2 – further improved damping

Will a network with known SSR risk automatically benefit due to this IBR with AGS?

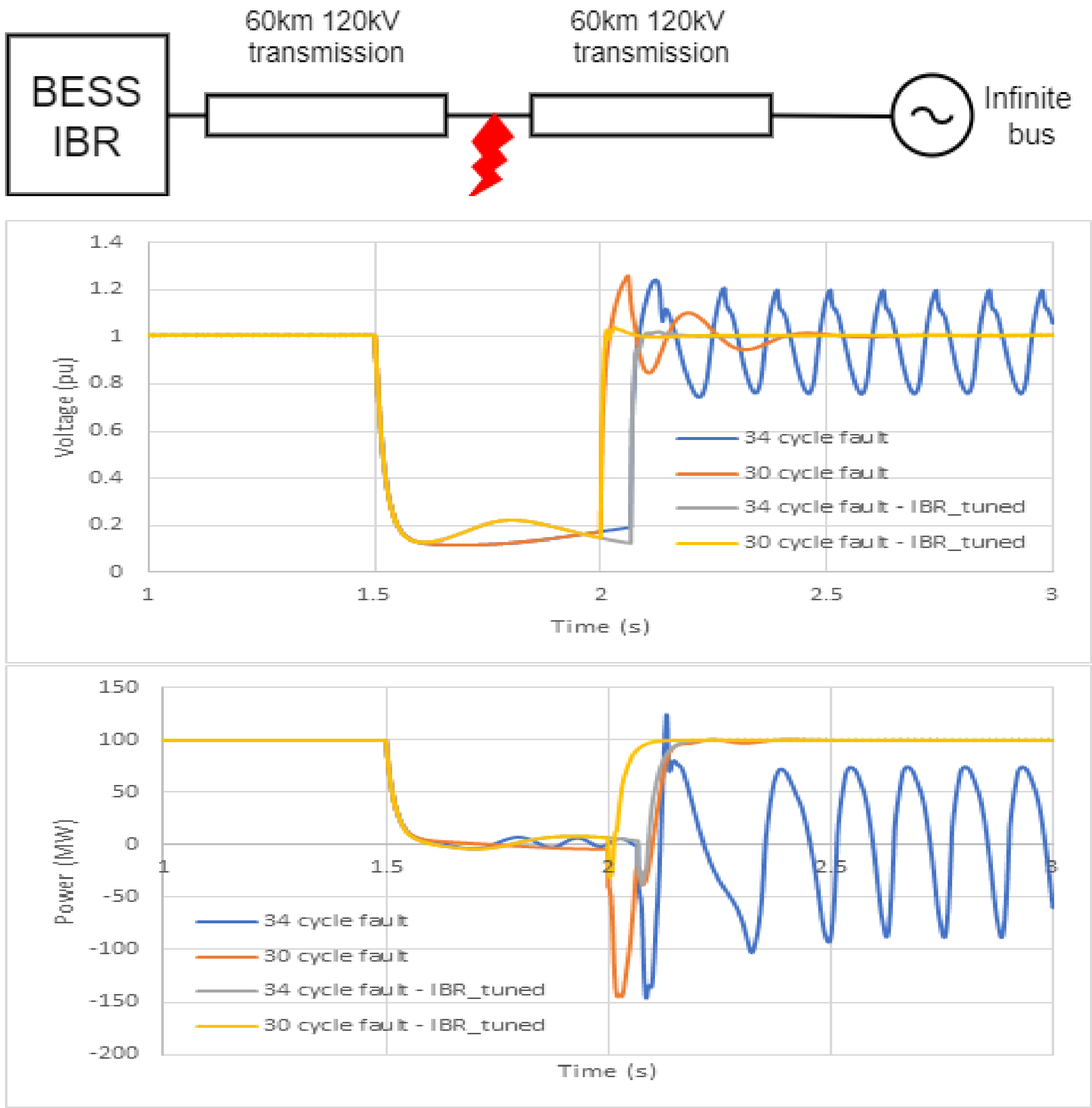




Transient Stability

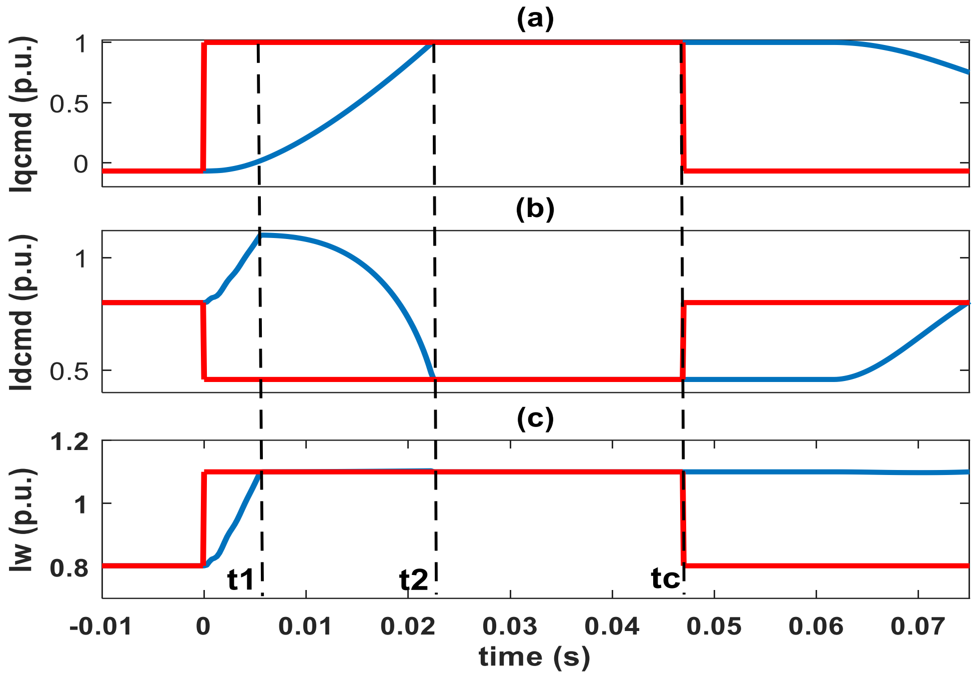
IBR's Critical Clearing Time (CCT)

- This is not related to acceleration/deceleration energy from conventional CCT perspective
- If appropriately tuned, stability of IBRs can be invariant to fault duration
  - Doesn't necessarily imply that CCT is not important



It is not all about PLL – Outer loops play a role too

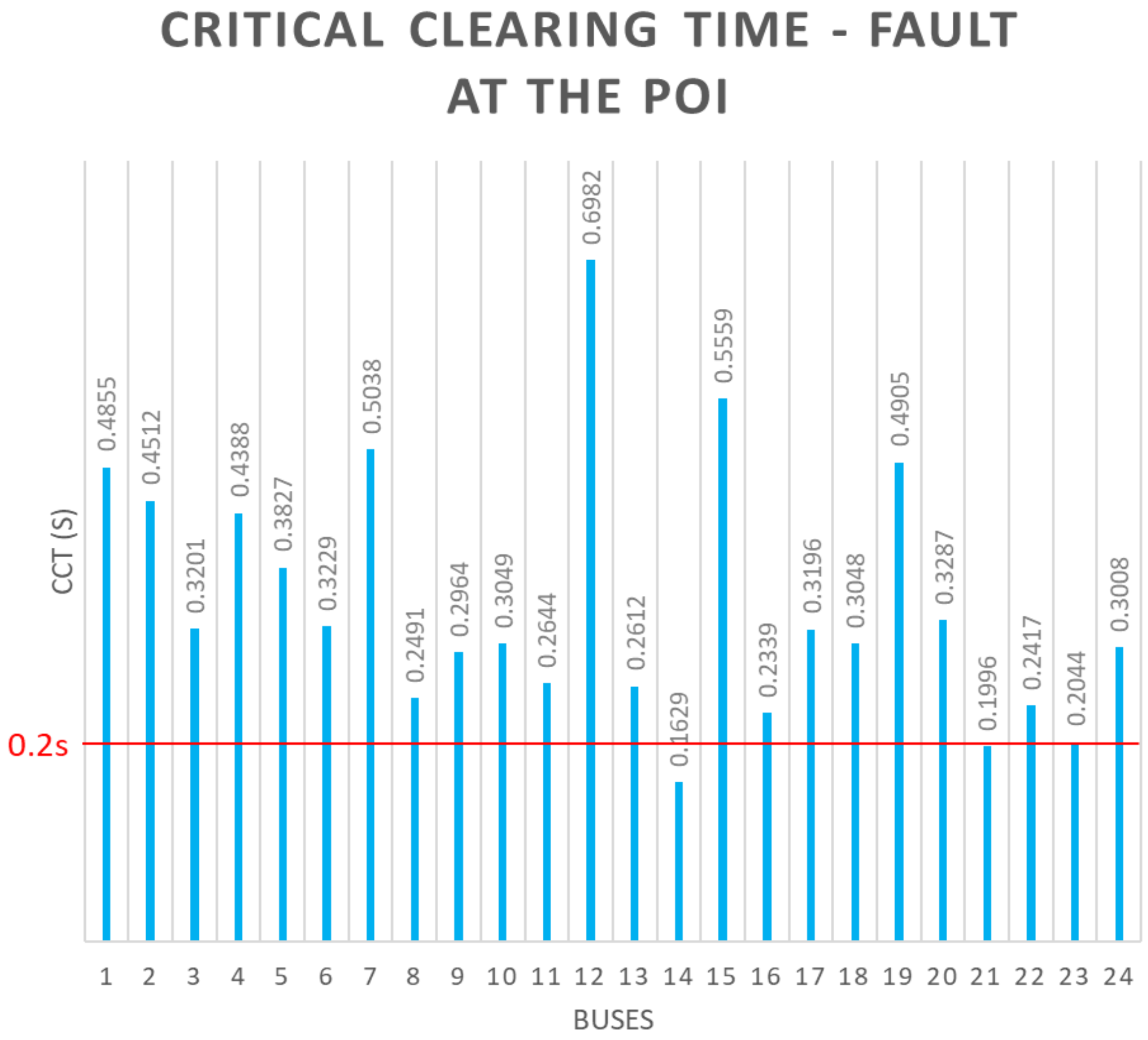
- Ignoring the influence of outer loop controllers on the dynamics of IBR output current causes errors in the CCT calculation
- To assess the CCT more accurately, the dynamics of current, and their limits, need to be considered.



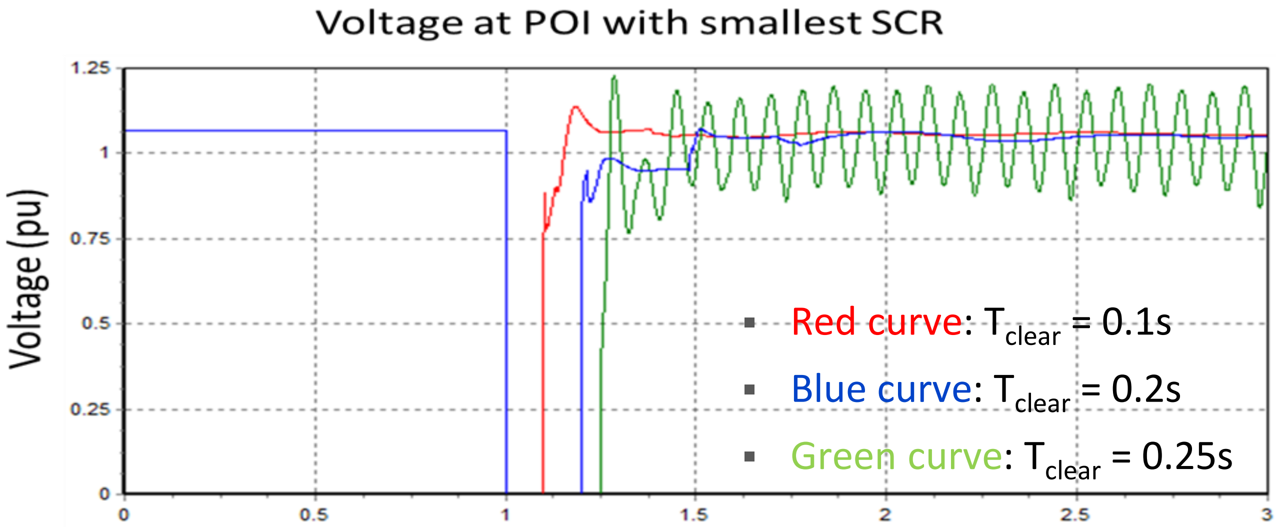
- The fault occurs at $t = 0$ and is cleared at $t = t_c$
- I_w is the total current magnitude
- The blue curve is the response considering the outer loop controllers while the red curve shows response without considering the controllers

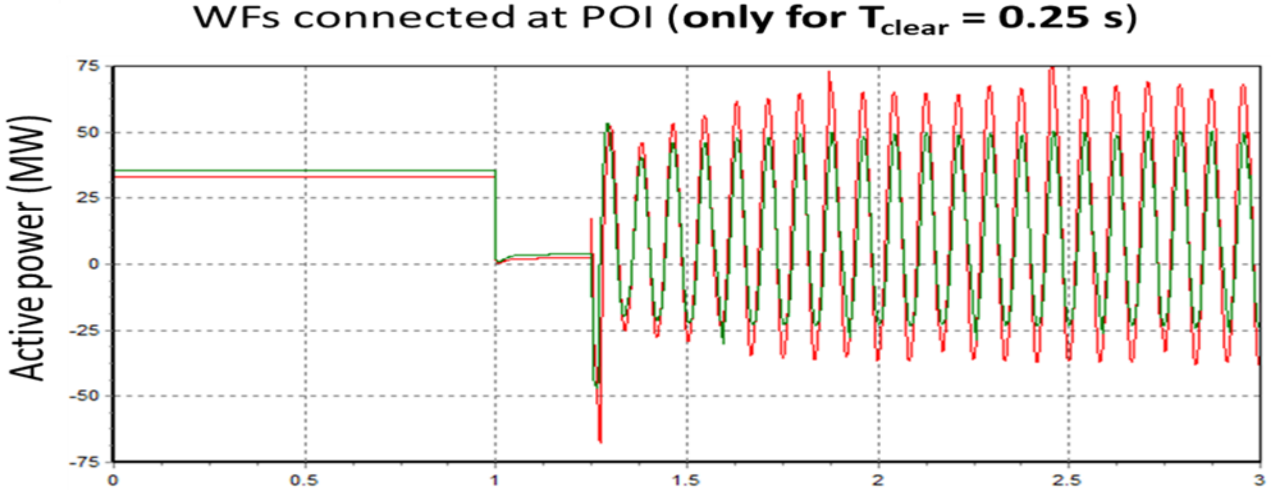
1. W. Wang, D. Ramasubramanian, E. Farantatos, D. Bowman, H. Scribner, J. Tanner, C. Cates, J. Caspary and Anish Gaikwad, "Evaluation of Inverter Based Resources Transient Stability Performance in Weak Areas in Southwest Power Pool's System Footprint," *CIGRE 2020 Paris General Session*, Paris, France, 2020, pp. 1-10
2. W. Wang, G. M. Huang, D. Ramasubramanian and E. Farantatos, "Transient stability analysis and stability margin evaluation of phase-locked loop synchronised converter-based generators," in IET Generation, Transmission & Distribution, 14 (22), 5000-5010, Nov 2020

Evaluation IBR large signal fault through for a region



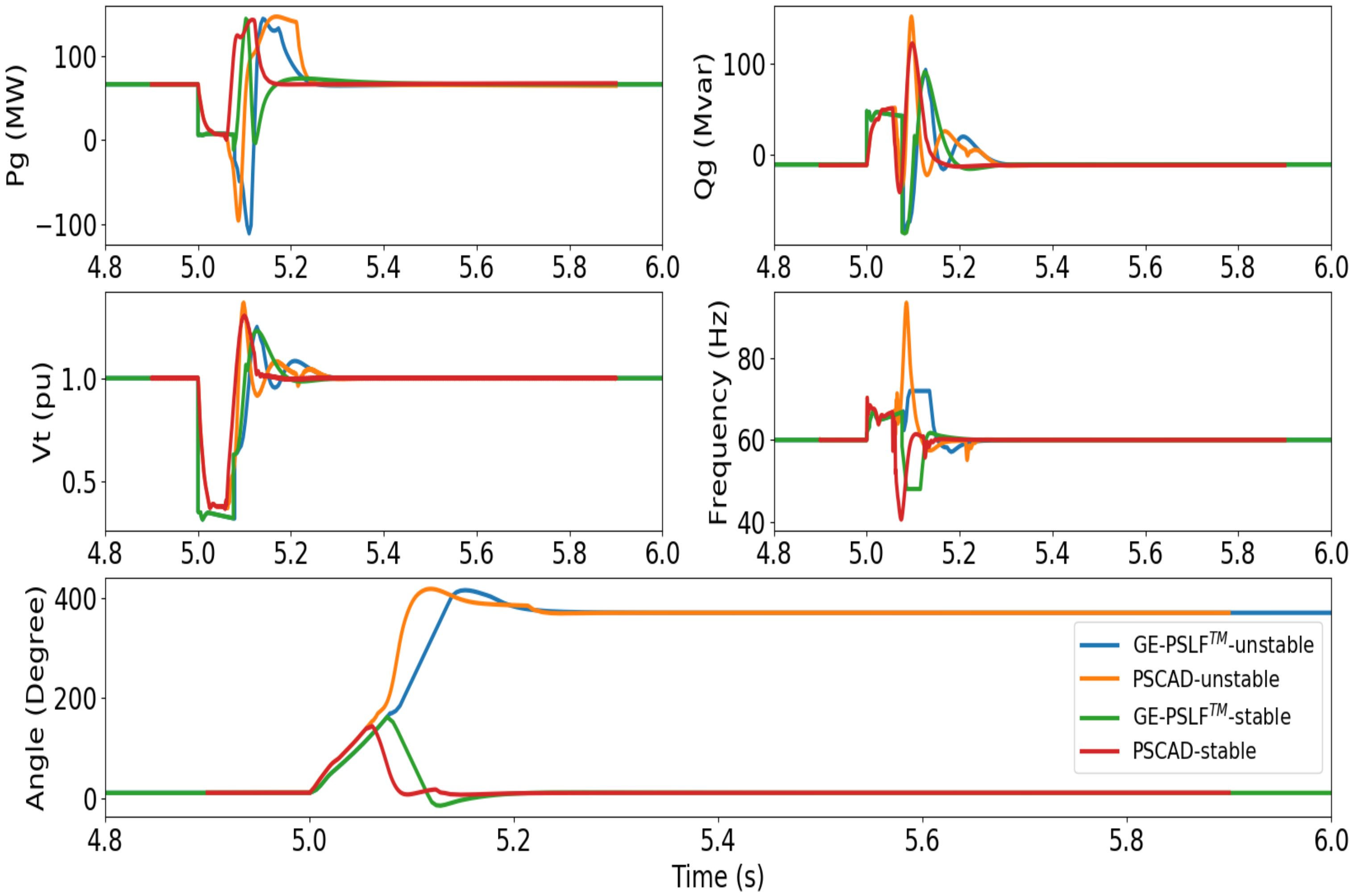
10 cycle clearing is delayed fault clearing threshold on network





G. Misyris, D. Ramasubramanian, M. Val Escudero, T. Kerci, and S. Murray, "Weak Grid Analysis for Interconnecting Inverter-Based Generation – Ireland Case Study," CIGRE Science & Engineering, vol. 29, pp. 1-18, June 2023.

Nuances regarding IBRs, transient stability, and CCT



Guidelines for Studies on Weak Grids with Inverter Based Resources: A Path from Screening Metrics and Positive Sequence Simulations to Point on Wave Simulations, EPRI, Palo Alto, CA: 2018, 3002013639

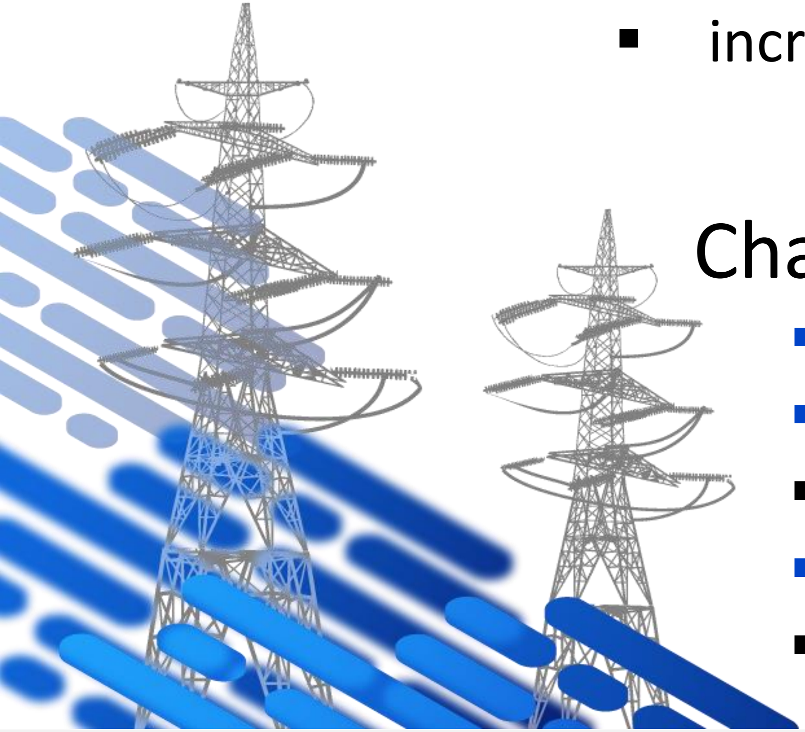
- Notion of CCT with IBRs can be quite different from synchronous machine
- Because of electronic synchronization, a re-synchronization can occur 2nπ radians later
  - But it can cause dc overvoltage

Blackstart and system restoration

How can inverters assist?

Improving the speed of recovery

- **re-energize** transmission network
- **restore** demand and offsite supplies to power plants
- assist with **frequency and voltage control**
- support **island development** efforts
- increase **fault current** contribution



Challenges (non-exhaustive):

- **‘*Feedstock*’ availability** and forecasting
- **Energization of large plant** and equipment
- Network **protection adequacy**
- **Adverse interaction** with other resources
- Maintaining **Power quality**

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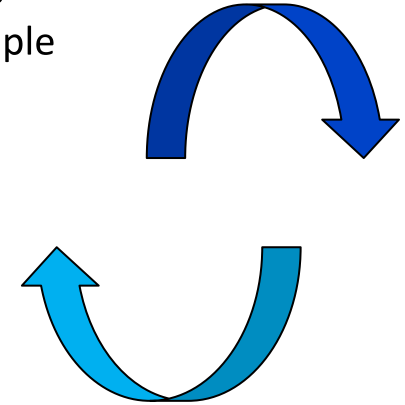
Inverter response and behavior during restoration

Inverter interaction with other converters, generators and loads during weak grid operation conditions (restoration) is **complex** and influenced by multiple control loops:

- Inner
- Outer
- Feedback
- Feedforward

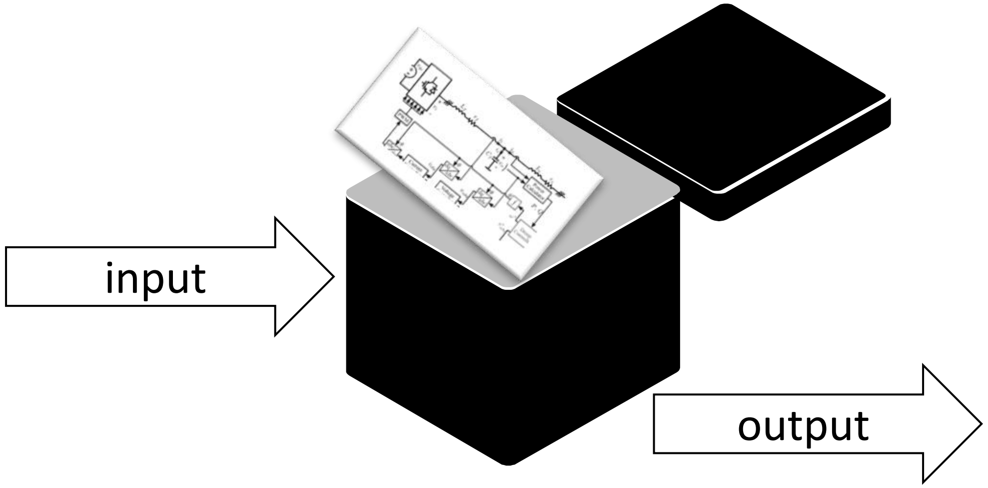


OEM/Vendor control designers:

- have expert knowledge at converter level - up to the point of connection
- use their experience and practical methods to understand implications
- have knowledge of hardware and control design

How can utility engineers

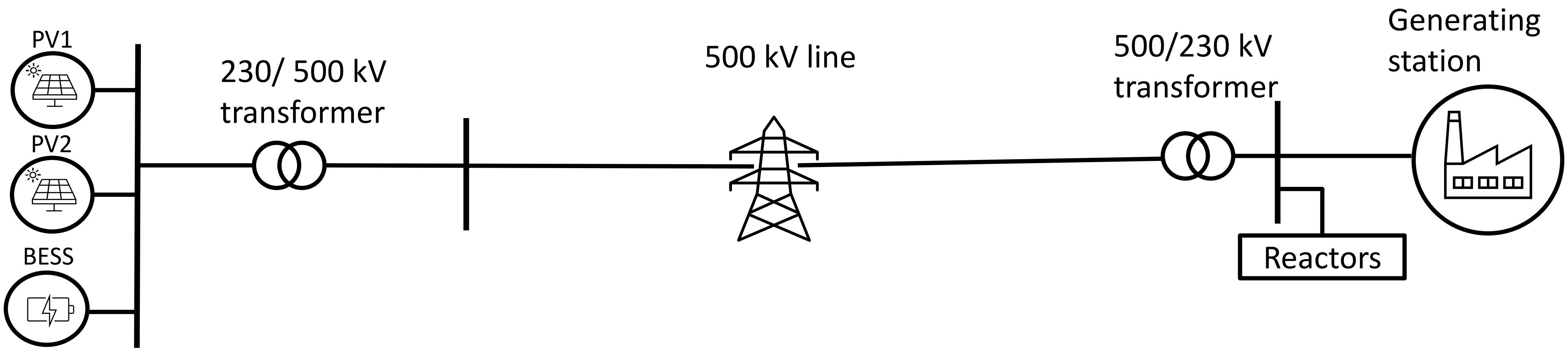
- assess impact on the transmission assets/devices/generation
- gain understanding of coupling and interaction effects between multiple control parameters
- not provided with information on the hardware and control design



Restoration process is already very **complex**

- Should planning and real-time capabilities evolve to handle more complicated concepts/difficult to understand processes
- Find solutions to take abstract and difficult to visualize formats and turn to something that can be intuitively understood (cause and effect)

Cranking path of the network for restoration



IBR
Rating:
PV1 300 MVA
PV2 250 MVA
BESS 400 MVA

- ✓ Inverters with capability for restoration (PV/BESS)

Transformers
Rating: 400- 1100 MVA

- ✓ Saturation/Hysteres is model included (Typical saturation data was assumed)

Transmission lines (20- 60 miles)

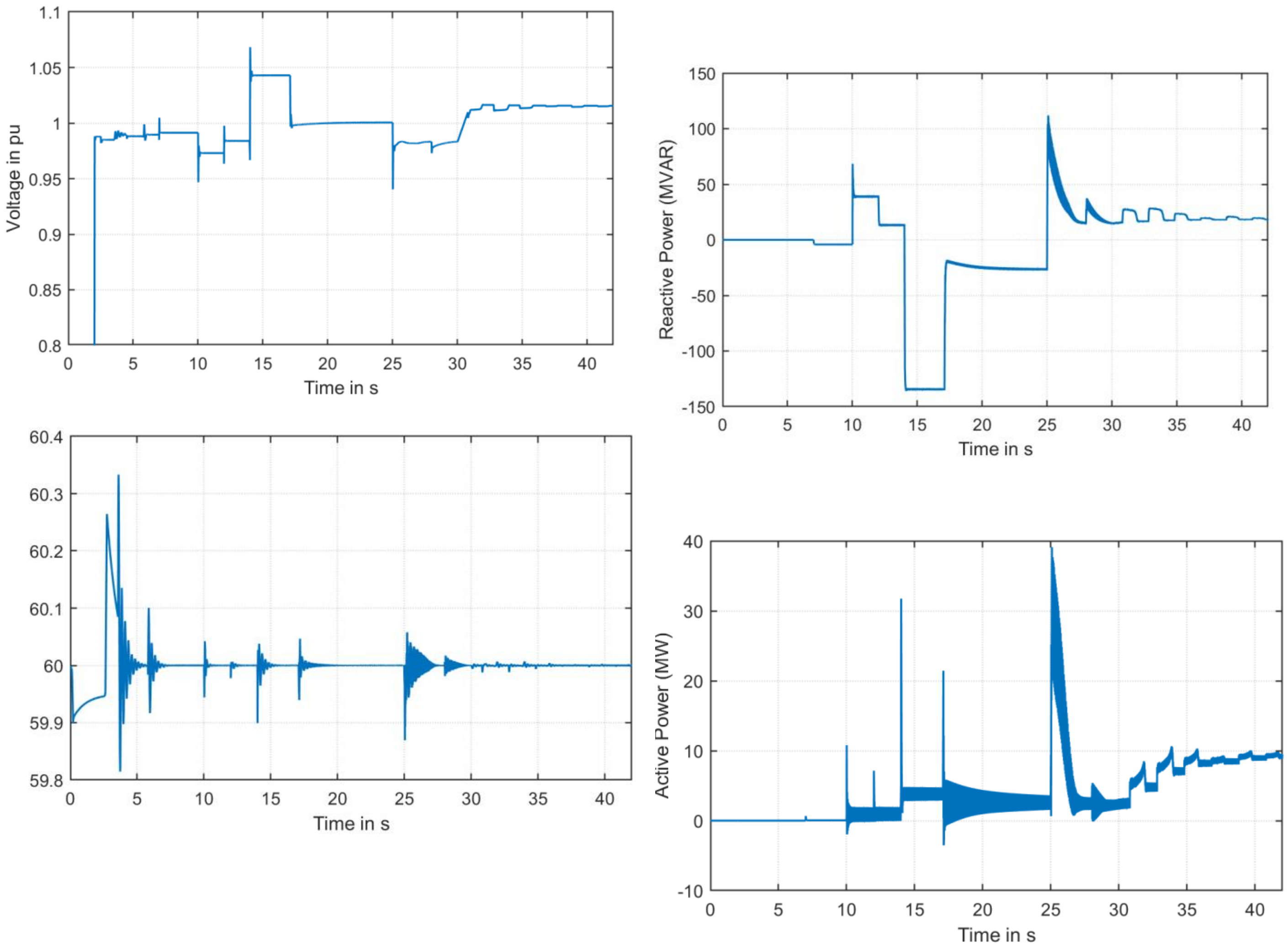
- ✓ Frequency dependent line model used
- ✓ Parameters obtained from real data

Generator station auxilary load

- ✓ Load composition details obtained from real data
- ✓ Three phase induction motor models (NEMA type B)

Overview of restoration from IBR to motor pickup

Sequence	Time
Synchronize the IBR plants	2-5 seconds
Energize the 230/500kV transformer	10-11 seconds
Energize 500kV Line	12-15 seconds
Energize the reactors	17-20 seconds
Energize the 500/230kV transformer	25-28 seconds
Energize motors sequentially	31-45 seconds



Plots show output from IBR

Key Takeaways

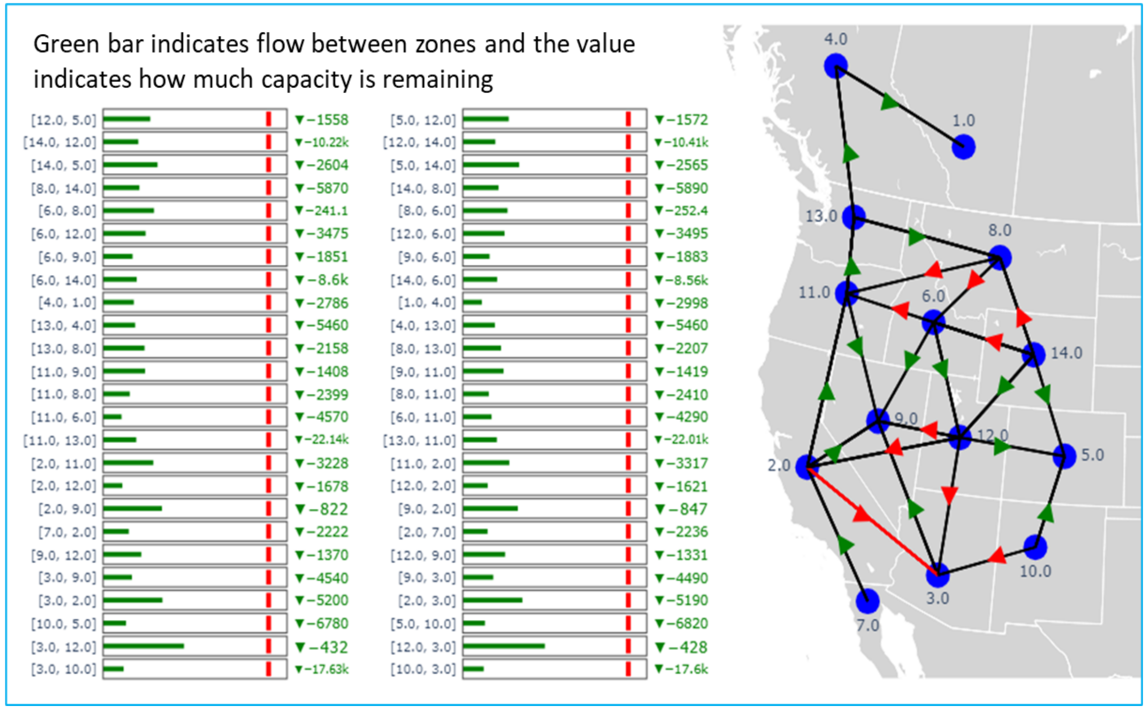
- ❖ No instability in voltage/frequency is observed under these conditions
- ❖ Generator auxilary load was successfully energized
- ❖ Transmission line generates high levels of charging current to be absorbed by IBR (~3Mvar/Mile)

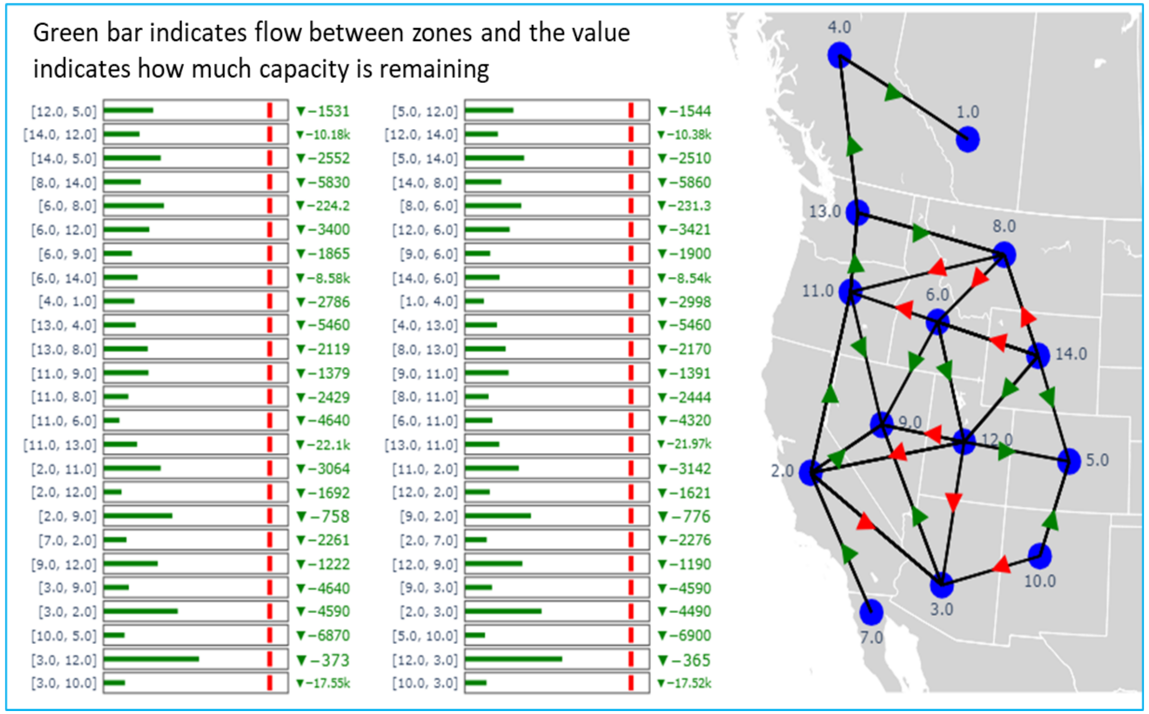
Oscillatory behavior observed in active power measurements is a result of non-linear magnetization characteristics of the network and should be considered carefully when evaluating IBR capability for restoration

Future directions

Hosting Capacity improvement with Grid-Enhancing Technologies (GETs)

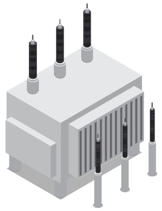
mini-WECC Case





Hosting capacity of around 3000 MW before hitting inter area line limit

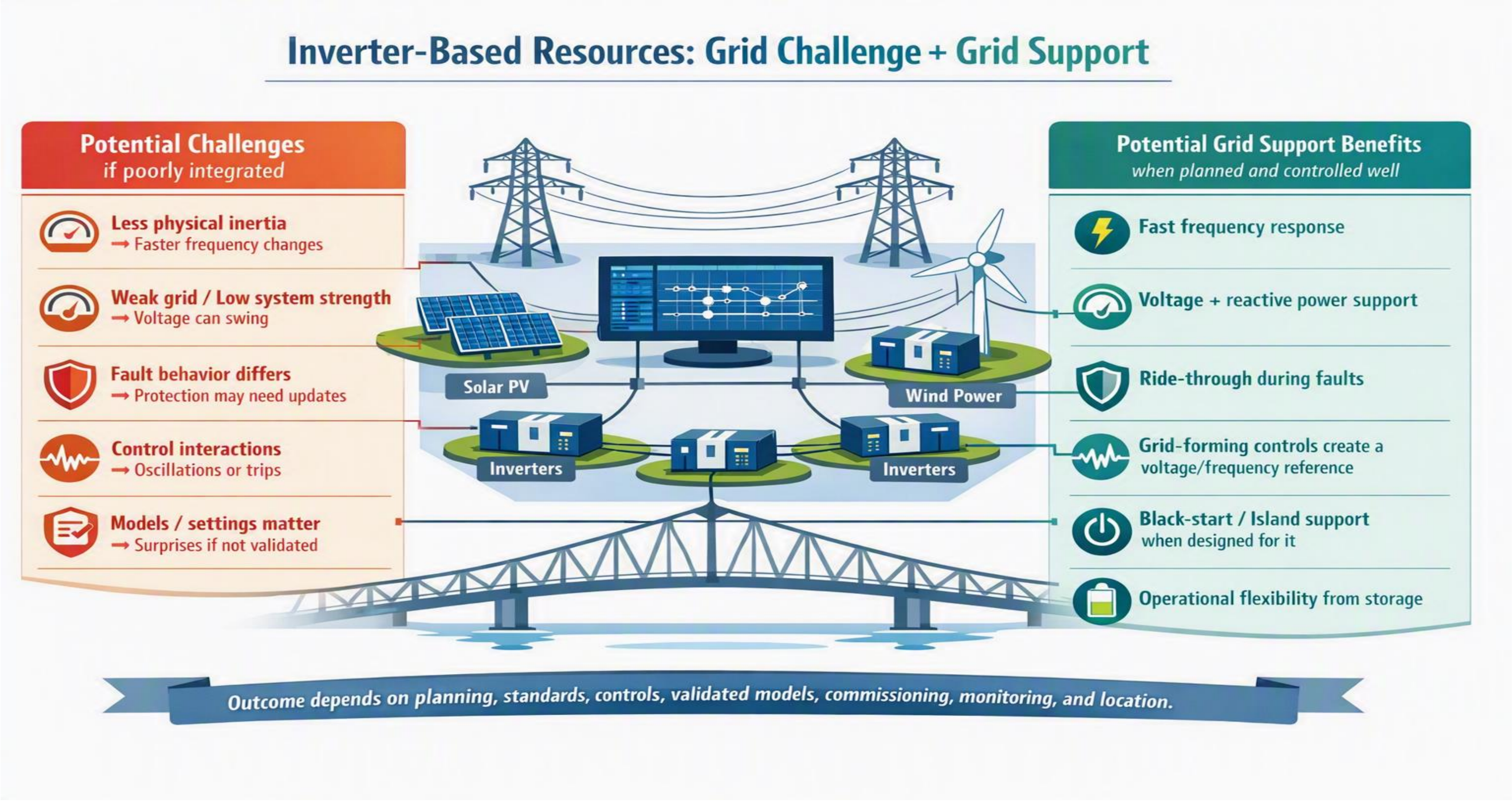
Increased utilization of the network



Power Flow Control Device

Hosting capacity of around 4500 MW before hitting line limit on internal zone lines

Increased utilization of the network


Inverter-Based Resources: Grid Challenge + Grid Support
Potential Challenges
if poorly integrated
Less physical inertia
→ Faster frequency changes
Weak grid / Low system strength
→ Voltage can swing
Fault behavior differs
→ Protection may need updates
Control interactions
→ Oscillations or trips
Models / settings matter
→ Surprises if not validated
Solar PV
Wind Power
Inverters
Inverters
Potential Grid Support Benefits
when planned and controlled well
Fast frequency response
Voltage + reactive power support
Ride-through during faults
Grid-forming controls create a voltage/frequency reference
Black-start / Island support when designed for it
Operational flexibility from storage
Outcome depends on planning, standards, controls, validated models, commissioning, monitoring, and location.

Example actions to prepare system w.r.t. the challenges

Group	Near-Term (0 – 6 months)	Mid-Term (6 – 18 months)	Long-Term (18 – 30 months)
Group 1: System Strength & Stability	EMT studies, identify weak nodes	Deploy GFM BESS, tune VSM/droop	Implement advanced oscillation damping controls
Group 2: Fault Ride-Through & Current Limiting	Benchmark FRT strategies, specify current limit requirements	Pilot hybrid current limiting, validate EMT performance	Standardize FRT specs, integrate adaptive schemes
Group 3: Control Complexity	Define parameter ranges for droop/VSM	Develop tuning guidelines, test negative-sequence control	Automate tuning with AI-based controllers
Group 4: Protection Coordination	Map network protection gaps, simulate FRT scenarios	Deploy adaptive relays, implement DTT where needed	Transition to IEC 61850-based schemes
Group 5: Reactive Support & Economics	Quantify reactive shortfall under FRT	Add local VAR support, hybrid limiters at IBR sites	Optimize IBR protection cost via advanced schemes

Near-Term
0 – 6 months

Mid-Term
6 – 18 months

Long-Term
18 – 30 months

These are draft/example timelines/actions

Reach out to me to learn more on how EPRI can help and support with these challenges

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