Australian experiences with grid issues in the energy transition

Energy transition in the National Electricity Market

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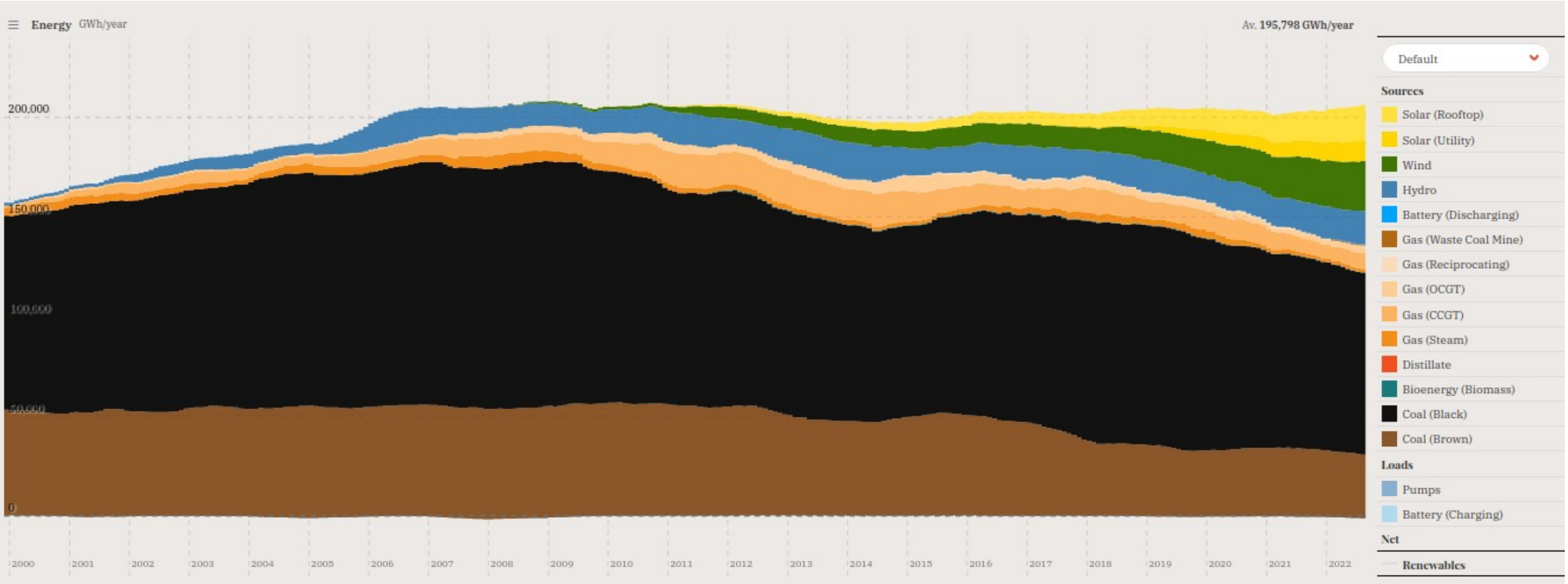
Energy transition in the National Electricity Market

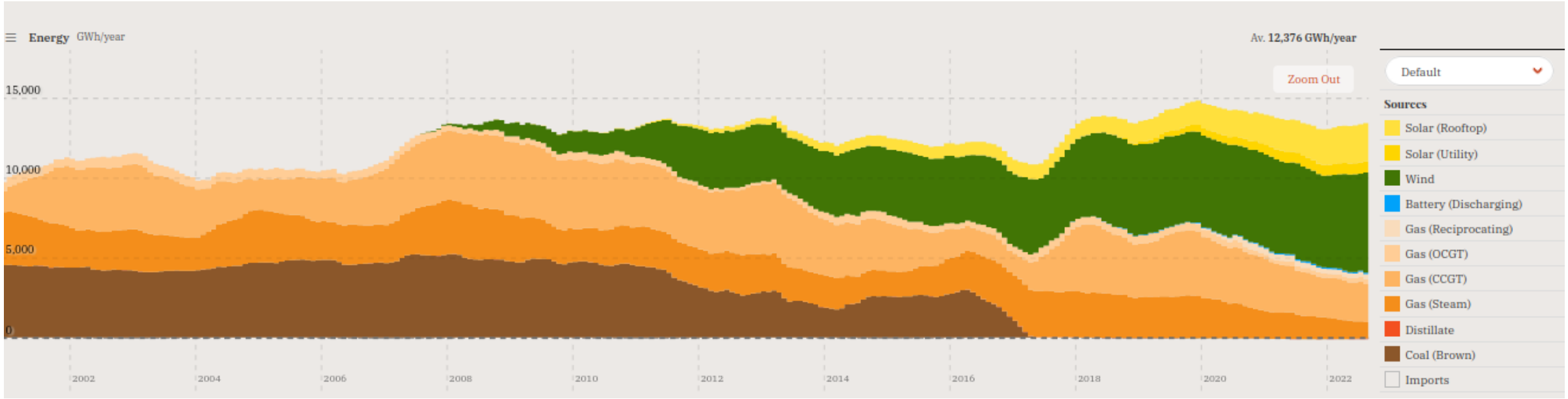
- Context
- Renewable Energy Penetration
  - Levels of synchronous generation
  - Minimum demand
- Reliability & coal closure
  - Investment and withdrawal of capacity
- Transmission augmentation

Context – National Electricity Market



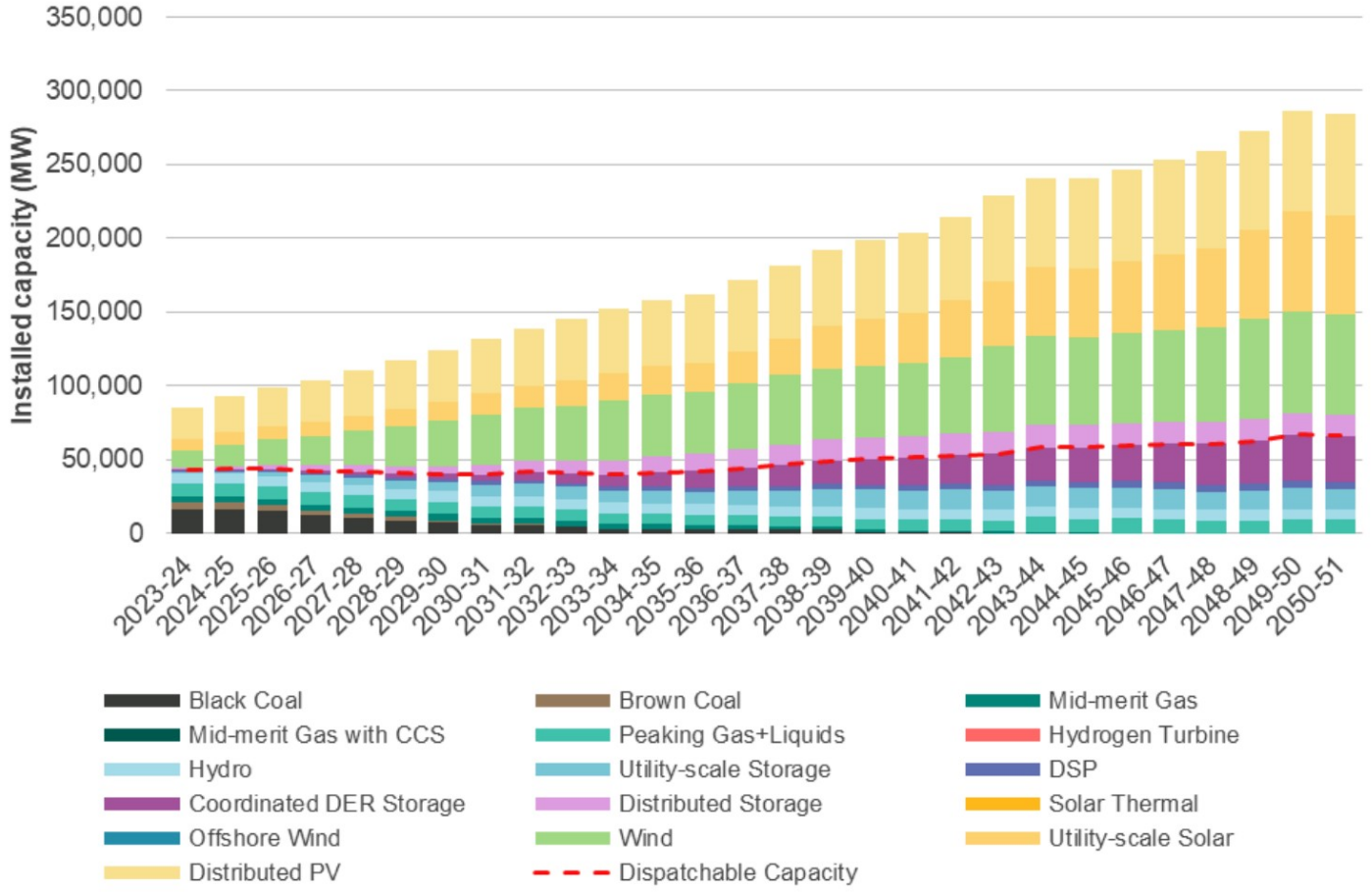
[Source: openNEM (author generated)]

Context – South Australia



[Source: openNEM (author generated)]

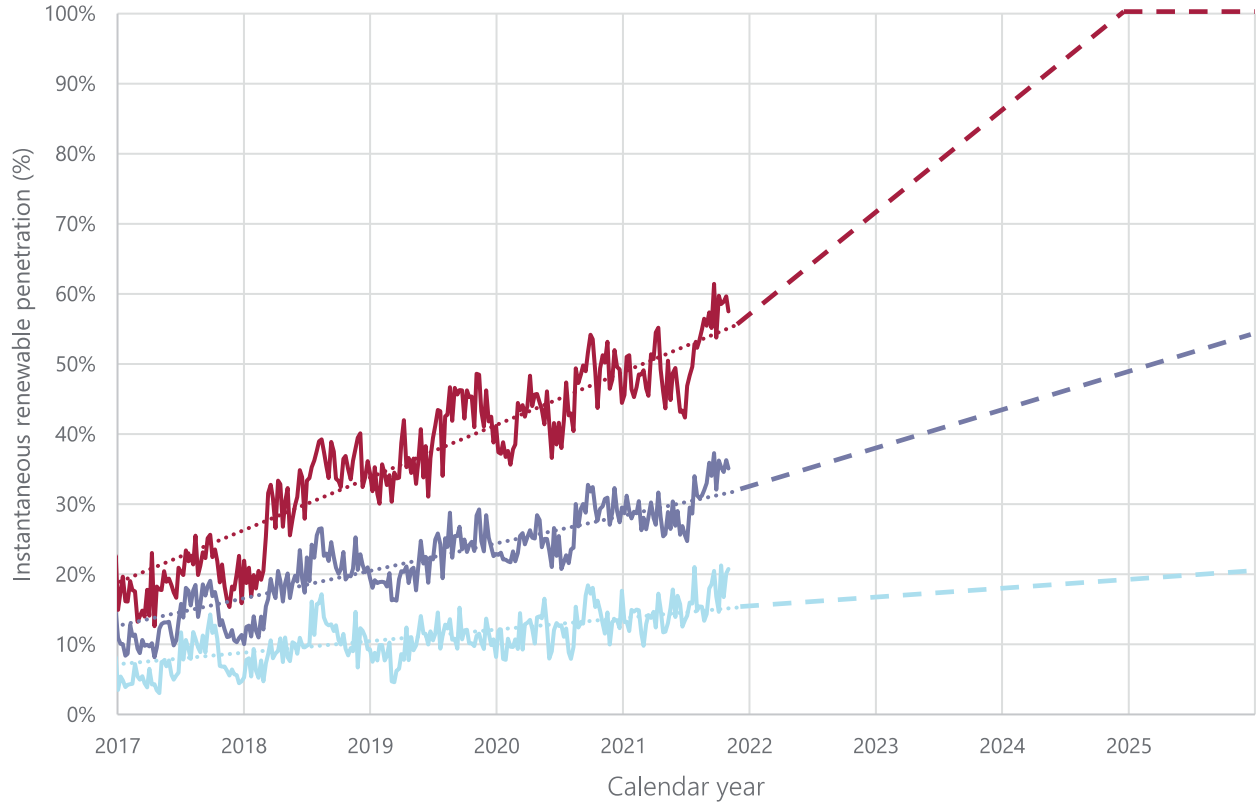
Context – expectations of a “step change”



[Source: AEMO ISP 2022]

Renewable energy penetration

Historical and projected NEM maximum, average, and minimum instantaneous renewable penetration*



Fewer synchronous generators	Ubiquitous rooftop solar	Extensive VRE
Coal capacity (GW)	*Installed DPV (GW)*	*VRE capacity (GW)*
Today 23	*Today* 15	*Today* 15
2025 21	*2025* 24	*2025* 23
2030 9.0	*2030* 35	*2030* 43

Widespread energy storage	Responsive demand	Structural demand shifts
Storage (GWh)	*VPP and demand response (GW)*	*Electric vehicles (number)*
Today 13	*Today* 0.7	*Today* 26 k
2025 20	*2025* 1.6	*2025* 225 k
2030 400	*2030* 6.0	*2030* 2.3 m

Operational demand	
Maximum (GW)	*Minimum (GW)*
Today 32	*Today* 15
2025 36	*2025* 9.4
2030 38	*2030* 4.9

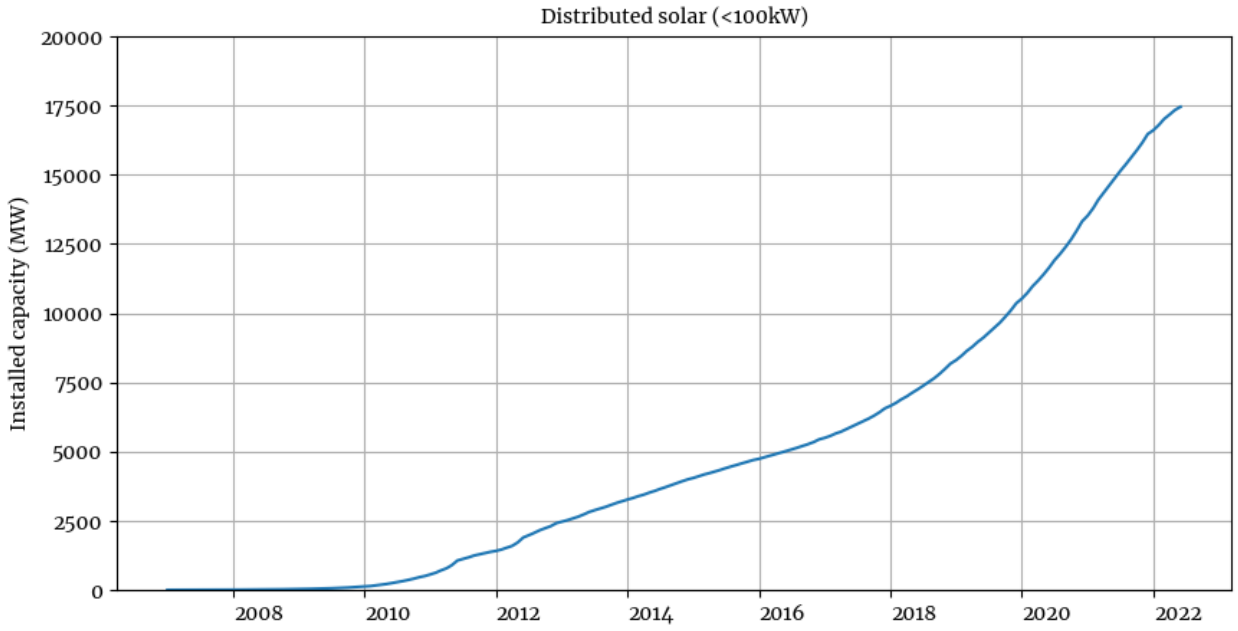
Notes:
Gigawatt (GW)
Gigawatt hour (GWh)
Variable renewable energy (VRE)
Virtual power plant (VPP)

[Source: AEMO, NEM engineering framework]

*'Renewable' generation defined as including grid-scale wind and solar, hydro generation, biomass, storage generation and distributed PV (DPV)

Minimum demand

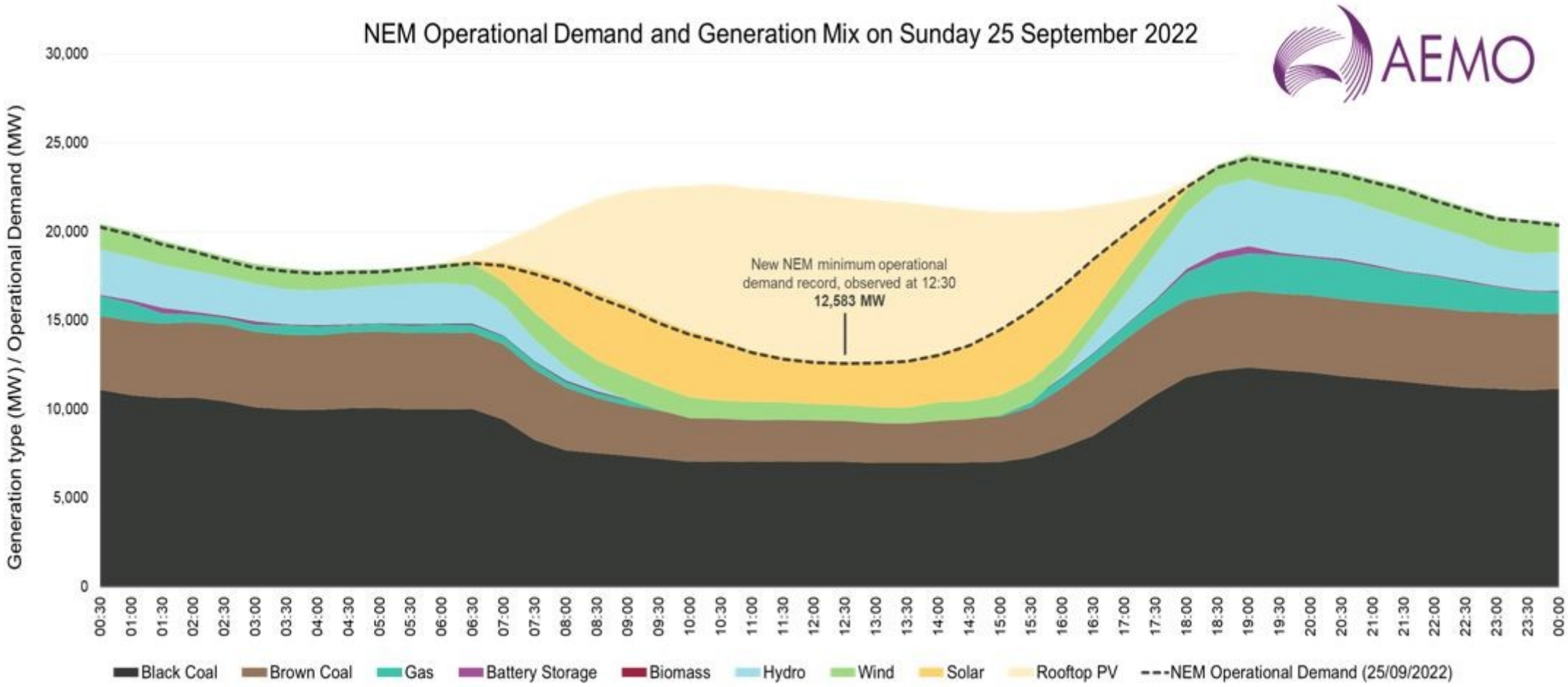
- Over 3 million rooftop solar systems installed in Australia
- Over 15GW of distributed solar (<100kW) installed in the National Electricity Market
  - Peak demand is about 35GW
  - Both mean and median demand is about 21GW
- This generation capacity is considered “behind the meter”
  - It is (largely) uncontrolled
    - There are limited
  - Largely visible to the market operator as a demand reduction



[Source: author generated]

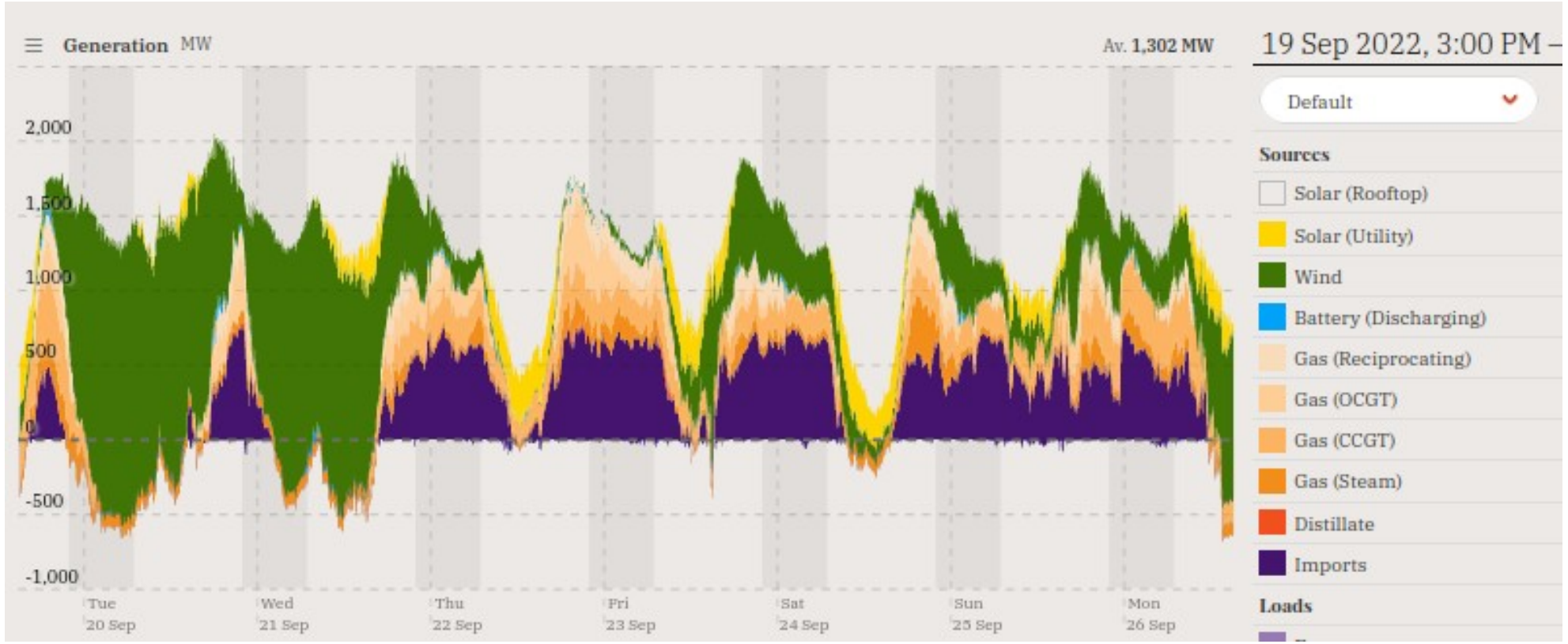
Minimum demand

- New minium system demand (operation demand) this weekend



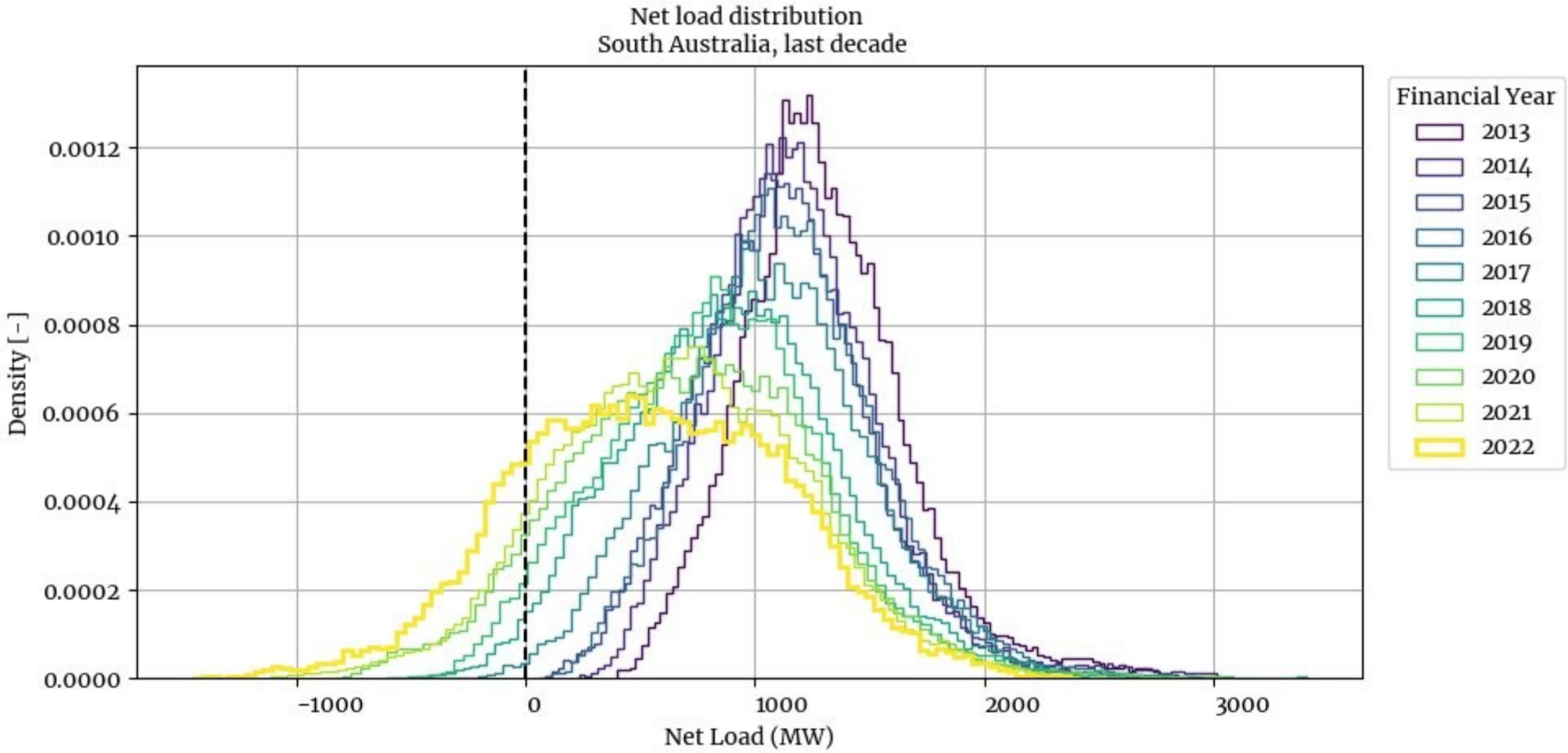
Minimum demand

- Minimum operational demand of 128 MW in South Australia
- Maximum renewable energy generation 142.8%% of local demand
- Minimum renewable energy penetration 0.09% of local demand



[Source: openNEM (author generated)]

Changing demand profile

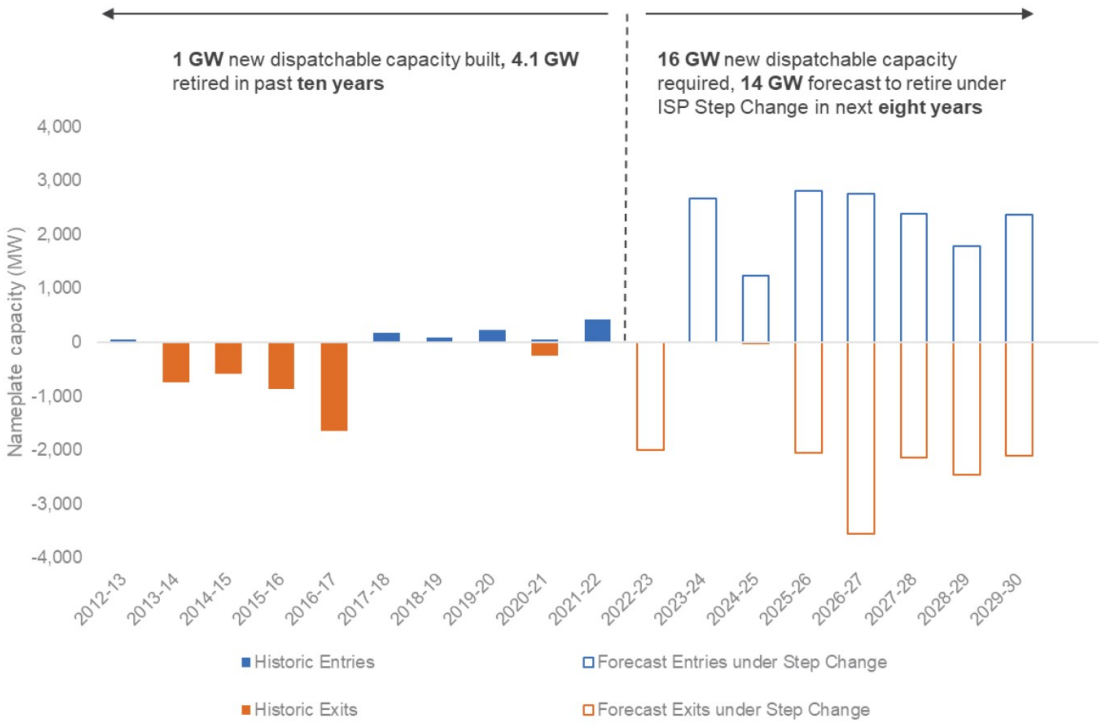


Changing demand profile

- Creates challenges for secure operation of the power system
  - As renewable generation increases and synchronous generation reduces:
    - Reduction in inertia and frequency response
    - Reduction in reactive power reserves
    - Low availability of raise frequency control services
- Creates challenges for physical and commercial operation of coal fired powered stations
  - Load reduces below minimum generation levels
  - Prices reduced to substantially negative levels, reducing economic viability of fleet
- Requires:
  - Additional service provision (e.g. inertia), including from batteries and power electronics
  - “Capacity mechanism” (?)
  - Transmission augmentation

Resource adequacy – Reliability and coal exit

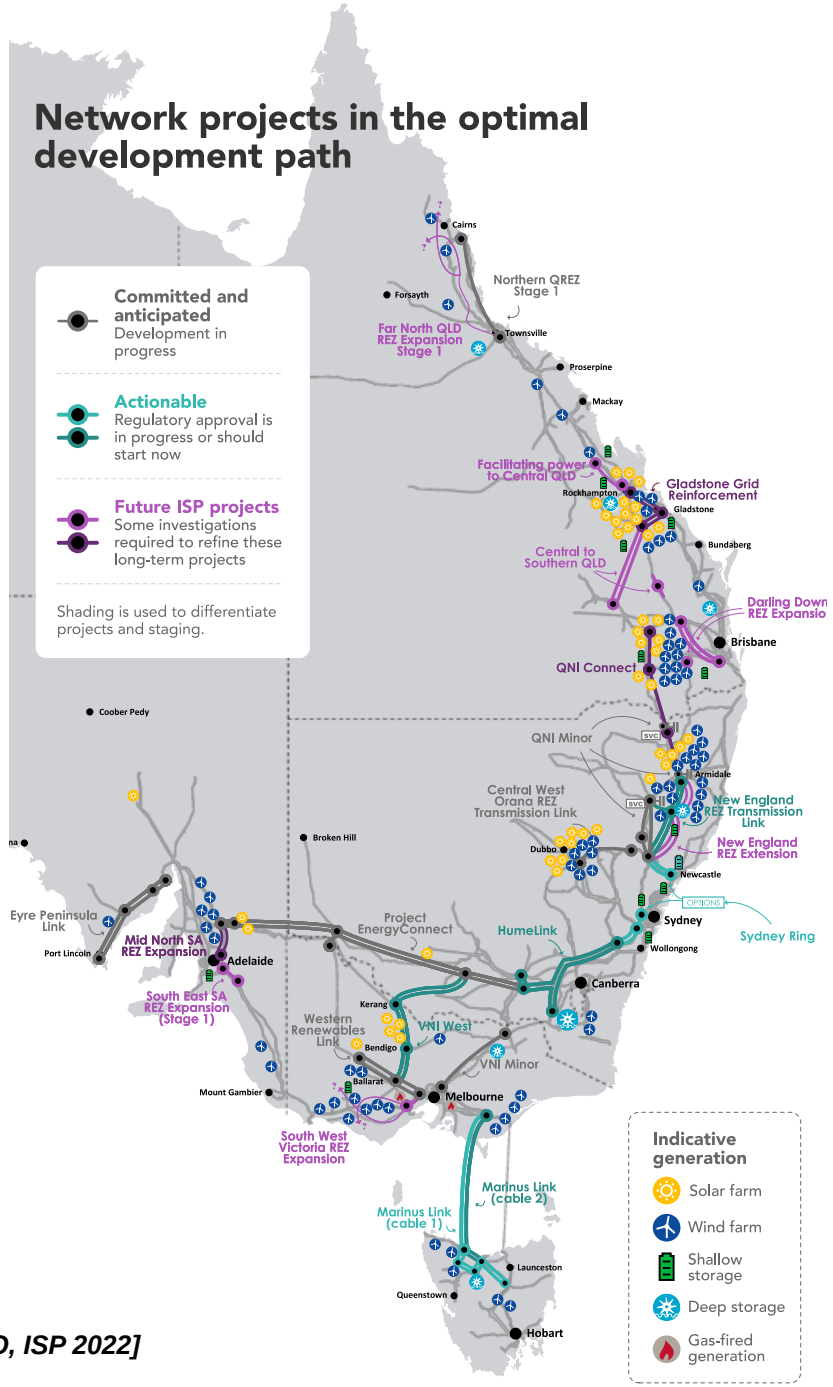
- Concerns remain about ability of out energy-only market to ensure sufficient dispatchable generation, as coal generation exits and energy mix changes
- Formal capacity market recently under discussion, (but since scrapped)
  - Questions remain about what mechanism will drive required investment
    - Strategic energy reserves?
    - Energy storage target?
    - Direct state investment?
- Uncoordinated withdrawal of coal could make for a volatile electricity market during the transition



[Source: ESB 2022, Capacity mechanism High-level Design Paper]

Transmission expansion

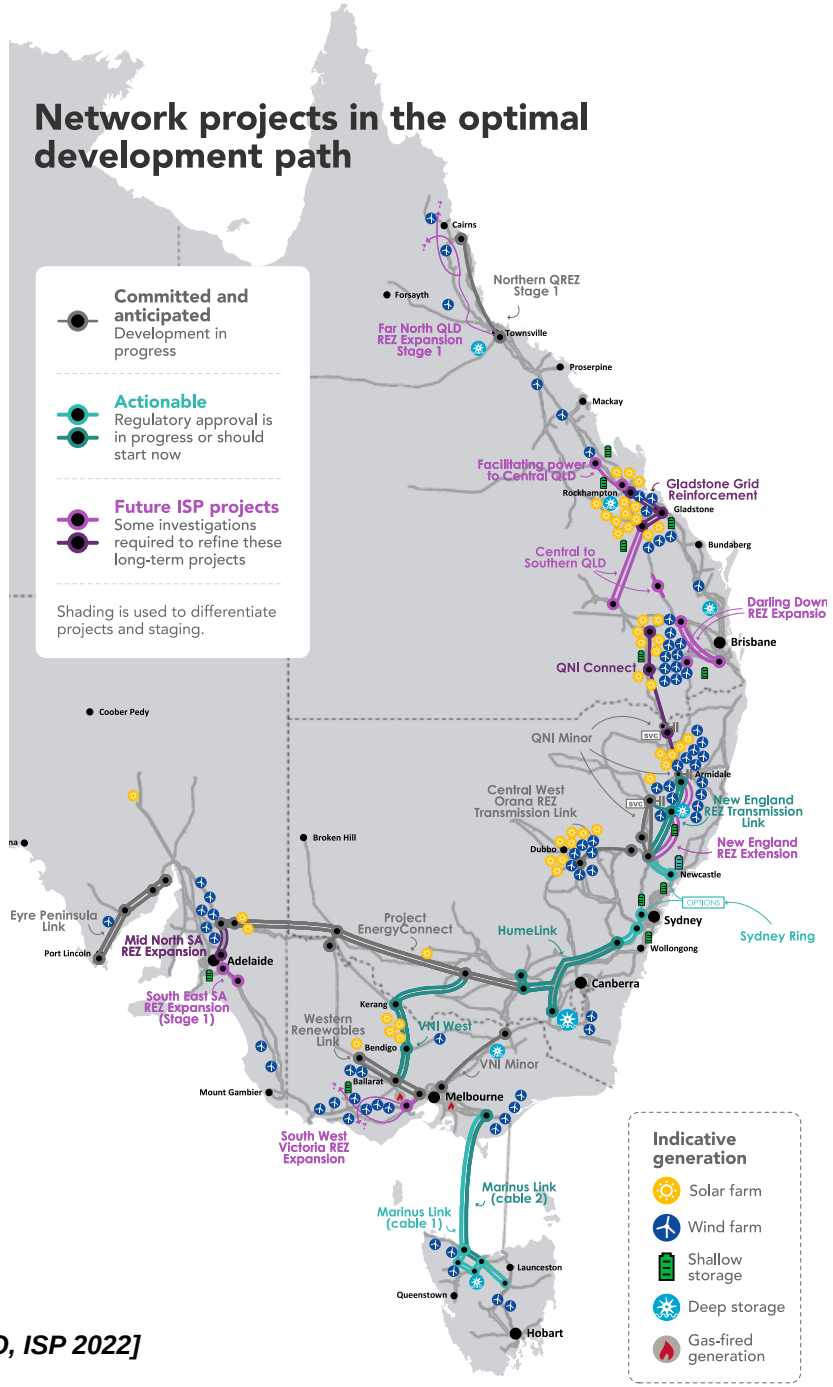
- The market operator conducts a large system planning exercise every 2 years, known as the Integrated System Plan (ISP).
  - This is least-cost optimisation exercise that explores a range of plausible scenarios
    - One of the them involves substantial increases in ‘renewable exports’ and electricity demand
  - It is *not* a market model or forecast of the future electricity system
- Primarily used to plan transmission augmentation
- The ISP identifies approximately $31 billion of transmission augmentations in the “optimal development pathway” and 10,000km of transmission lines
  - $12.8 billion is currently “actionable” (meaning it will begin progressing through regulatory process)
  - Some have substantially more transmission augmentation (the export scenario has $85 billion worth of transmission costs)



[Source: AEMO, ISP 2022]

Transmission expansion

- The regulated asset base of the current transmission system is approximately $22 billion
  - Current system includes approximately 40,000km of transmission
- Federal Government has announced the creation of a “Re-Wiring the Nation” Corporation
  - $20 billion of concessional finance to help development of transmission system
  - Operating on a cost recovery basis
- Substantial reforms to the currently regulatory framework are being discussed
  - The current approach (“Regulatory Investment Test for Transmission”) is a public cost benefit analysis test.
  - Considered too slow, incremental and not fit for purpose (not designed for significant rebuild of network).



[Source: AEMO, ISP 2022]

Summary

- Rapid influx of renewable generation substantially changing the dynamics in the national electricity system
  - Generation mix dominated by non-synchronous generation
  - Challenges with coordinating distributed, ‘behind the meter’ generation
- Could pose challenges to reliability
  - Questions remain about ability of our energy market to encourage sufficient investment to ensure reliability
  - Careful coordination required to prevent unnecessary or disruptive price shocks
- Significant investment in transmission assets required
  - Large build out by historical standards
  - Also requires careful coordination and central planning to ensure connections are built in time, but without incurring excessive and unnecessary costs for energy consumers.

Thank you

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Extra: Net load duration curve, South Australia