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THE UNIVERSITY OF MELBOURNE

Melbourne Energy Institute

MEI*network*24 Seminar Series

2 May 2024

Seminar #1:
System overview - from generation to customer

Speaker:
Chris Mock, *Manager – Engineering Strategy*
Australian Energy Market Operator (AEMO)

Moderator:
Dr Adrian Panow, *Director Major Projects*
Melbourne Energy Institute

MEI*network*24 Seminar Series

Seminar topic	Month
1. System overview: from generation to customer	**2 May 2024**
2. Transmission and distribution networks	4 Jun 2024
3. Wholesale markets	17 Jul 2024
4. Financial markets	7 Aug 2024
5. Retail markets	3 Sep 2024
6. Distributed energy resources	8 Oct 2024
7. Energy communities and microgrids	7 Nov 2024

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System Overview: From Generation to Consumer

Melbourne Energy Institute
Seminar Series – 2 May 2024

Chris Mock

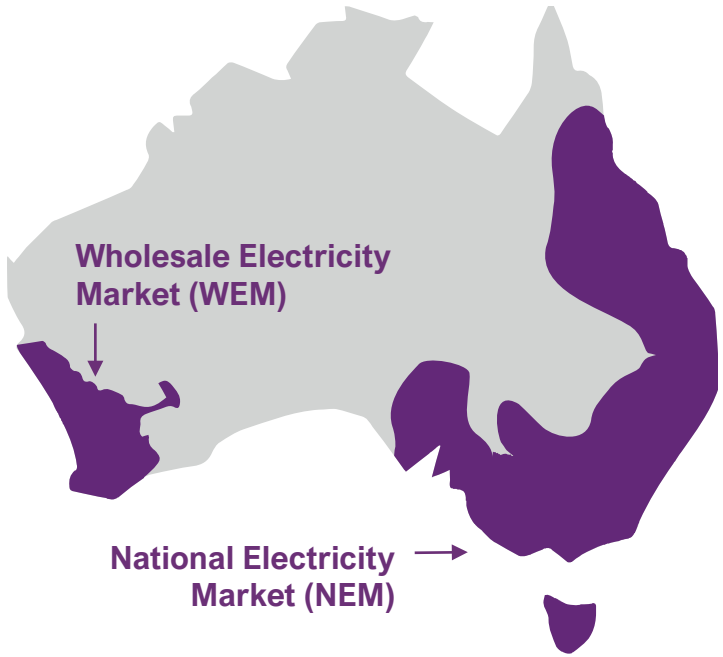
About AEMO

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

AEMO SERVICES

AEMO Services is an independent subsidiary of AEMO, established in 2021 to enable the transparent provision of advisory and energy services to National Electricity Market jurisdictions.

Electricity



Gas

Declared Wholesale Gas Market (DWGM)

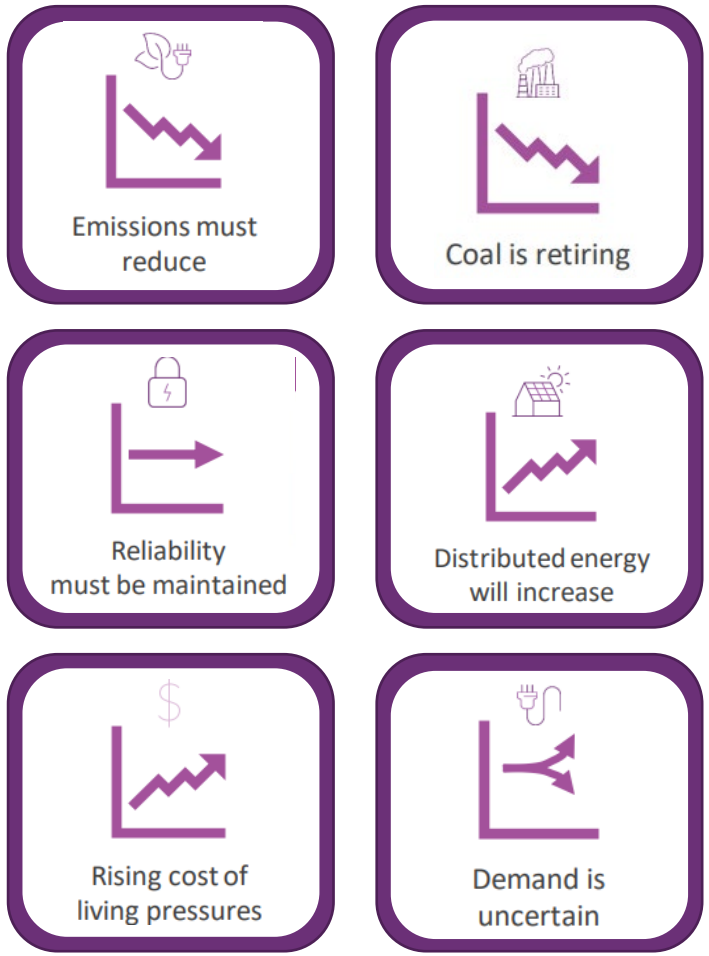
Short Term Trading Market (STTM)

and

Gas Supply Hub (GSH)

The energy transition is well underway

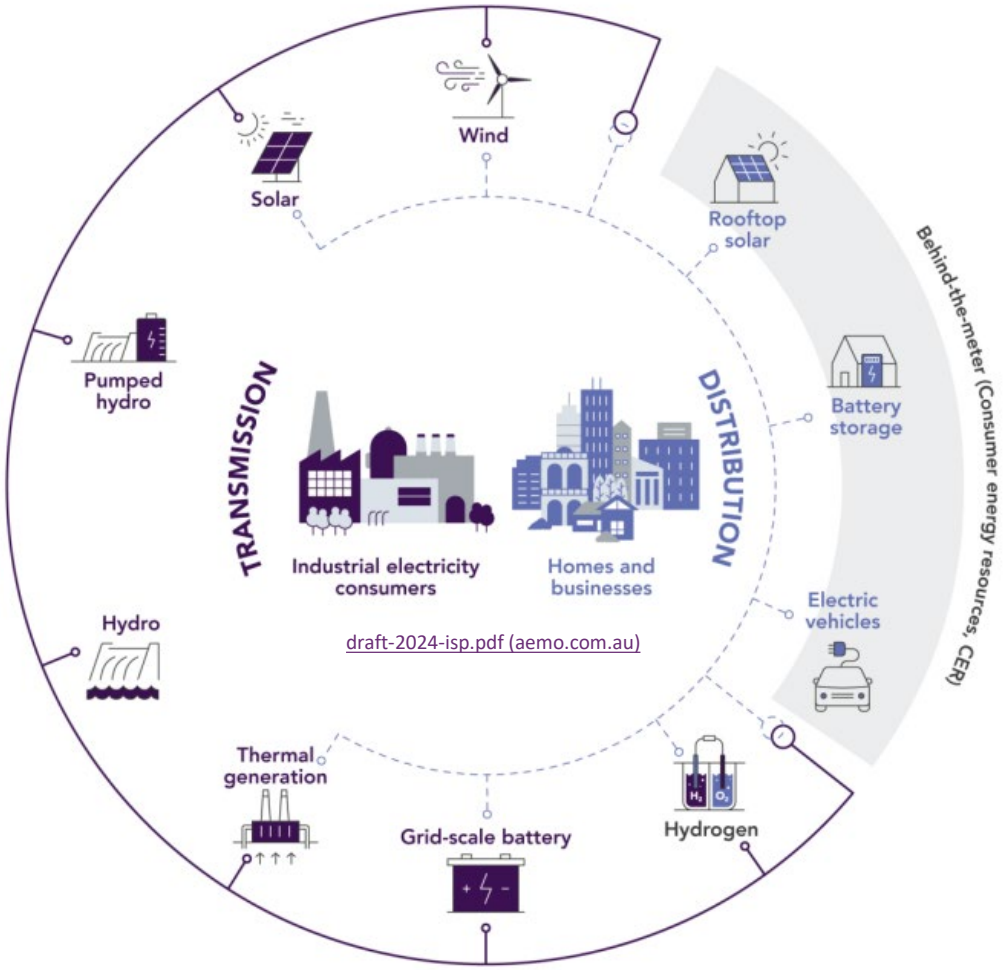
- Australia's governments have committed to adopt a target of net zero emissions by 2050.
- Coal-fired electricity generation is retiring two to three times faster than anticipated.
- Household and business electricity consumption from the NEM is forecast to nearly double by 2050.
- Urgent investment is needed so that Australian homes and businesses can continue to enjoy a secure, reliable and affordable energy.
- **Renewable energy connected with transmission, firmed with storage and backed up by gas-powered generation is the lowest cost way to supply electricity to homes and businesses throughout Australia's transition to a net-zero economy**



Draft 2024 ISP: key facts and figures

draft-2024-isp---overview.pdf (aemo.com.au)

Changing role of the grid



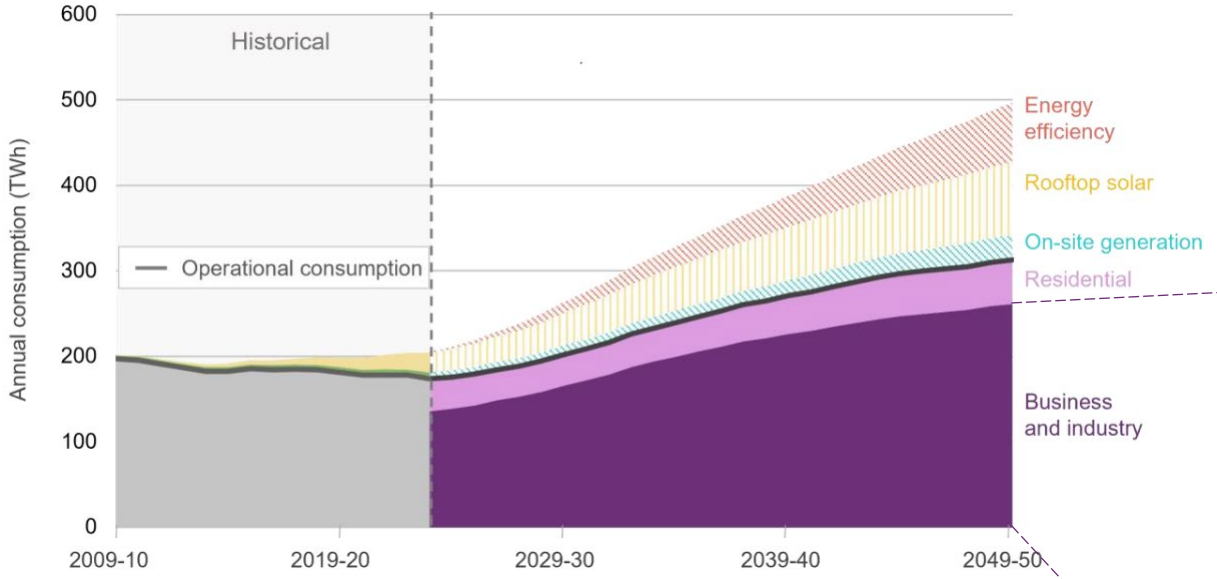
- **A power system with both grid and behind-the-meter energy supply**
- Future energy consumption from the NEM will rise by approximately 108% by 2050, largely from business and industry, as households increasingly meet their own electricity needs.

Consumers

Future energy use

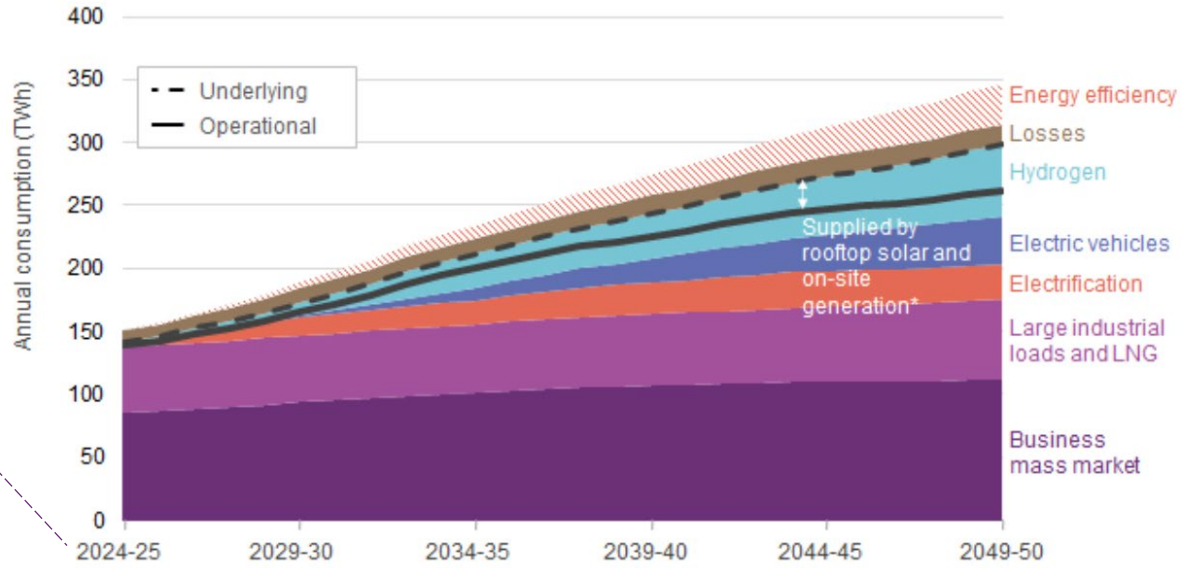
NEM Electricity Consumption

Draft 2024 ISP Step Change scenario

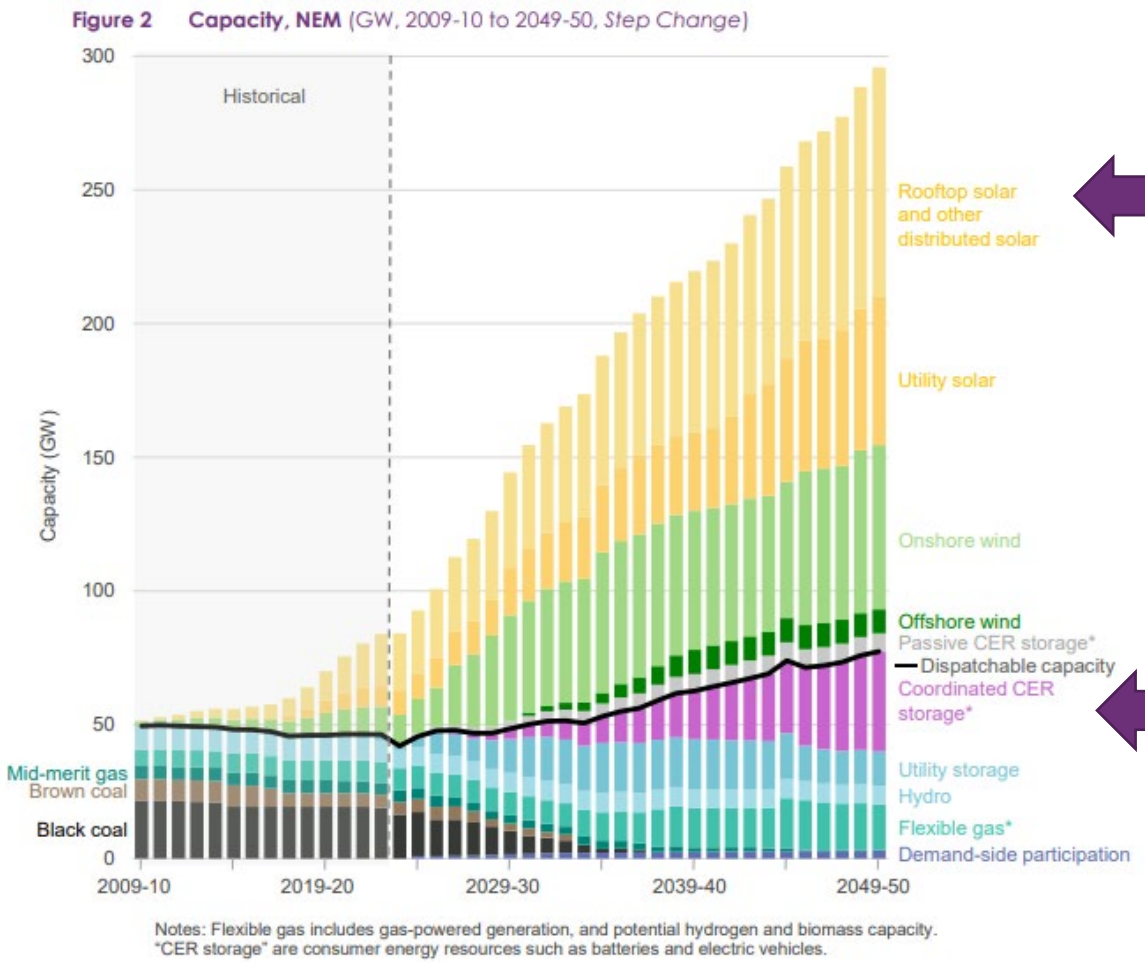


Business and industry electricity consumption

Draft 2024 ISP Step Change scenario



Consumer energy resources



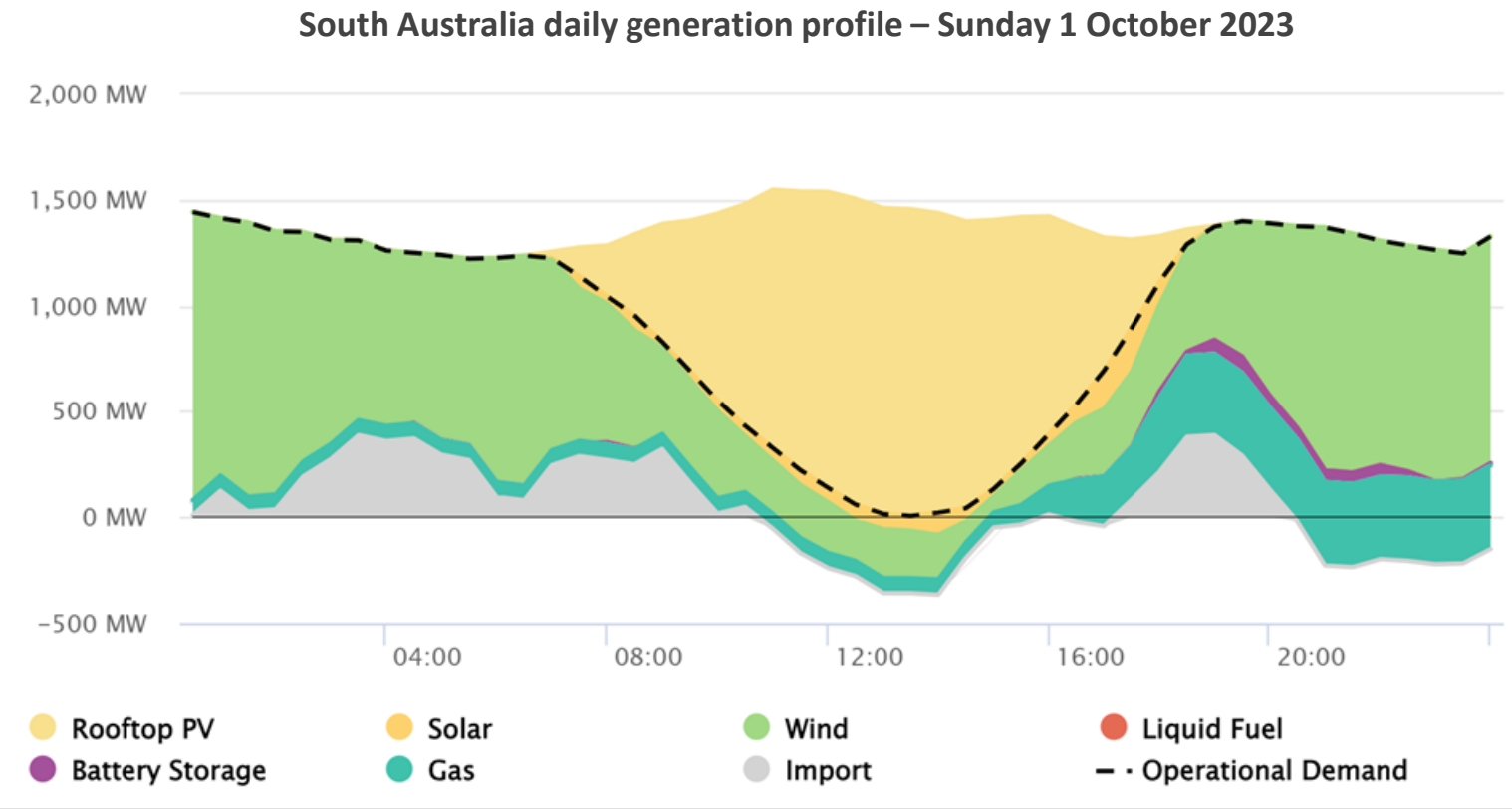
4x increase in rooftop + distributed solar by 2050 facilitating the use of consumer-owned batteries and virtual power plants (VPPs)

Coordinated CER:

- ~0.2 GW today
- 3.7 GW in 2030
- 37 GW by 2050 (~48% of dispatchable capacity)

Source: AEMO – Draft 2024 Integrated System Plan

Distributed PV driving changes in operational demand



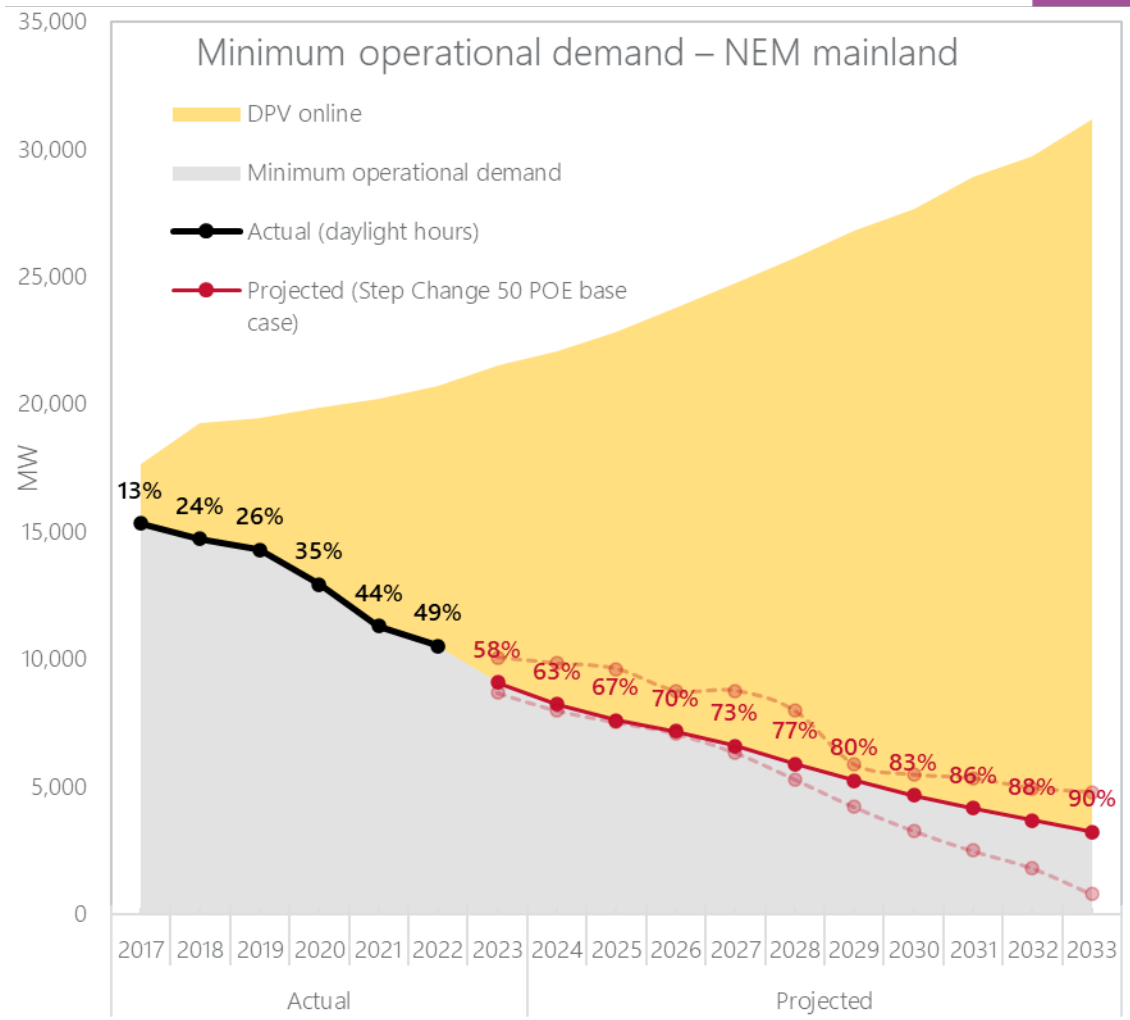
Half-hour ending 13:30

- Record low SA operational demand of 5MW
- Distributed PV accounted for 99.7% of SA underlying demand
- Output from SA grid-scale generators maintained at low level, with net excess exported to VIC

AEMO Quarterly Energy Dynamics, Q3 2023

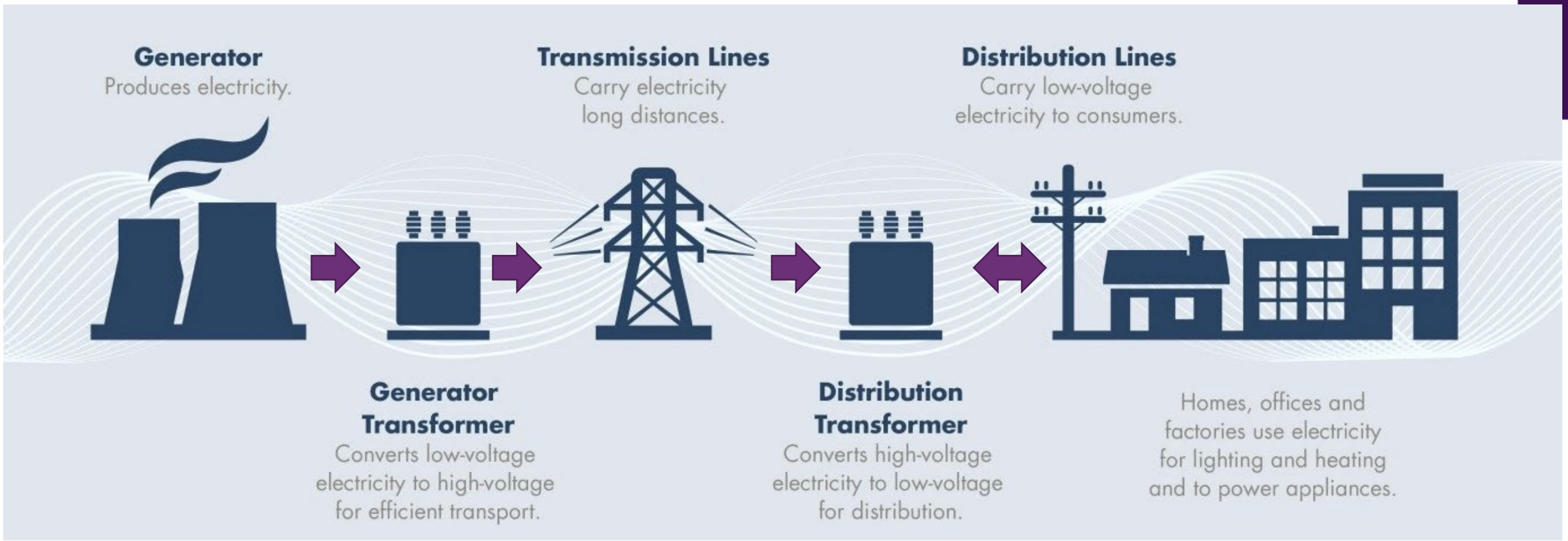
Minimum operational demand

- AEMO must keep operational demand above certain minimum load thresholds
  - Synchronous generators currently needed for system security
  - Load on the transmission network needs to remain high enough to support voltage management during system normal conditions
- Minimum system load continues to drop across the NEM



Network

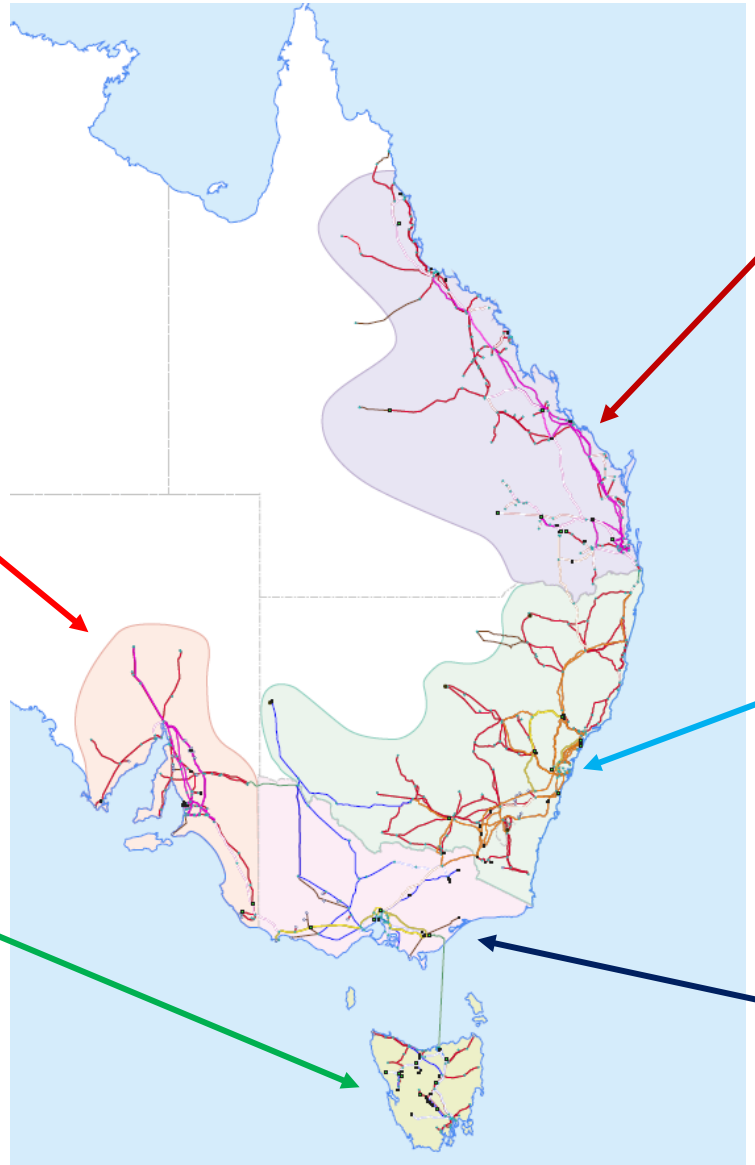
Centralised network



The network – asset owners

TNSP: Transmission Network Service Provider

DNSP: Distribution Network Service Provider



TNSP: Powerlink

DNSPs: Ergon Energy, Energex (Energy QLD)

TNSP: ElectraNet

DNSP: SA Power Networks

TNSP: TransGrid

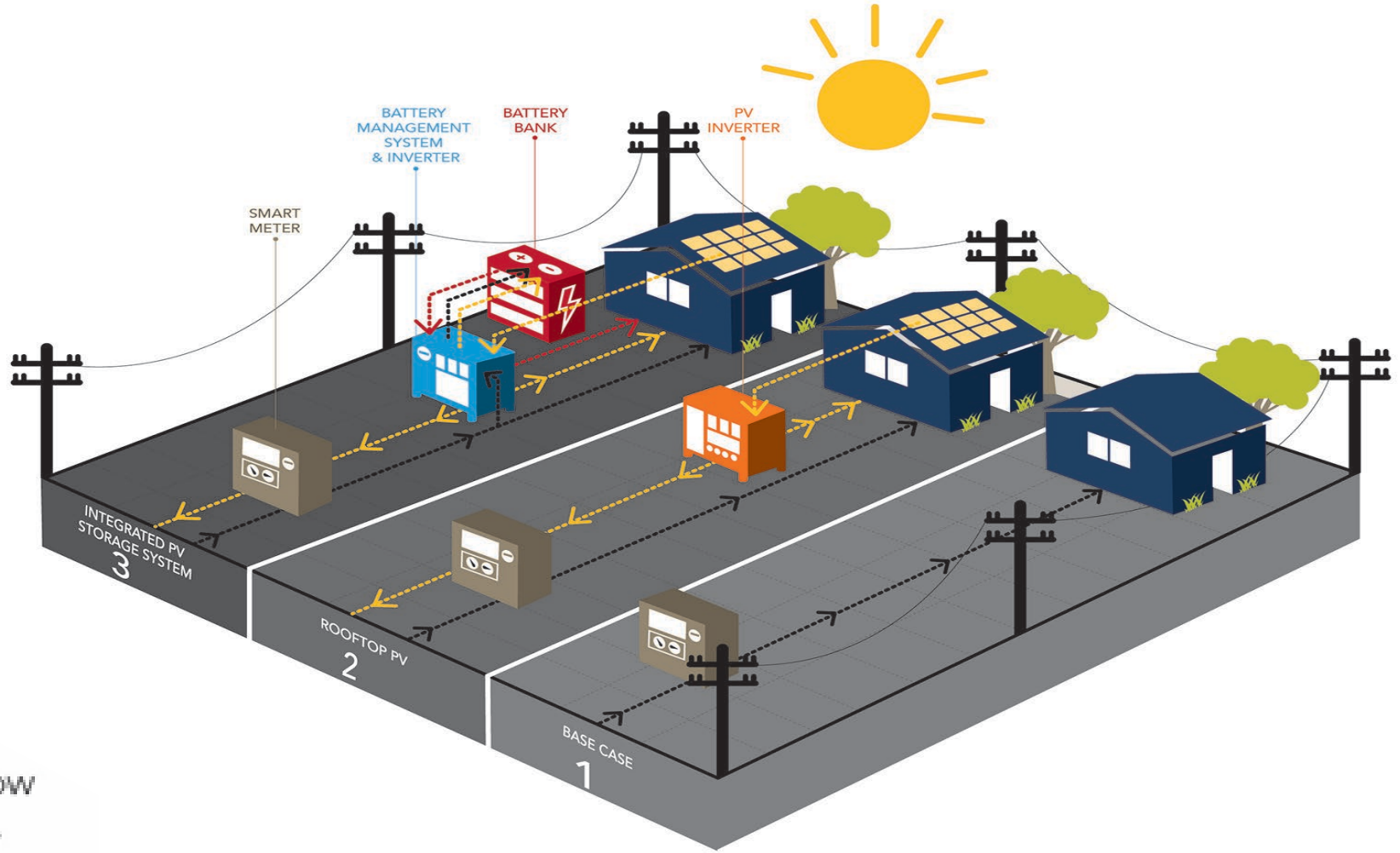
DNSPs: Ausgrid, Endeavour Energy, Essential Energy, Evo Energy

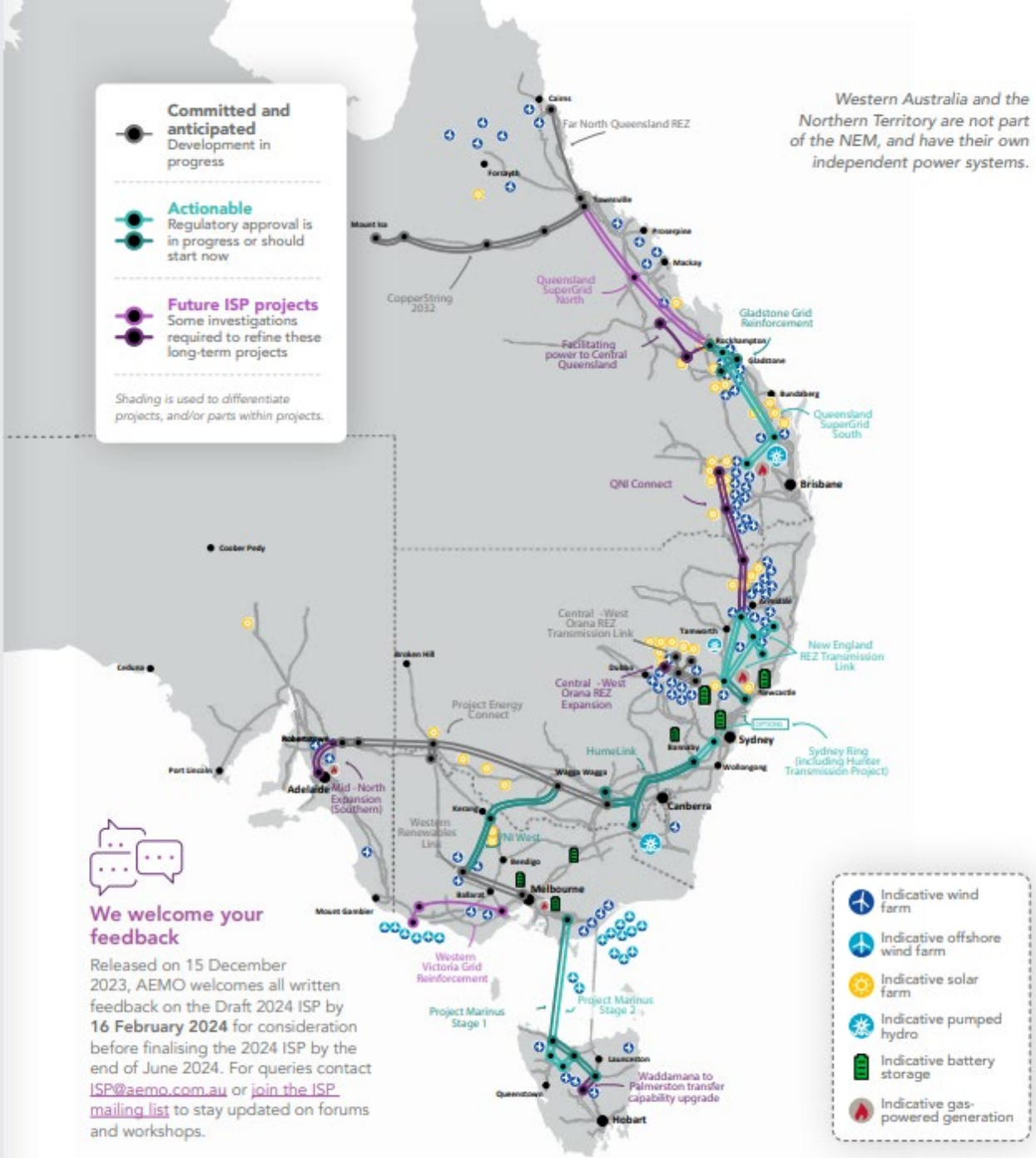
TNSP and DNSP: TasNetworks

TNSP: AusNet Services, TransGrid

DNSPs: AusNet Services Distribution, CitiPower, Jemena, Powercor, United Energy

Changing role of the grid





Towards 10,000 km of transmission investment required

Close to 10,000 km of new transmission lines and upgrades required to existing networks by 2050 to connect new generation across the power system.

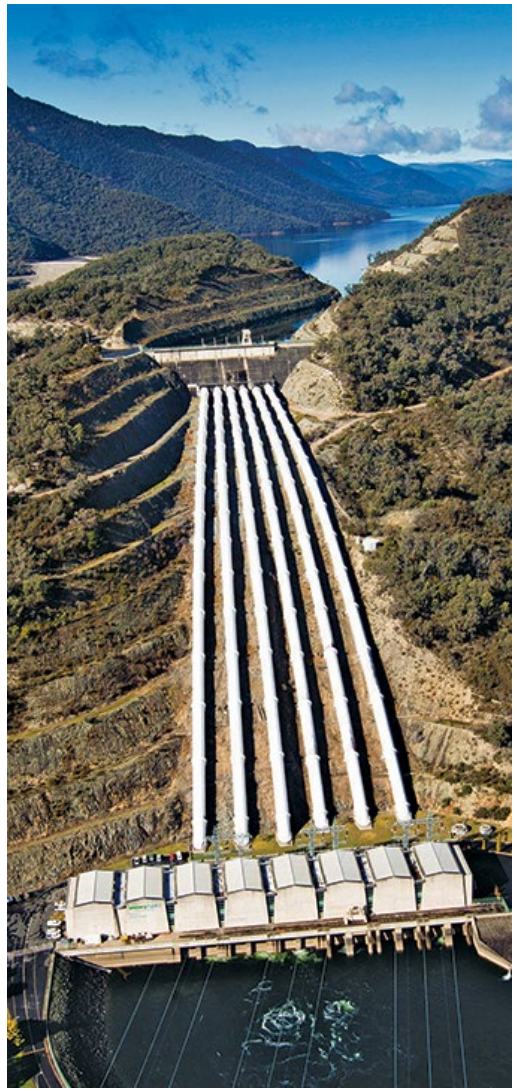
draft-2024-isp---overview.pdf (aemo.com.au)

Generation

Synchronous generation

Coal:
Yallourn
Power Station

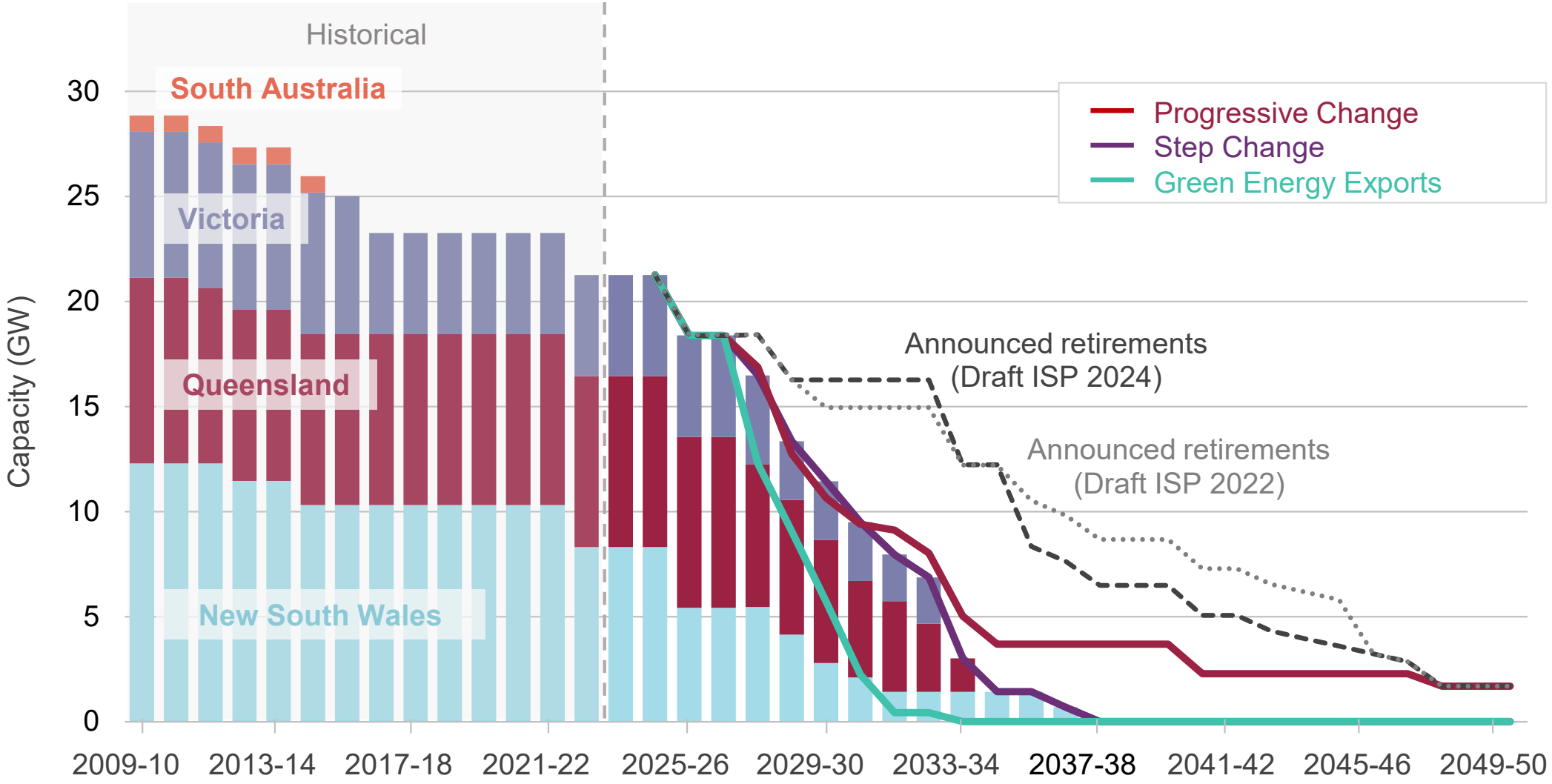
Gas:
Mortlake
Power Station



Hydro:
Tumut 3
Power Station

Sources: Herald Sun, Oil and Gas Review, NSW Resources and Energy

Coal retiring two to three times faster than anticipated



Non-synchronous generation

Wind:
Hornsdale Wind Farm

Battery:
Victorian Big Battery

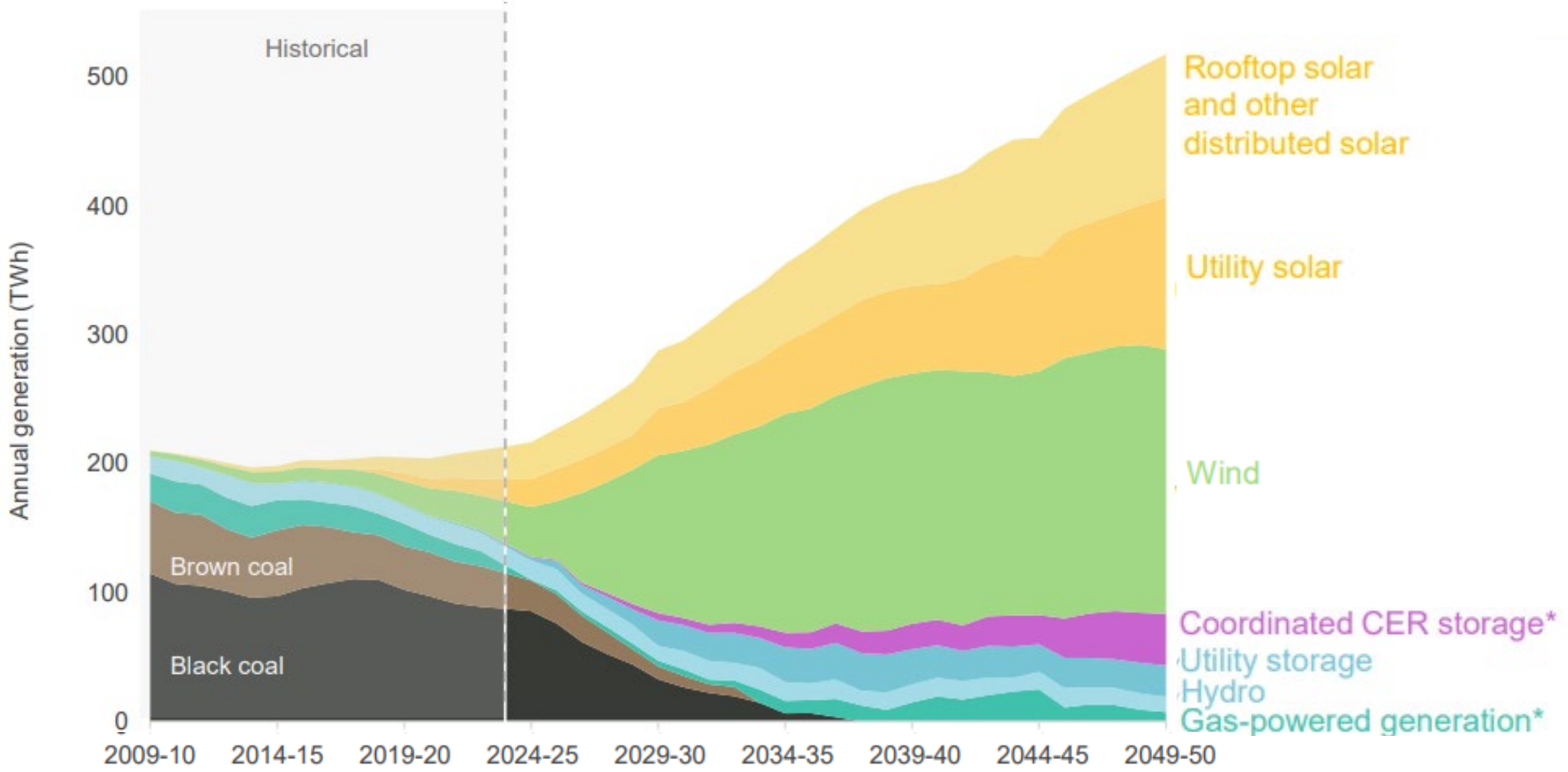
Rooftop PV: *University of Queensland*

Large-scale PV:
Nyngan Solar Farm

Sources: AGL, Siemens, Trina Solar, Aurecon

The changing generation mix

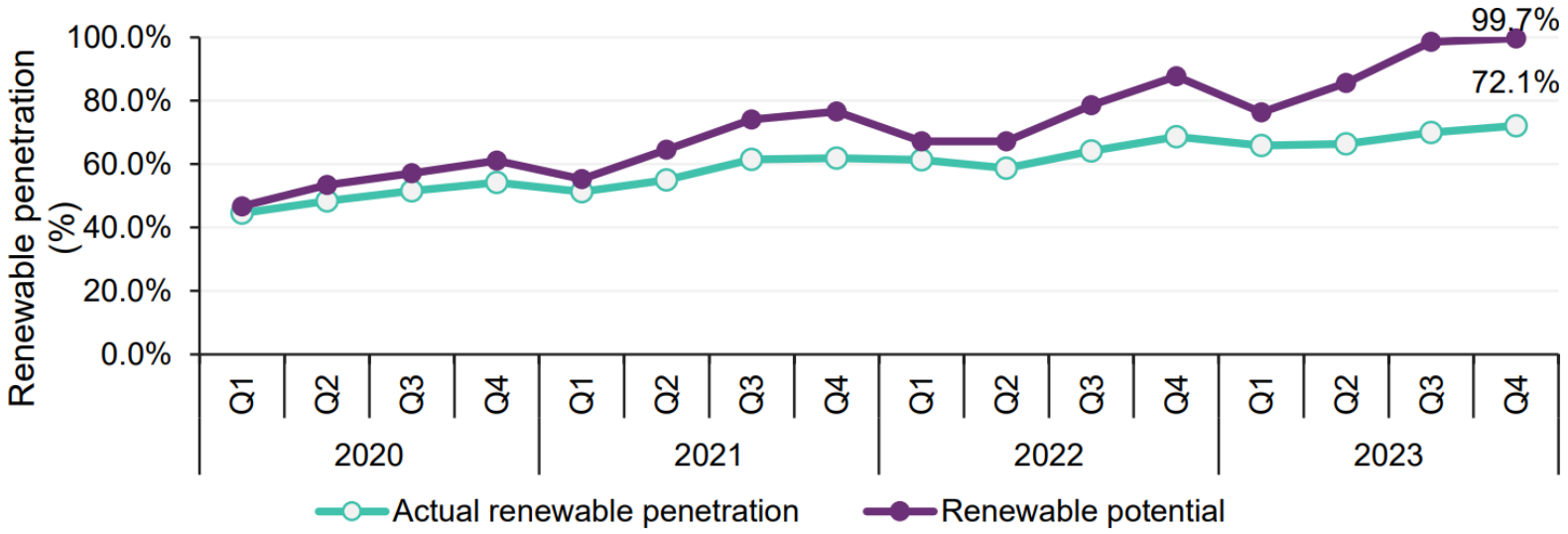
National Electricity Market (NEM), 2009-2050 (GWh)



Draft 2024 ISP publication webinar (aemo.com.au)

Increases in renewable penetration

Record high actual and potential renewable penetration
AEMO Quarterly Energy Dynamics, Q4 2023

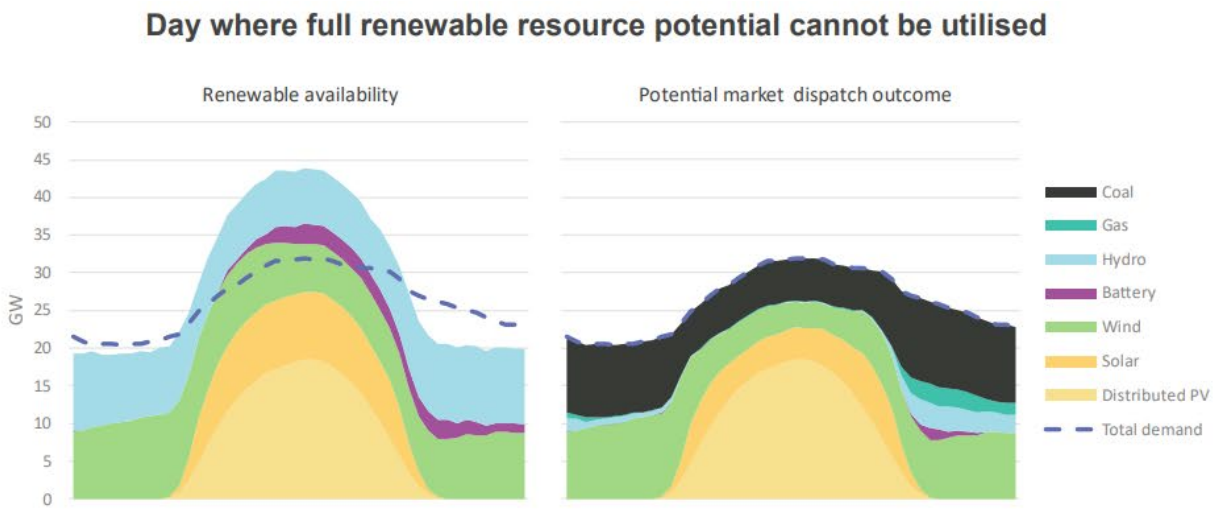


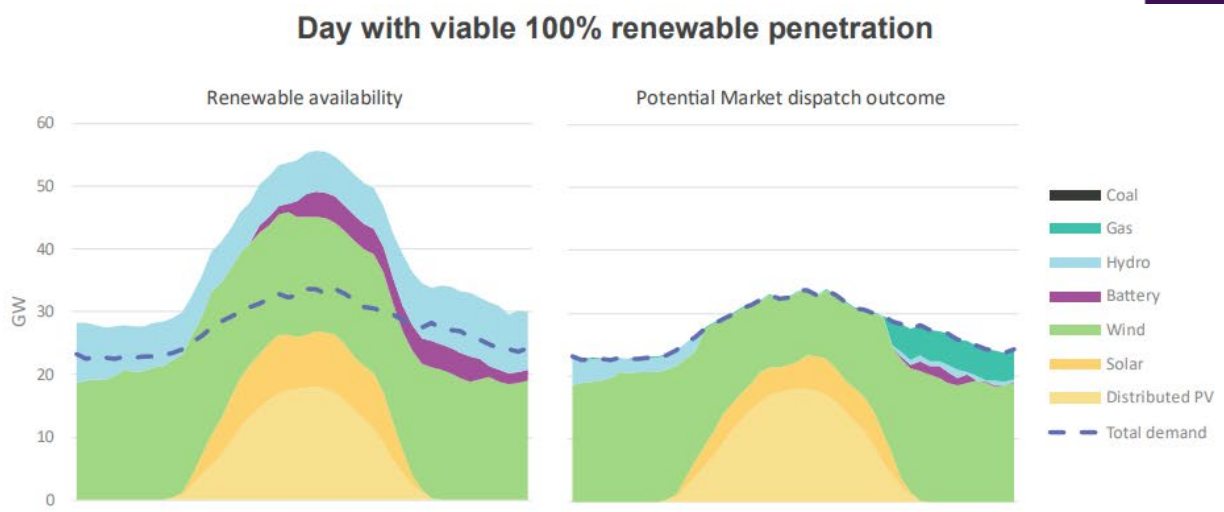
Renewable potential and penetration

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.

Utilisation of renewable resource potential





- It may not be possible to dispatch the market at 100% renewable penetration the first time that 100% renewable resource potential.
- Operating a secure and reliable system under these conditions will require sufficient reserve margins and sources of essential system services, at the time of 100% renewable operation and during the surrounding periods.
- Economic bidding behaviour from market participants may further influence whether renewable resource potential is dispatched.

Engineering Roadmap

Challenges of timely risk identification in the transitioning NEM

Situation

- The NEM and WEM are transitioning toward, or have already reached, **globally unprecedented and untested operational conditions** across a range of different power system phenomena.

Challenge

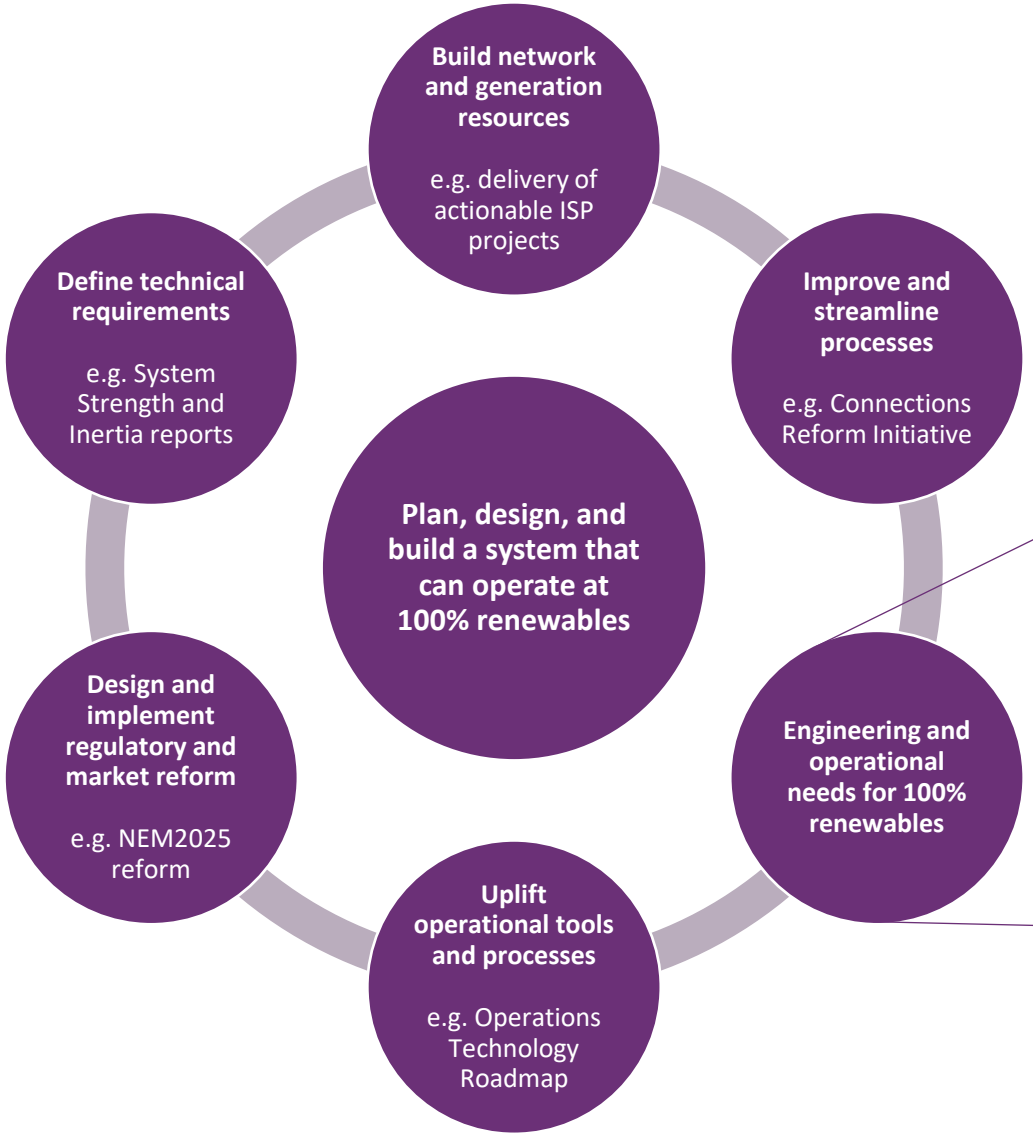
- Existing power system analysis methods may not be fit-for-purpose in identifying the needs of the future power system.
- Detailed studies, sometimes open-ended, are required to identify security risks as the power system transitions to higher proportions of renewable generation.

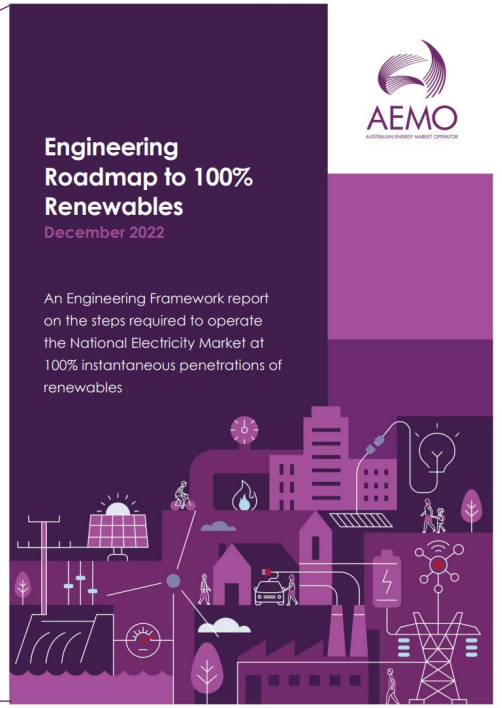
Risk

- If these studies are not performed in a timely enough manner to enable the deployment of new assets and processes to enable secure system operation under new conditions, constraints need to be applied to force large synchronous machines to remain online.

Example outcome: Curtailment of renewable generation, and additional directions payments to maintain minimum synchronous units online in South Australia over the period 2018-2021

Preparing for 100% renewables





Engineering Roadmap journey

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

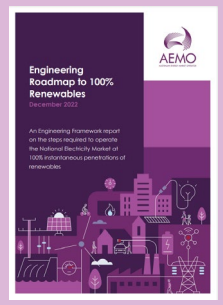
1	Fewer synchronous generators online
2	Ubiquitous rooftop solar
3	Extensive grid-scale VRE
4	Structural demand shifts
5	Responsive demand
6	Widespread energy storage

Comprehensive gap analysis

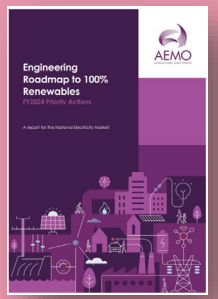
300+ individual potential gaps

FY23 priority actions

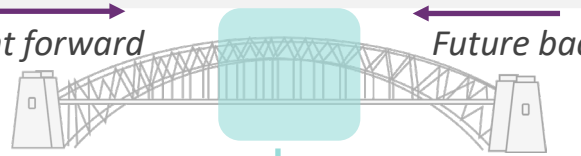
Engineering Roadmap to 100% Renewables



FY24 priority actions

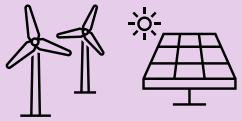


Present forward — *Future back*



Scope of roadmap

Detailed**, engineering-focused roadmap**



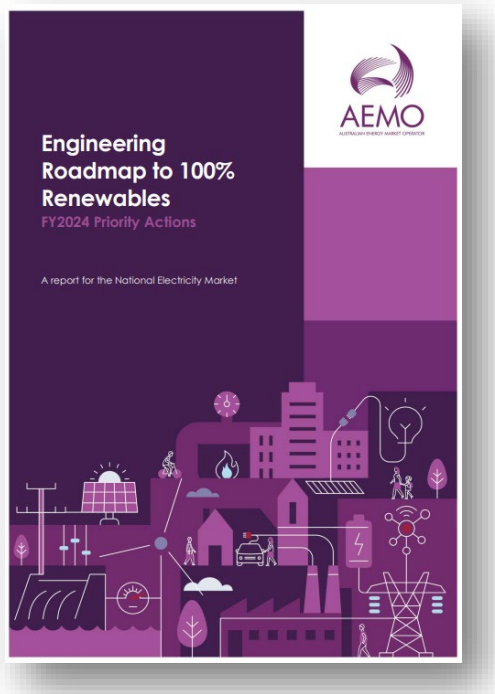
AEMO's view of the **technical, engineering, and operational actions** required to **operate the NEM at 100% instantaneous renewables** for the first time

Technical base to **inform industry prioritisation of steps** necessary to transition through key milestones on the way to 100% renewables

Provide confidence around **underway actions** and highlight **areas requiring further attention**

Engineering Roadmap – FY24 priorities

Priority actions identified largely cover four key objectives that AEMO sees as pivotal to progress:



- Enabling high penetrations of distributed energy resources (DER)
- Enabling new technologies to address system needs
- Conducting future power system studies
- Building operational readiness

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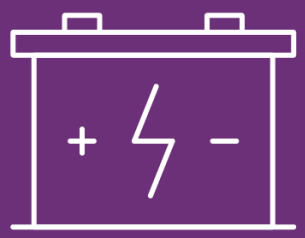
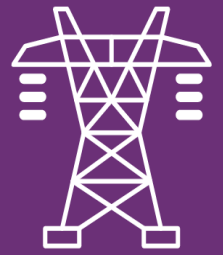
FY24: Enabling high penetrations of DER



Performance, visibility and controllability, and necessary operational coordination and data exchange, for securely operating a high DER power system, allowing consumers to optimise for their own circumstances and to harness DER flexibility in an increasingly two-way power system.

- Short-term measures to improve **installation compliance of new DPV inverters** to AS4777.2:2020, reducing potential DPV disconnection during disturbances.
- Establish strong **governance frameworks** for assessing and enforcing ongoing compliance of DER inverters to meet performance requirements.
- Establish effective **emergency DPV shedding schemes**, operational roles and procedures.
- Establish **roles and responsibilities** between AEMO, DNSPs, TNSPs and participants.

FY24: Conducting future power system studies



Understanding emerging issues on the power system as it moves towards uncharted operating conditions, and quantifying gaps in known system requirements for immediate emerging operating conditions.

- Conduct **screening studies of fault level requirements** over a range of 100% renewable energy system conditions.
- Perform **targeted future system dynamic studies**, identify emerging phenomena, and interactions between phenomena.
- Conduct **system restoration studies for high DPV** conditions.
- Further assessment of **system security issues** associated with **increasing penetrations of DPV**.

FY24: Enabling new technologies to address system needs

Accelerating efforts to support grid-forming inverter development and promoting opportunities for technologies to include multiple system services as part of their solution design.

- Promotion of **inertia provision as part of system strength solutions** (of any technology type), where this would lead to more efficient/timely deployment of capability to meet future system needs.
- Collaboratively develop resources to support the **practical application of the voluntary grid-forming inverter specification**.
- Utilise existing and proposed **grid-forming projects to build knowledge and consensus** on the system support capabilities of this technology.

FY24: Building operational readiness

Enhancing operational capabilities to adapt to a changing power system, including improved modelling approach and tools, monitoring and situational awareness, and increasing readiness efforts to securely operate the power system in new configurations for the first time.

- Collaborate with industry participants and relevant stakeholders to **develop plan to trial South Australia with fewer synchronous generators online**.
- Pending outcomes of preliminary scoping, explore **system requirements to support operation of Tasmanian region with 100% IBR generation**.
- **Collaboration between Bureau of Meteorology and AEMO** to develop a sustainable business model for acquiring, curating and releasing **new weather observations** that will provide enhanced now-casts and forecasts for the energy sector.