Avoiding Reliability Must-Runs/ System Support Resources

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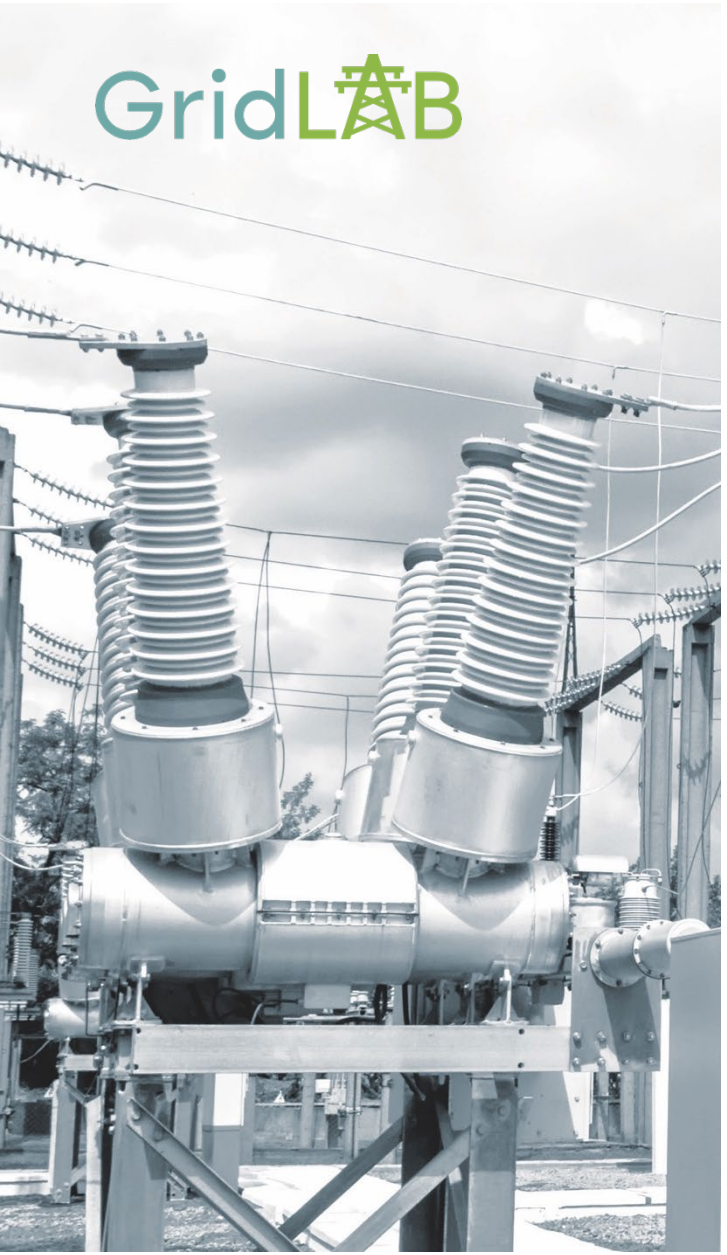


Reliability Must-Runs Provide two categories of services:

"Real Power" (MW)

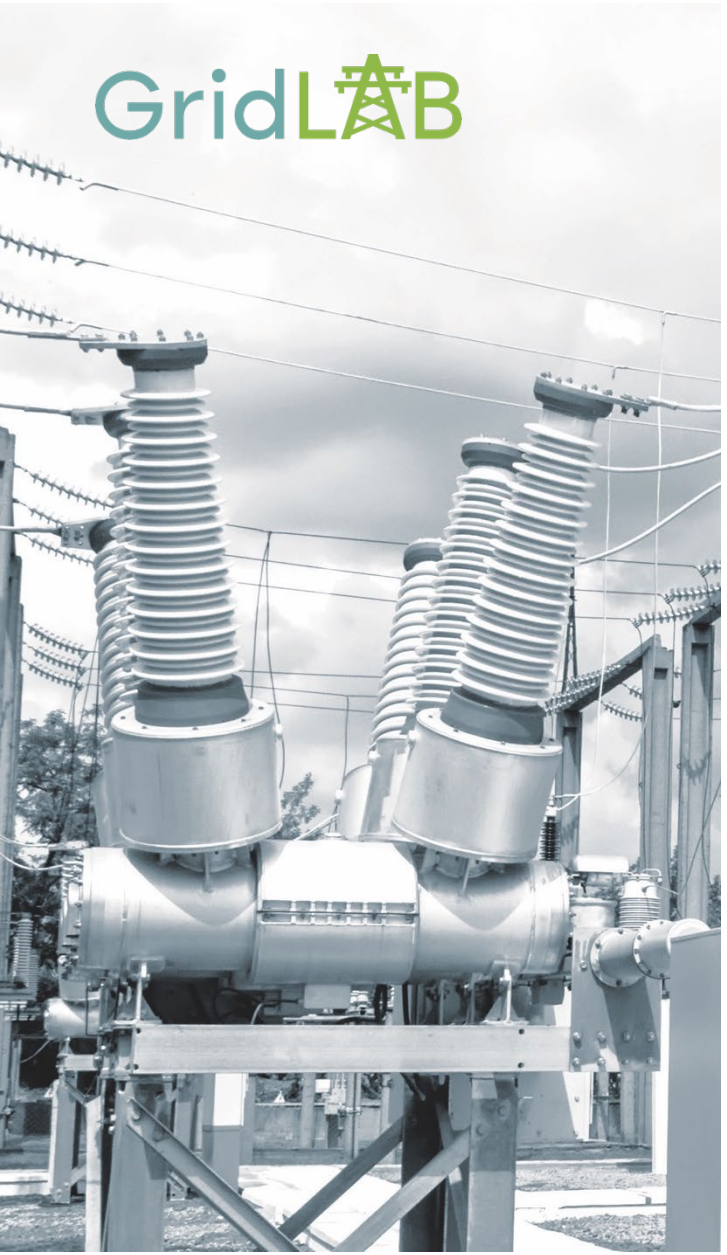
Needed to prevent

- Thermal Overloads
- Resource Shortfall
- Reserve Shortfall
- Frequency Drop (Inertia)

"Reactive Power" (MVAr)

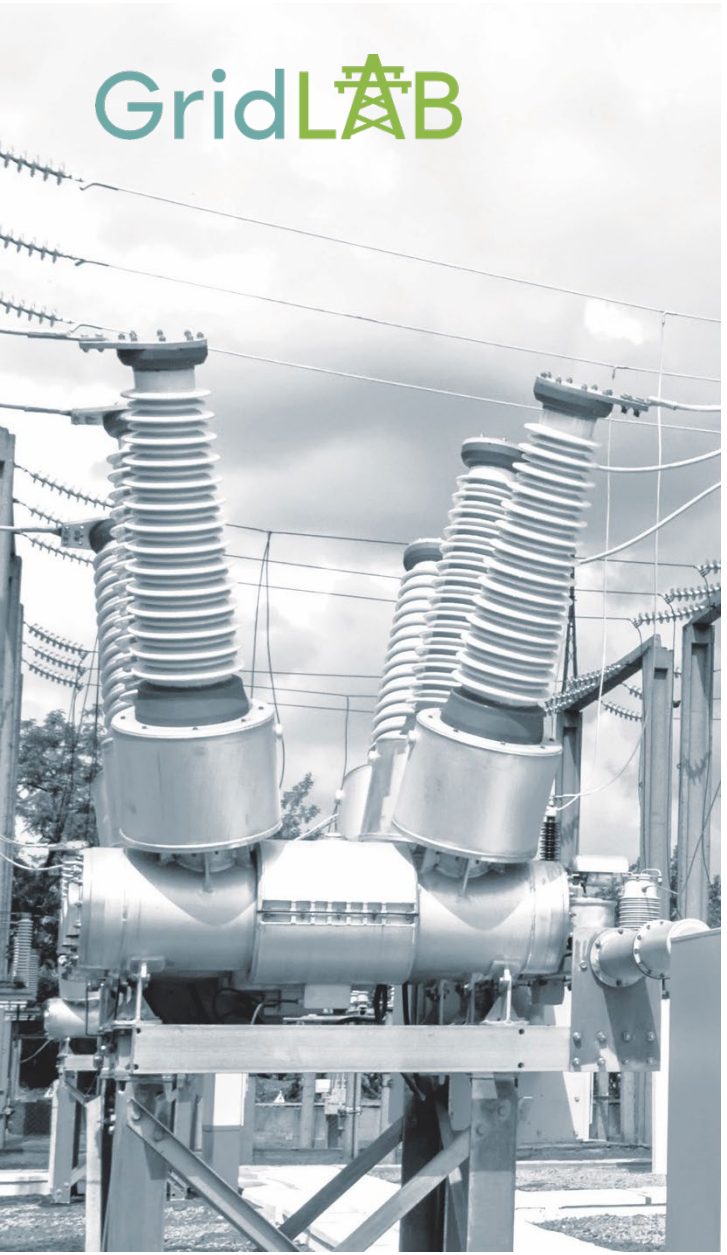
Needed to prevent

- Dynamic Instability
- Voltage Collapse



Current Planning Process:

- Many legacy power plants were intentionally sited inside large load areas or major line crossings, which means removing them introduces grid reliability issues near the location of the power plant
- Retirements are often announced within one year or less of proposed shut down
- When a power plant is removed, significant transmission upgrades are often needed to move real or reactive power into the "hole" created by removing the power plant
- Transmission Planning Groups can typically only propose "wire" solutions including new lines, transformers, substation upgrades etc.
- Thus, Reliability Must-Runs are triggered until the transmission upgrades can be completed which can take many years.



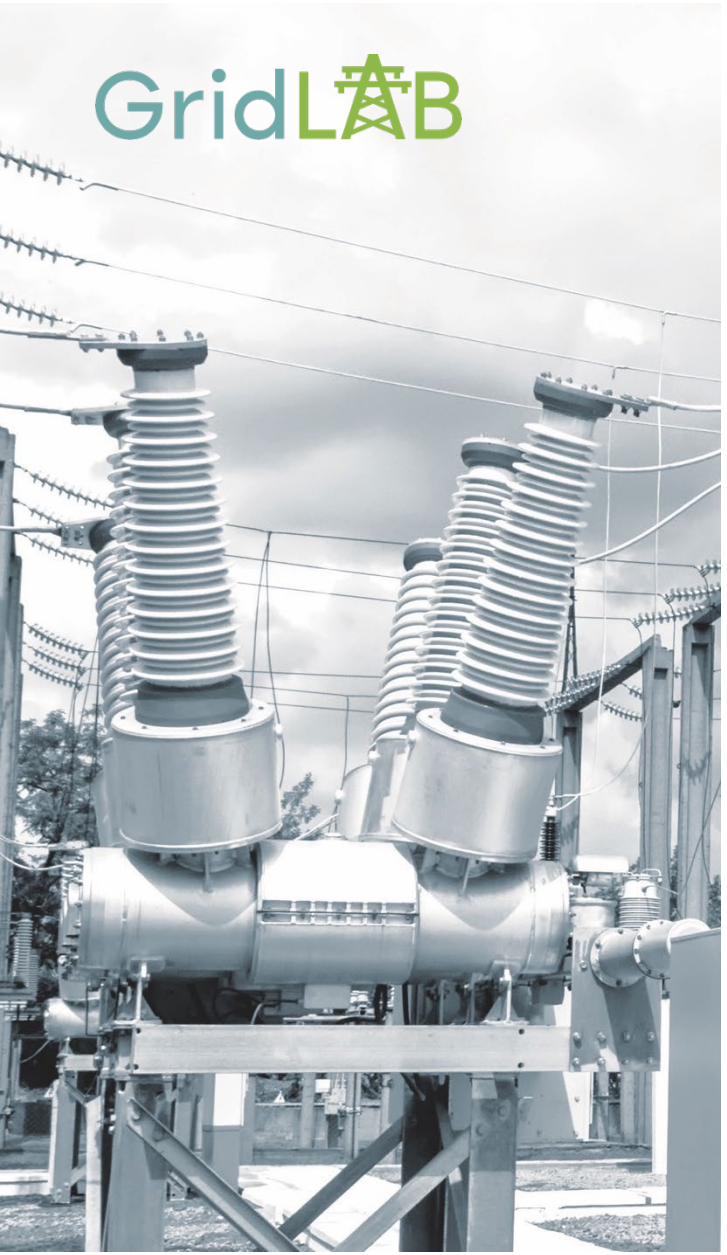
Results:

Rush Island, MO (MISO) Ameren

- RMR until 2025 or until transmission upgrades can be completed
- Transmission upgrades including ~1000 MVAR Static Synchronous Compensators (STATCOMs)
  - Expensive, use up interconnection capacity, and do not provide real power or energy
- Queued renewable and storage resources were evaluated and did not solve the problem

Brandon Shores, MD (PJM) Talen Energy

- PJM seeking RMR until 2028 or until transmission upgrades can be completed
- $785 million in Transmission Upgrades needed to fix multiple issues, including new 525 kV line route
- 260 MW of storage at Brandon Shores stuck in interconnection queue until 2026



A better way?

- Sherco, MN (MISO) Xcel Energy
- Dolet Hills, LA (MISO) Cleco Power
- Joppa and Edwards, IL (MISO) Vistra
- Ventura Energy Storage, CA (CAISO) SCE

Possible Routes:

- Surplus interconnection service (FERC 845): adding new generation at the site of an existing plant, that would continue operating
- Material Modification Process: Owner requests generator change under the existing LGIA
- Generator replacement: adding new generation at the site of a retiring plant
- Storage as a Transmission Asset: Allow TOs to propose energy storage as a solution

Sherco Coal Plant (Becker, MN) Xcel Energy

- 2,238 MW 3-unit coal plant
- Retiring in phases by 2030
- Replacing with 710 MW solar plant, possible long duration storage

2015 – Xcel files with MN PUC to retire units 1 & 2 in 2023 & 2026

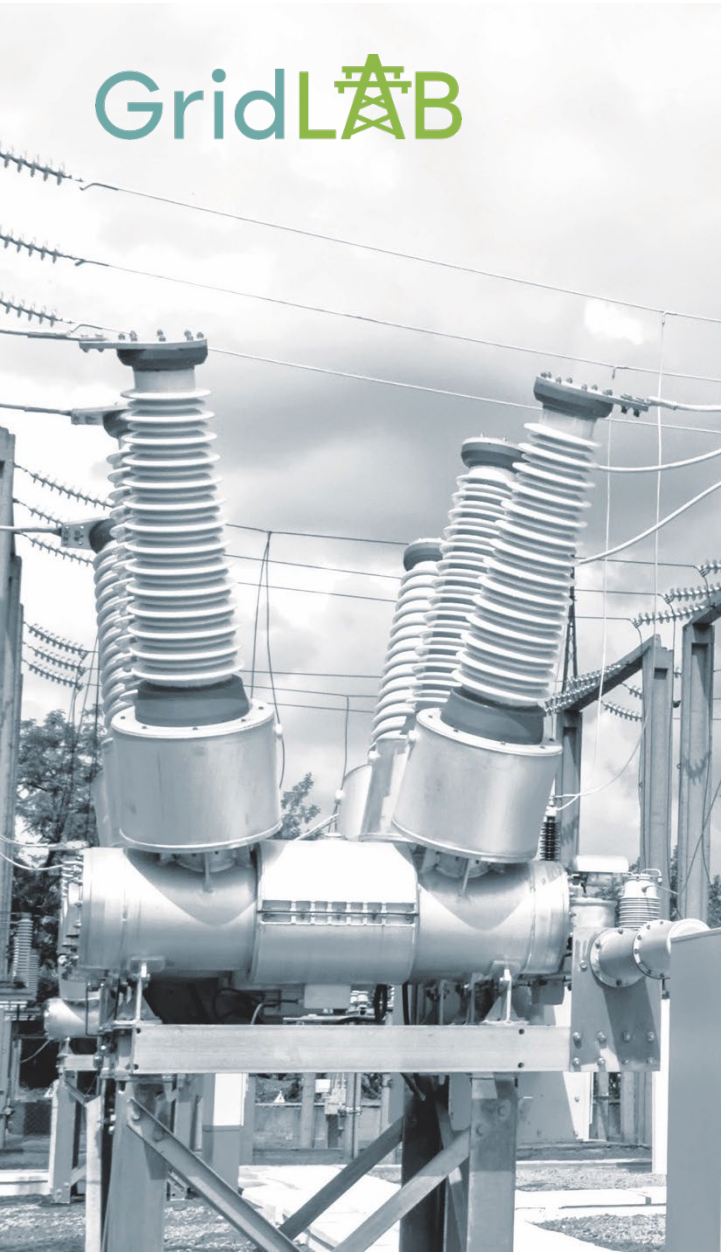
- Originally planned to be replaced with combined cycle and 50 MW solar
- MISO studies the retirement under "attachment Y process"

2019 – Xcel plans to retire unit 3 in 2030

2020 – Xcel IRP intervention demonstrates no reliability need for the combined cycle

2022 – Xcel plans 460 MW solar plant using unit 1 interconnection capacity

2023 – Xcel plans additional 250 MW solar plant using unit 2 interconnection capacity

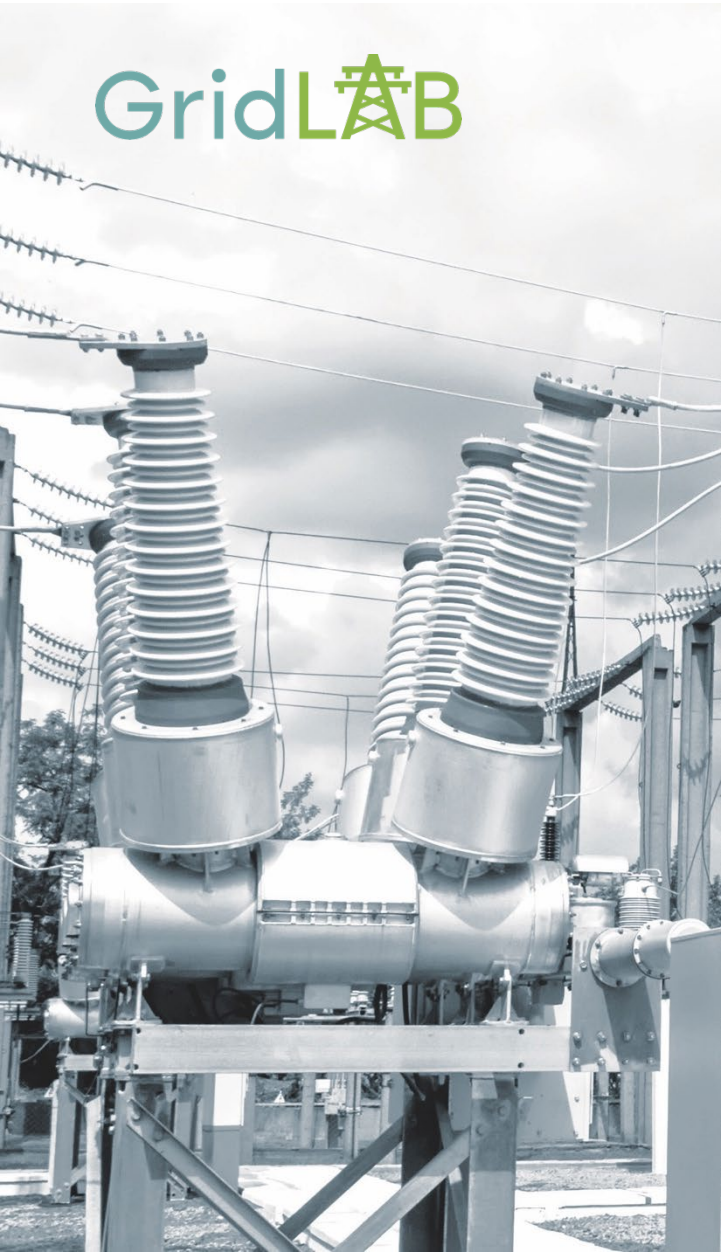


Sherco, MN (MISO) Xcel Energy

How to replicate:

1. Require ample notice (5+ years) for retirement (to give Transmission Planners time to study and propose solutions)
2. Provide a process for clean repowering in ISO interconnection queue (Interconnection Transferability)
3. Require clean repowering plans to be included in the IRP process ("you know these plants will retire soon, what is your plan?")

*This will be different in non-IRP areas like PJM



Key Points:

- Continuing to run resource planning and transmission planning in separate processes will, *by definition*, result in a suboptimal results at the system-wide level
  - Transmission Operators typically cannot propose "generation" solutions like storage
  - Resource Planners typically use generic "interconnection costs" when evaluating renewable alternatives
- Grid Forming Inverters, especially when paired with storage, can provide all services provided by RMRs and usually can be built faster than transmission upgrades
  - Two caveats:
    - The duration is limited compared to thermal generation (4-6 hours)
    - The system must be able to charge the storage
- DLRs, GETs, and DERs can provide services, but typically only address thermal overloads (MW) and steady state voltage problems

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Additional Resources

- ESIG Members have collected a library on Grid Forming Inverter Based Resource capabilities, modeling best practices, and initiated code development.
  - https://www.esig.energy/event/2022-special-topic-workshop-grid-forming-ibrs/
- NERC has established a definition for Grid Forming Inverters and continues to study their applications in North America
  - https://www.nerc.com/comm/RSTC_Reliability_Guidelines/White_Paper_Grid_Forming_Technology.pdf
- National Labs and Industry are investigating potential for GFMs to support a 100% renewable grid in Hawaii (this will drive a lot of industry knowledge over the next 2-3 years)
  - https://www.nrel.gov/docs/fy22osti/83545.pdf