Global Insights: Australia

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Future of the Grid, Johannesburg

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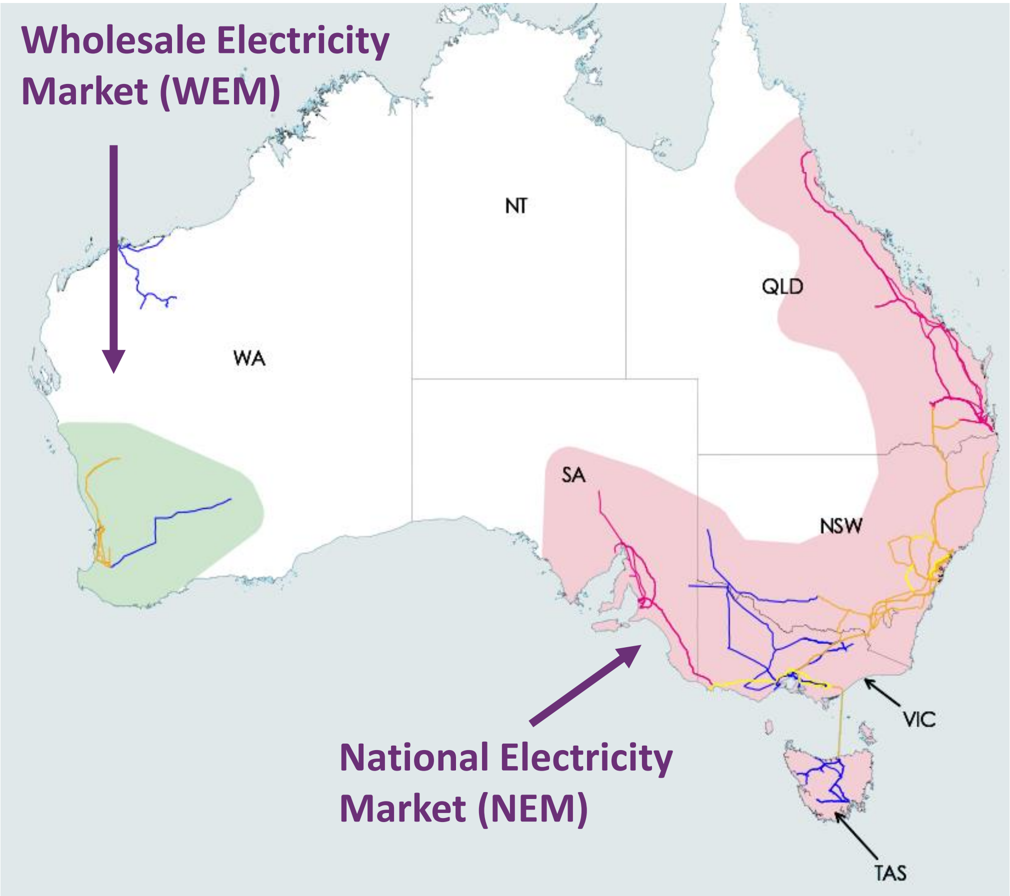
Agenda

1. An introduction to Australia’s two largest power systems
2. Insights from the NEM
3. Insights from the WEM

About AEMO

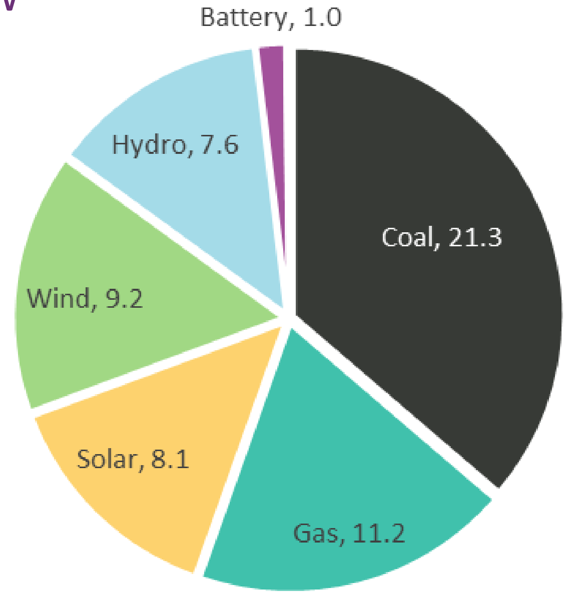
- AEMO is a member-based, not-for-profit organisation.
- We are the independent energy market and system operator and system planner for the National Electricity Market (NEM) and the WA Wholesale Electricity Market (WEM).
- We also operate retail and wholesale gas markets across south-eastern Australia and Victoria's gas pipeline grid.



NEM overview – 2023 to 2050

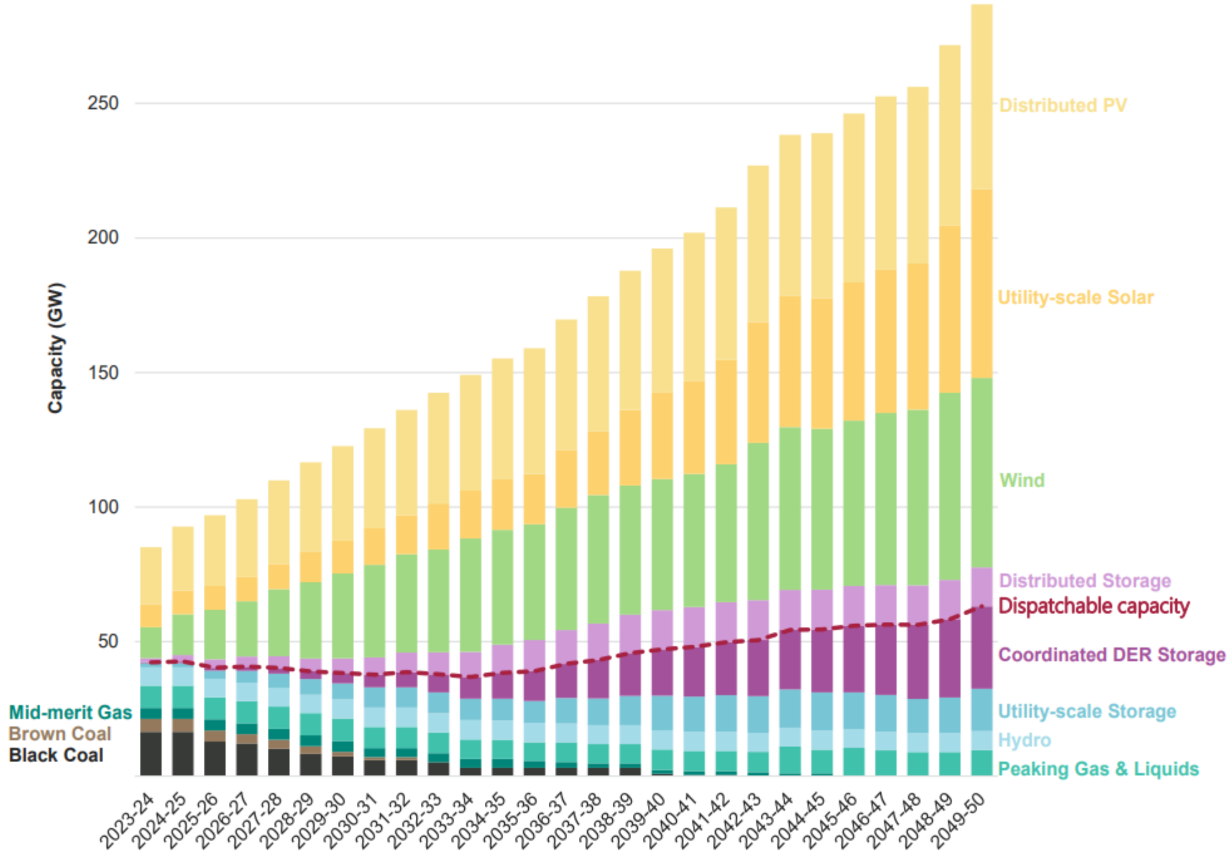
Max demand 35.8 GW
Min demand 11.9 GW

Installed generation capacity (GW)

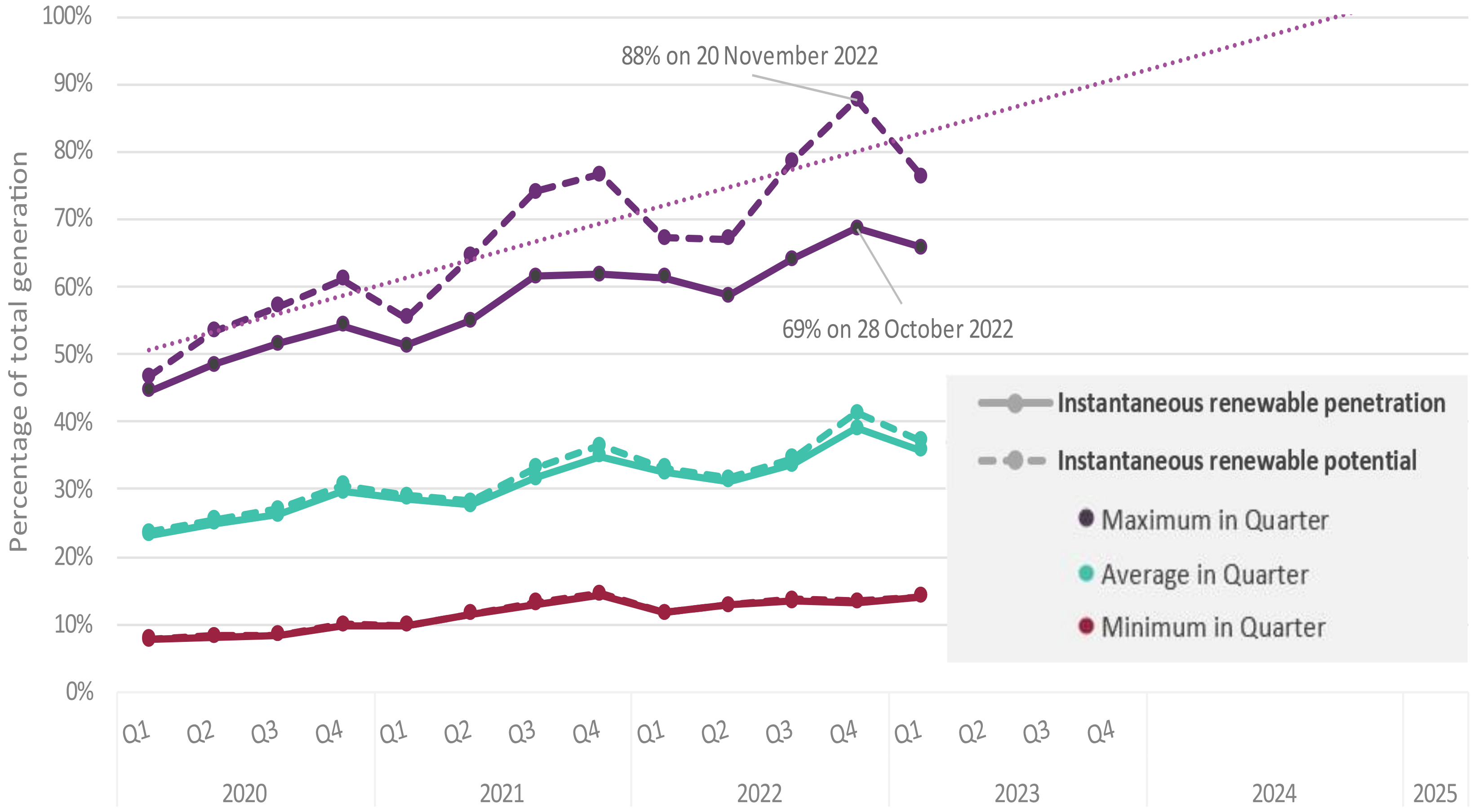


- Fuel mix in past 12 months:
  - 61% coal
  - 6% gas
  - 8% hydro
  - 8% solar
  - 17% wind

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



Increases in Renewable penetration



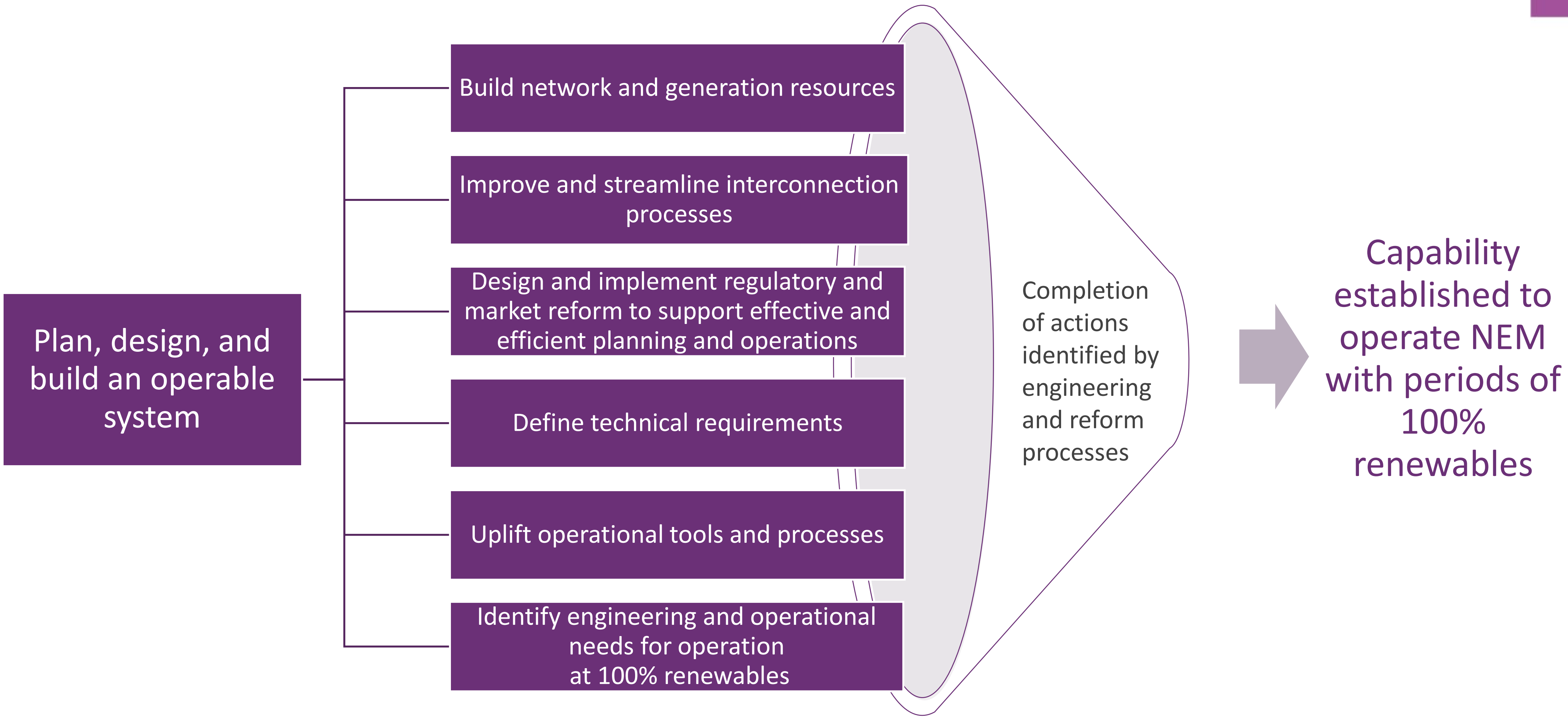
Renewable potential and penetration

Renewable potential refers to the total available energy from renewable generators at an instant in time given the weather conditions at that time, regardless of whether those generators ultimately provide all that electricity into the NEM.

Renewable penetration refers to the proportion of NEM generation sourced from renewables at a given instant in time. This can be less than the corresponding renewable potential at that time.

Tas, SA, WA penetration milestones above 90%!

Preparing for 100% renewables



Engineering Roadmap journey to date

March 2021 | July 2021 | December 2021 | June 2022 | December 2022 | June 2023

Engineering Framework | **Engineering Roadmap**

Stocktake of work in progress across industry

Defining Future Operational Conditions

1. Fewer synchronous generators online
2. Ubiquitous rooftop solar
3. Extensive grid-scale VRE
4. Structural demand shifts
5. Responsive demand
6. Widespread energy storage

Comprehensive gap analysis

300+ individual potential gaps

Engineering Framework Priority actions for 2022-23

Engineering Roadmap to 100% Renewables

2023-24 Priority actions report (this report)

1. Priority actions for FY24
2. Update on FY23 actions

Present forward → ← *Future back*

Engineering Roadmap structure

Power system security

- Frequency & inertia
- Transient & oscillatory stability
- System strength & converter driven stability
- Voltage control
- System restoration

System operability

- Monitoring & situational awareness
- Operational processes
- Power system modelling

Resource adequacy & capability

- Utility-scale variable renewable energy (VRE)
- Distributed energy resources (DER)
- Structural demand shifts
- Transmission
- Distribution
- Firming

Key insights from NEM

- Set clear policy goals if you can
- Establish a blueprint for generation and transmission expansion requirements
- Establish a coordinated plan for non-renewable generation retirements
- Plan early to identify future power system requirements
  - Frequency control and reserves
  - System strength
  - Inertia
  - Dynamic reactive support
- Define and enforce strong performance standards for new generation
- Establish streamlined interconnection processes for new generation
- Initiate regulatory changes (if needed) as early as possible to enable future requirements
- Seek to trigger early investment (noting workforce and supply chain challenges)
- Parallel pathways needed for system strength replacement
  - Synchronous condenser conversions to existing sync gens
  - New synchronous condenser procurement
  - Accelerate proof, at scale, of grid forming battery capabilities. How well can they substitute for syncons?

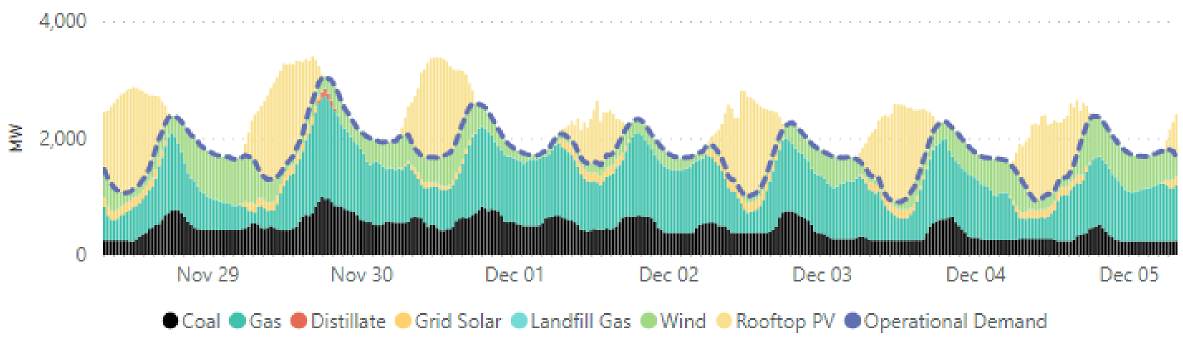
Insights from Western Australia

AEMO WA context

Summer peaking system

- Strong reliance on gas

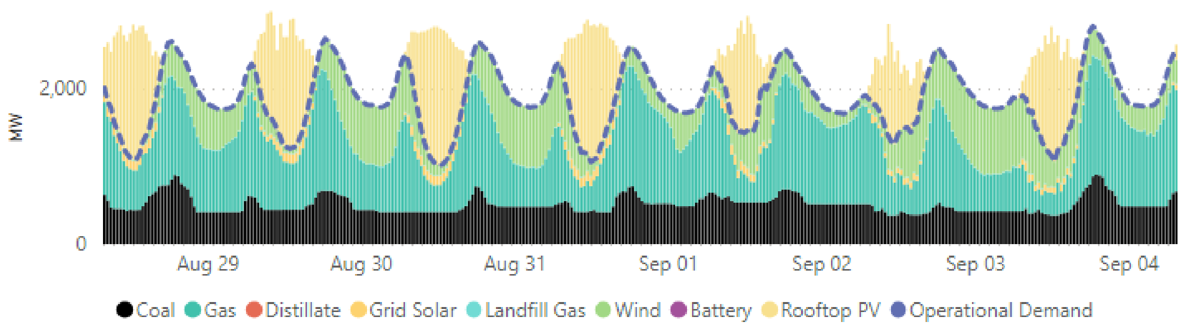
Generation by fuel type



Spring low loads

- Rooftop PV reduces minimum demand

Generation by fuel type



The **Wholesale Electricity Market** (WEM) has:

- Reserve Capacity Market
- Energy Market
- Essential System Services* (Ancillary Services)
  - Regulation up and down
  - Contingency raise and lower
  - Rate of Change of Frequency (ROCOF) control service
- Single Network Operator
- Combination of Government and Private generation

System parameters

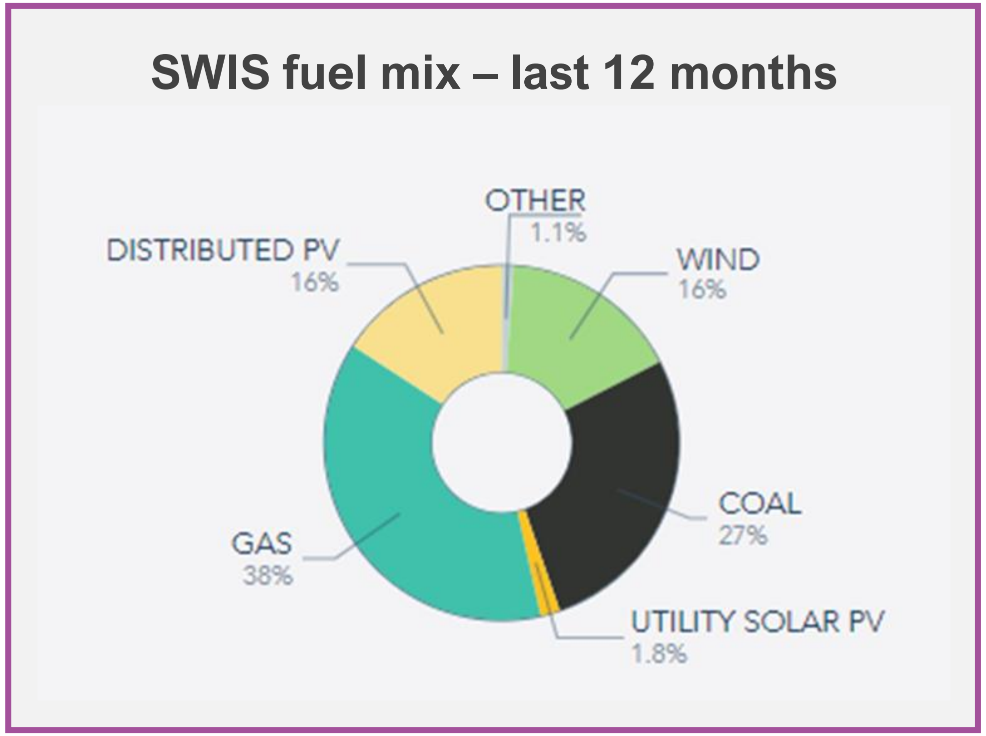
The SWIS is an isolated power system

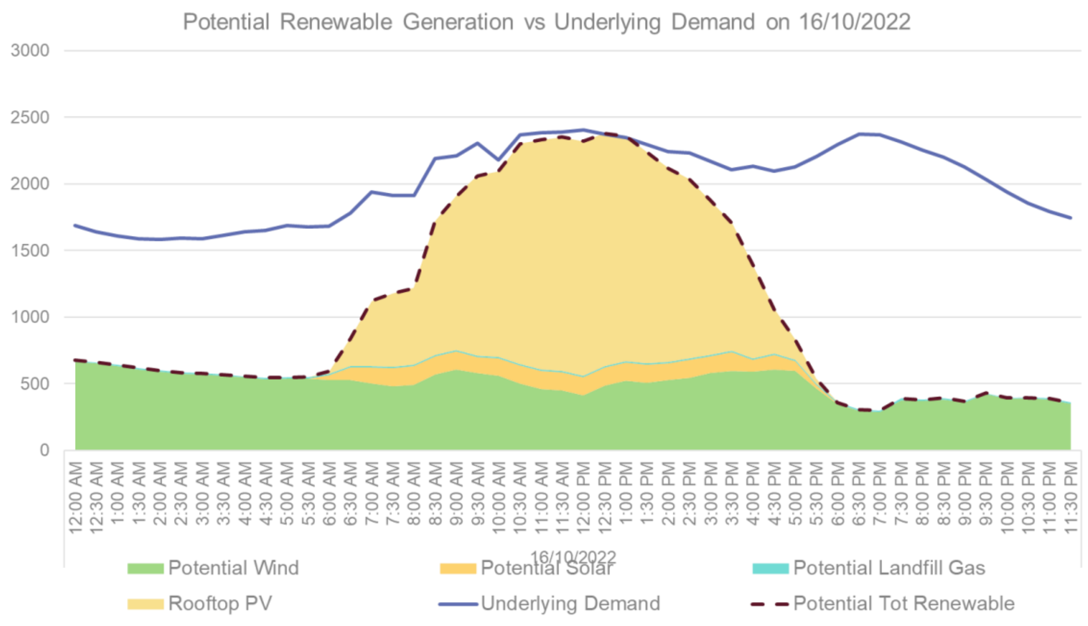
- Peak load ~ 4 000 MW
- Minimum load ~ 626 MW
- Installed Rooftop PV ~ 2 400 MW
- Maximum contingency size 350 MW

*New Markets begin on 1 October 2023

Reserve Capacity Market, together with Energy and Essential System Services

SWIS energy transition is on the way to 100%



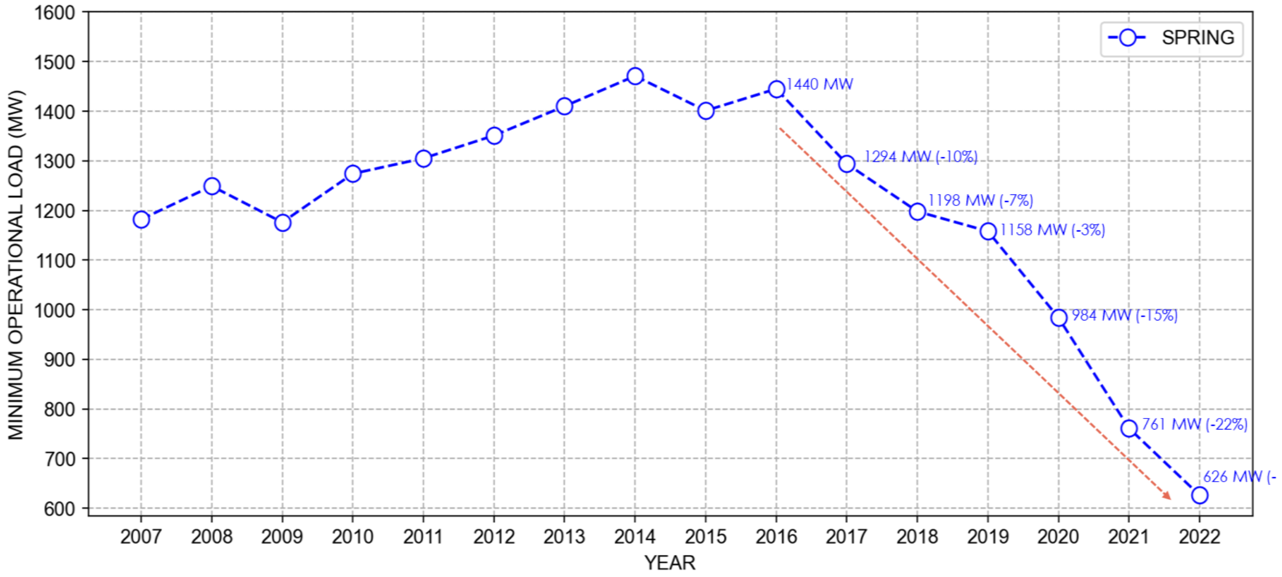


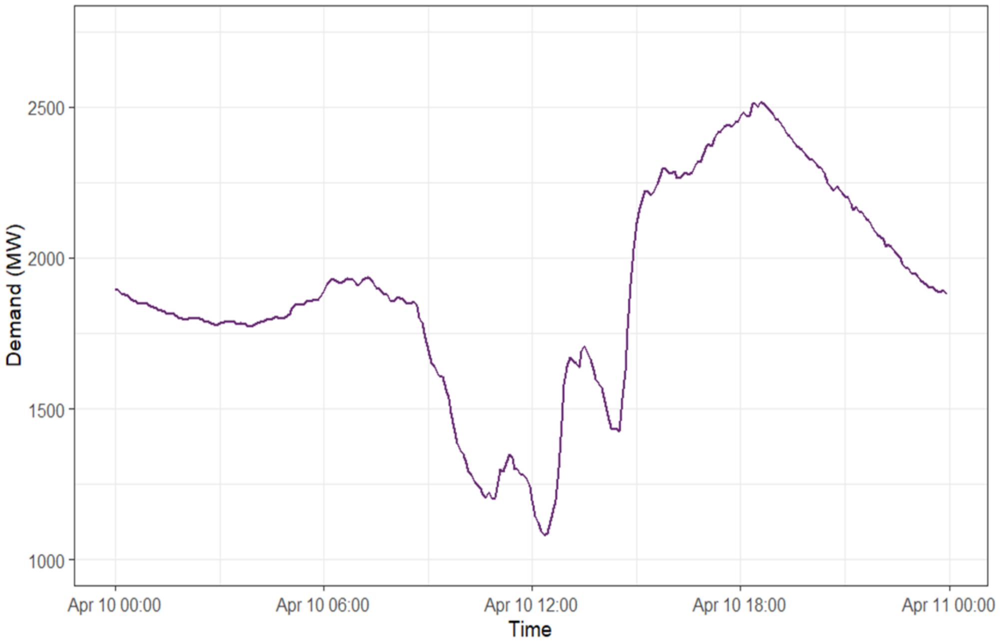
A decade ago, coal and gas supplied over 90% of all electricity generation in the SWIS.

Today, renewables account for around one-third of annual electricity supply, and up to 84% of supply within a trading interval.

There are periods of time where there is sufficient renewable generation to meet the underlying demand

Reducing minimum demand





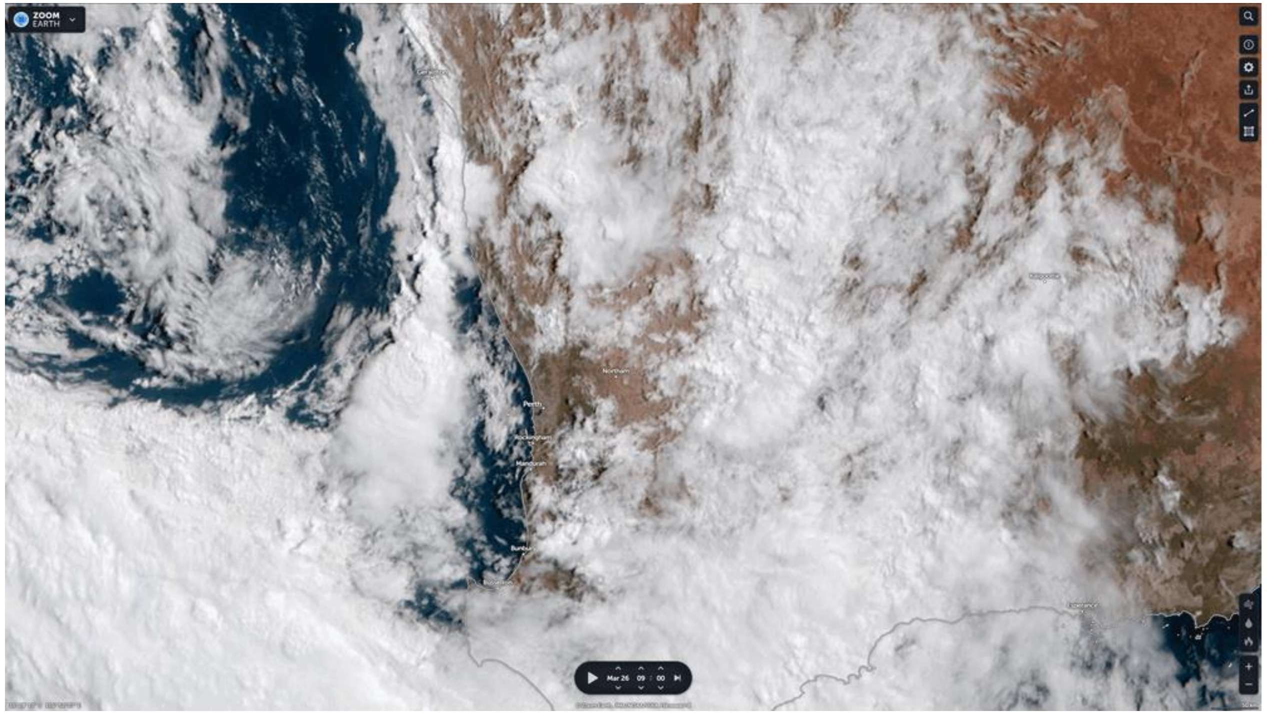
Increasing rooftop PV decreases operational demand, and increases net volatility

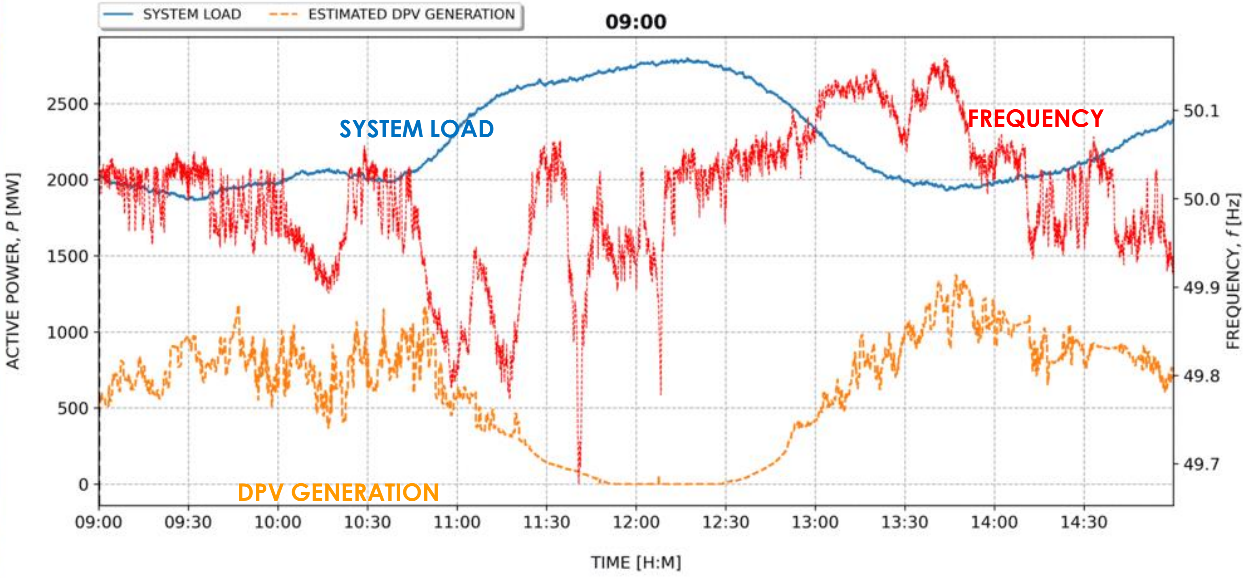
- About 39% of homes currently have rooftop PV, this is expected to increase to 60-65% over the next 10 years.
- It is expected that it will continue reducing, though at a slower rate, for approximately the next 5 years, and will then start increasing again.
- The DER forecasts consider increasing rooftop PV, Electric Vehicle update and Distributed Energy Storage Systems (DESS).

Weather Volatility

Higher levels of DPV penetration increase the volatility (real-time up and down movement) in load that is attributable to uncontrollable and largely unpredictable weather events, for example, cloud movement.

On 26th of March 2022, there was a swift cloud formation over the Greater Perth Metro area between 10:30 and 13:30 resulting in a power swing of around 1000 MW in less than two (2) hours in the output of DPVs in the SWIS. The DPV generation swing manifested in an 800 MW system load swing (40% relative to system load).





Impact of rooftop PV

Reducing minimum demand

Able to keep on sufficient synchronous generators to provide system strength and inertia

Considerations

- Commissioning of large batteries
- Generators reducing minimum demand capability
- Contracting for load in the middle of the day
- Disconnecting rooftop PV

Effectiveness of Under Frequency Load Shedding

As feeders turn into generators, UFLS trips "generators"

Response

- Differentiation at lower levels is required
- Only feeders when exporting
- Review of feeder allocations at different times

Rooftop PV is largest contingency

The voltage dip associated with an equipment fault also disconnects rooftop PV

Considerations

- Estimate of PV tripping in different areas
- Consider as part of contingency size and carry reserve
- Enhanced inverter specification

System restart

Historical system restart pathways relied on residential load, which may not be there in the middle of the day

Considerations

- Reviewed system restart pathway
- Researching into different options

No single solution can address each of these impacts. Each requires a multi-faceted approach.

WA Roadmap

1. Coal and high emitting technologies will retire from the system over time
2. The majority of the energy needs will be directly served by renewable energy sources
3. The system will be instantaneously operated at 100% renewables at times
4. DER will actively participate in the market alongside enhanced visibility and control of unregistered DER
5. Storage will play a key role in both providing Essential System Services and energy shifting
6. For the next 10+ years a level of “backup” generation from fossil sources will be required to manage dunkelflaute (sustained lull in wind and solar PV) and insufficient storage capacity
7. System demand will increase due to electrification and new industry development

Observations and insights from an operator

- **Multiple parties** required to develop new polices, frameworks, markets and rules to implement changes across a range of issues.
- **Compliance focus** is essential both for large generators but also for ensuring DER meets applicable standards.
- The impact of **weather** on the system is growing exponentially, both from a supply and demand side.
  - As DER plays an increasingly larger role, the need for more accurate real time forecasting of cloud cover and associated actions to be taken as a result of this, becomes critical
- Detailed **modelling** takes time, requires new models and needs to be set up prior to the issues materialising.
- The **tools** that are needed to manage the power system in the future are a big step forward from those available today.
- All of these elements require **resources**, with a range of different skills. There are benefits in developing partnerships with academic and research institutions.

The energy transition is well underway

The future electricity supply will be built on four pillars:

1. **Low-cost renewable energy,** taking advantage of the abundant wind and solar resources.
2. **Firming technology** like batteries, and gas generation, to smooth out the peaks and fill in the gaps from that variable renewable energy.
3. New **transmission and modernised distribution** networks to connect these new and diverse low-cost renewable sources of generation to our towns and cities.
4. A power system **capable of running, at times, entirely on renewable energy**.

AEMO

AUSTRALIAN ENERGY MARKET OPERATOR

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