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Transition to Grid Forming Applications:

→ Why and by when is it needed?

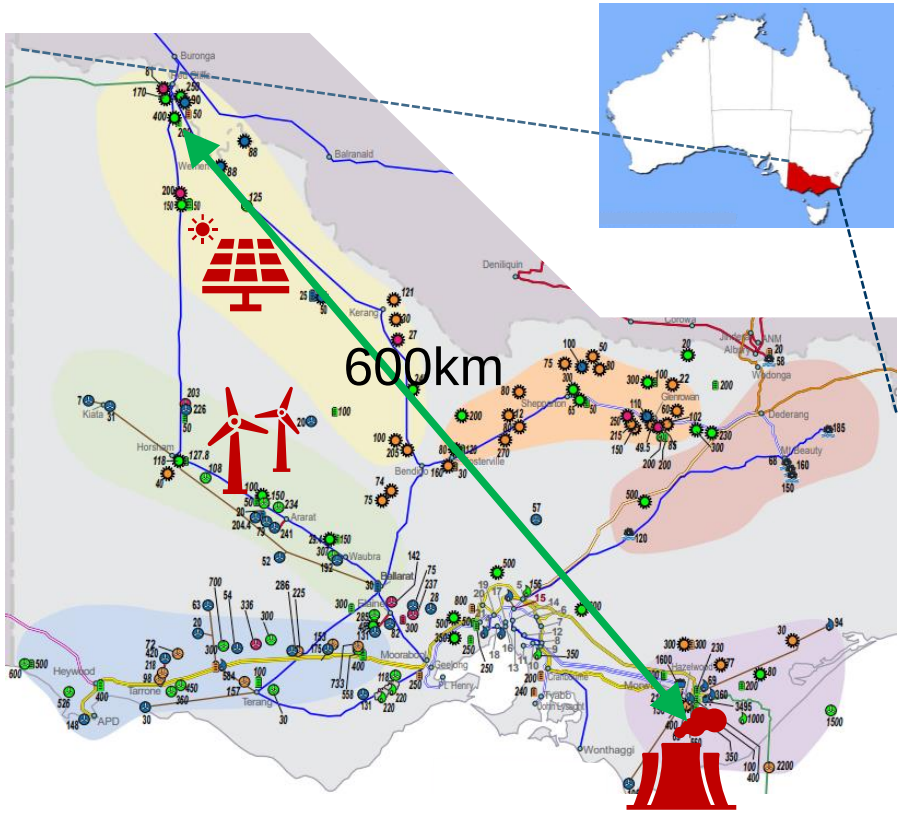
Victoria's Rhombus of regret aka the Trapezoid of broken dreams…

West Murray Zone oscillatory instability first observed in 2019, but anticipated in 2016

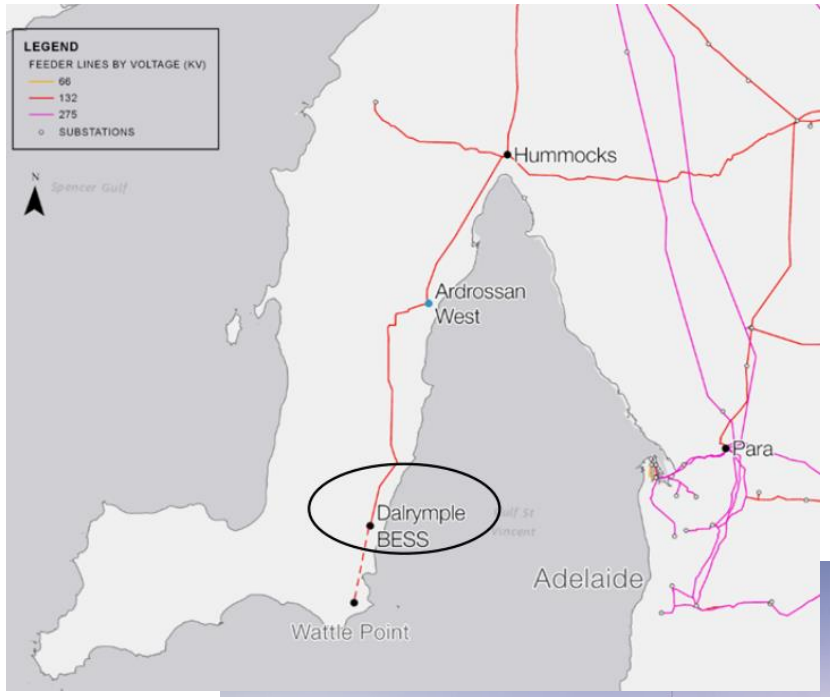
- Remote from main grid and sources of system strength
- 500MW of solar farm in close proximity
- Constraints to half capacity for almost 2 years, while sync cons were installed.
- All impacted solar farms used GFL inverters…

Every region is unique…

- But emerging challenges are observed in many regions of the NEM where we find low system strength and high concentration of IBR
- Convoluted assessment process has slowed rate of interconnection, but relief is on the way…



Grid Forming?

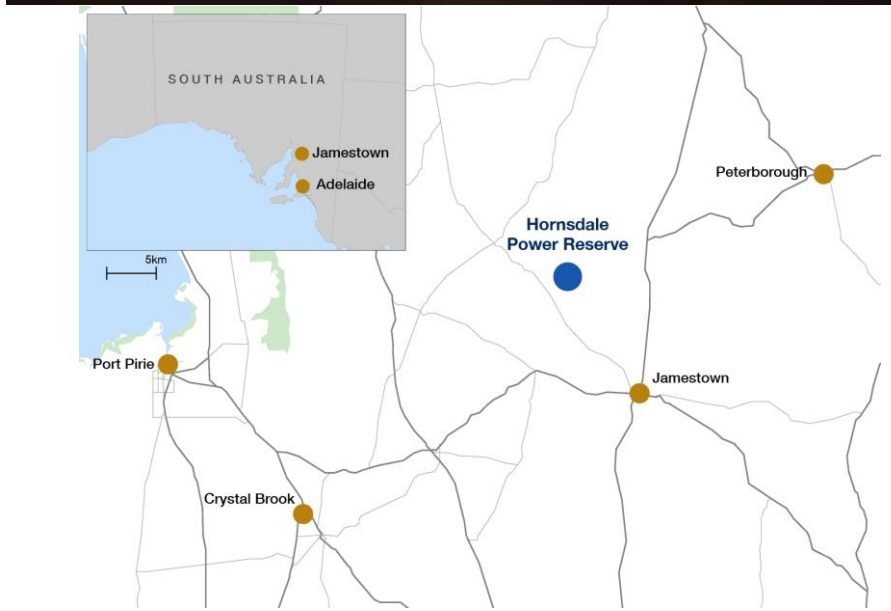


ElectraNet's ESCRI Battery

ENERGY STORAGE for COMMERCIAL RENEWABLE INTEGRATION

- Located on lower York Peninsula in South Australia
- 30MW, 8MWh ABB built GFM BESS
- Built to strengthen the grid and improve reliability to Dalrymple's -1 to 8MW load
- BESS is charged from nearby wind farm
- Designed to contribute to overall SA network security – contributes to the SA SIPS and provides FCAS, provides energy arbitrage
- Switches from GFL when main connected to GFM when islanded
- Large microgrid or grid connected GFM?

Virtual synchronous machine?



Neoen's SA Big Battery (Hornsdale Power Reserve)

- Located North of Adelaide in South Australia
- 100MW, 129MWh Tesla built GFL BESS
- Expanded by 50MW, 65MWh
- BESS is charged from nearby wind farm
- Designed to contribute to overall SA network security – contributes to the SA SIPS and provides FCAS, provides energy arbitrage
- Initial tests for VMM conducted on expanded component, with upgrade of whole facility from late 2021
- Proved VMM effectiveness during Callide event in May 2021 providing FFR

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The shape of things to come

→ Engineering's great leap forward?

Figure 15 Evolution of the annual share of total generation from renewable sources for each least-cost development path

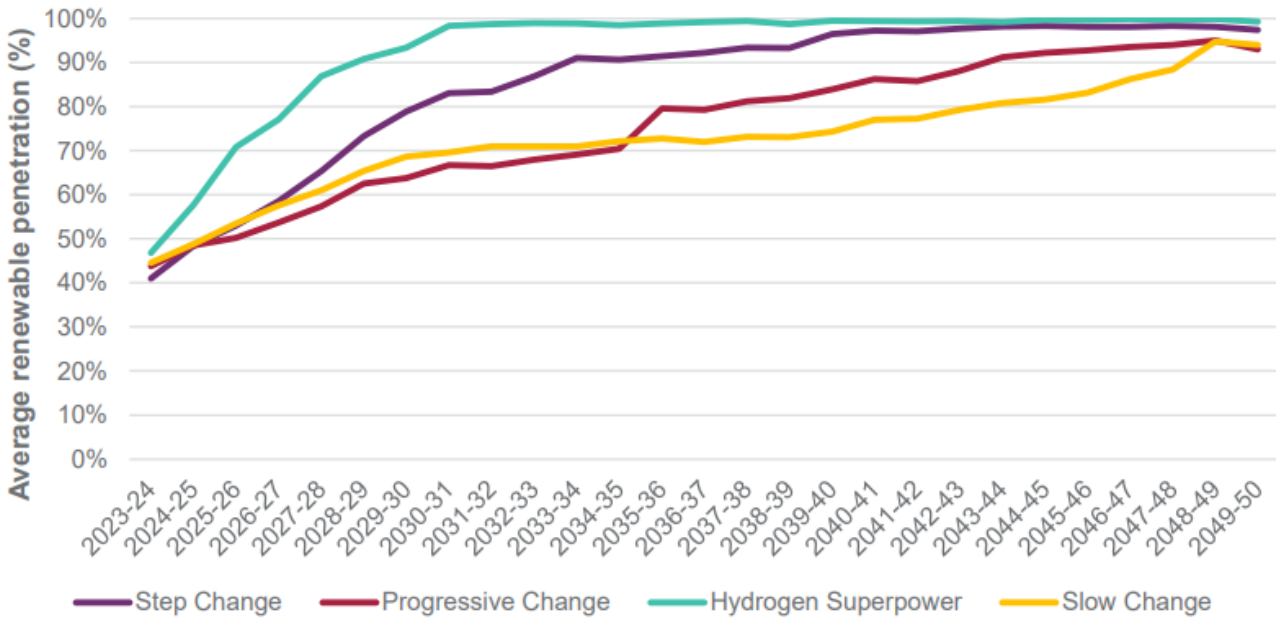
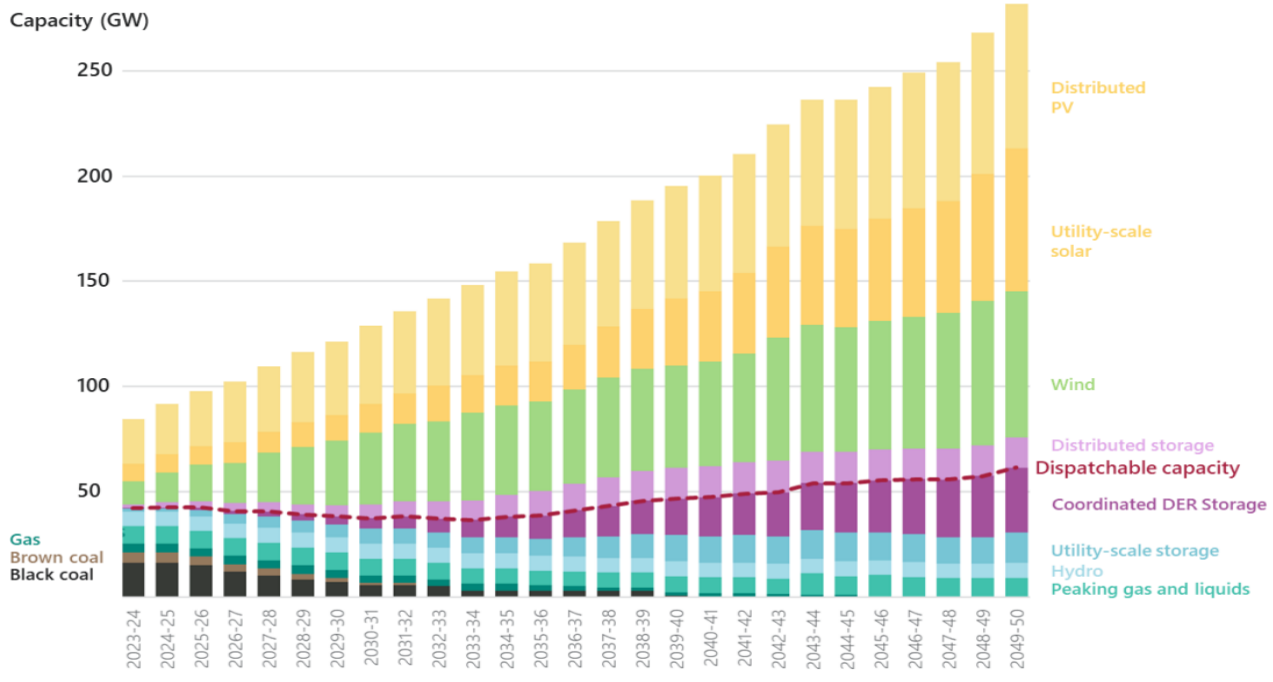


Figure 1 Forecast NEM capacity to 2050, *Step Change* scenario, with transmission



Decarbonisation means:

- Less synchronous generators
- More asynchronous intermittent generation
- Lower system inertia
- Lower system strength

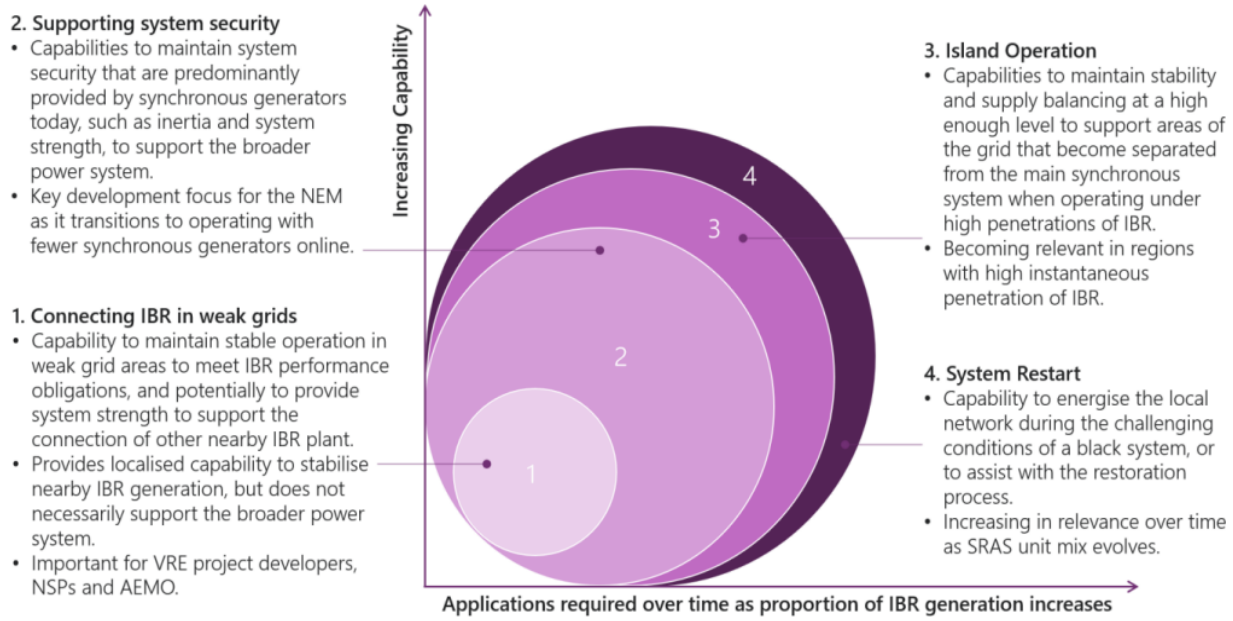
How do we build the bridge?

Advanced Inverters

Functional requirements

- Operate stably in low system strength networks.
- Deliver system strength.
- Control system frequency.
- Provide inertia.
- Restart black systems.
- Do everything a synchronous generator does, but faster...

Figure 1 Increasing relevance of applications detailed in this paper



AEMO: Application of Advanced grid scale inverters in the NEM, Aug 2021.

Australia's NEM relies on 23 GW of firm capacity from coal, and 20GW of storage and gas…

By 2050 we will require 45GW, 650GWh of storage as coal and gas generation retires/withdraws.

The gap is being filled:

- ARENA announced massive competitive funding for LSBS (>70MW) fitted with advanced inverter technology.
- Existing and planned advanced projects: ESCRI (30), Hornsdale (150MW), Torrens Island (250MW), Wallgrove (50MW)…
- >5,000MW of BESS projects planned

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Thank You

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