Australia's Energy Transition: Lessons from the world's rooftop solar leader

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Outline

- Context
  - Industry
  - Market
  - Governance & policy
- Outcomes
  - Generation, storage, subsidies, electricity prices, retail markets
- Lessons
  - Technology change in supply and demand
  - Transmission
  - Governance, markets and regulation

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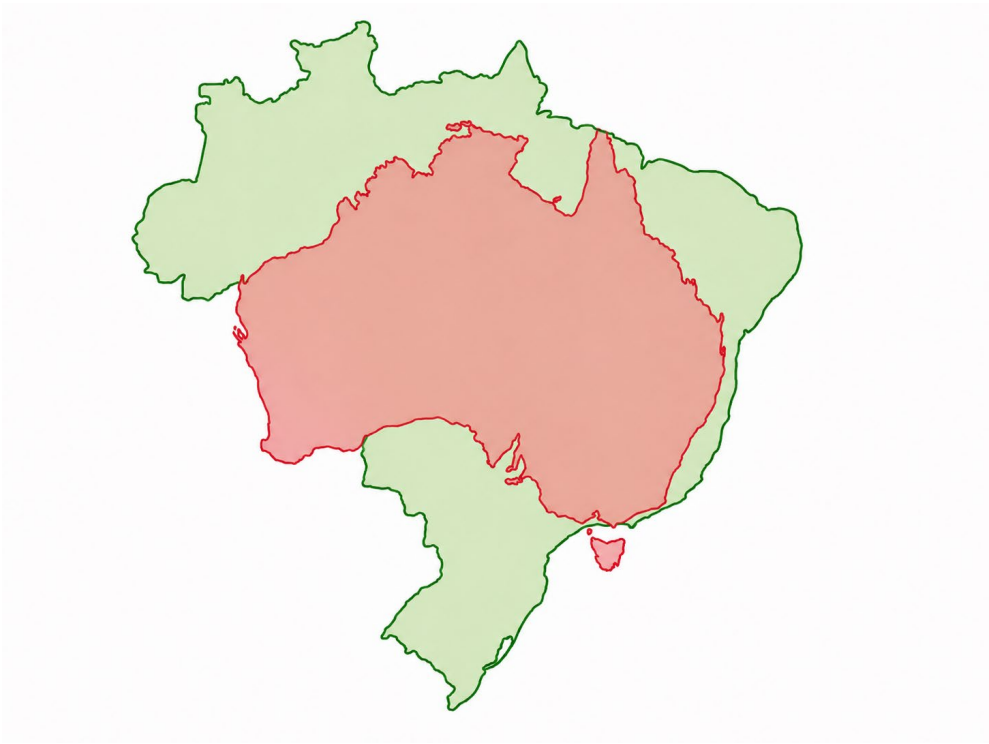
Introducing Australia



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Context: introduction to the “National Electricity Market”

- Five regional markets; one of the world’s longest interconnected power systems, serving population of 24 million (~12 million homes)
- Average grid/end-use demand (2025): 22/25.3 GW
- Max/Min demand (2025): 33 / 9.7 GW
- 28 GW, 29 TWh per annum of rooftop solar (13 % of final demand)
- 44% of free-standing homes (about 30% of all homes) have rooftop solar – world’s highest.
- 1 kW (per capita) of rooftop solar – world’s highest.
- Distributed storage now growing quickly (~ 450k households with batteries, 20 kWh on average)

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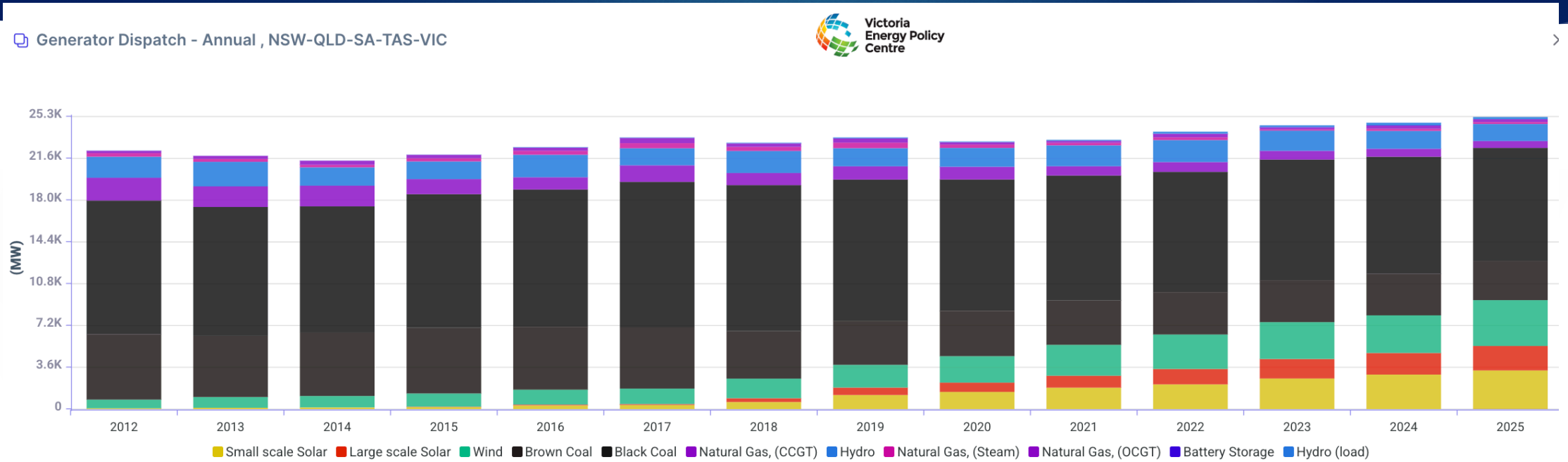
Context: electricity supply is changing gradually



52%	coal
16%	wind
13%	rooftop solar
8%	farmed solar
6%	hydro
4%	gas

In 2025, 58% of production from fossil fuels and 42% from renewables (37% from variable renewables)

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Context: markets

Wholesale

- Created in 1998; “gross” (mandatory) spot market, energy-only, five-minute, cash-settled every day. Minimum price cap: -AUD1,000/MWh; max price cap +AUD20,000/MWh
- Financial contracts (mainly exchange-traded) are mainly contracts-for-difference; but also some cap contracts.

Retail

- All customers can choose their retailer (except in Tasmania), since 2009
- Voluntary regulated “default” offers;
- Many regulatory obligations on bill format, payment terms
- Customers have right to export behind-the-meter generation to the grid.

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Context: decentralisation

- Australia has global highest rooftop solar capacity per capita (~1 kW per person) and is likely to soon be the leader in behind-the-meter storage. Several factors explain this:
  - 2/3rd of homes are free-standing or semi-detached with large roofs and mostly owned not rented;
  - Australia has large middle-class able to afford capital outlays;
  - Retail (grid) electricity prices are high;
  - Rooftop solar (and batteries) are politically popular and so has long had policy support;
  - Australia has well-established supply of electricians and related technicians;
  - Government cleverly devolved technical standards to the industry.

Context: Governance

Many aspects of the governance of electricity in the NEM are unusual:

1. Australia is a federal country but governance and policy in NEM is built on “co-operative federalism” (power sharing between federation and states). (As the energy transition progresses, ironically governance is centralising while electrical power is decentralising!)
2. Regulation is “bi-furcated” between an entity (answerable to the states) that designs regulation and an entity (answerable to the federal government) that implements the regulations.
3. The (“national”) power system operator also operates the wholesale market, plans (most of) the transmission expansion and has been given executive authority to ensure its plans take effect.

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Context: Policy

- Since creation of NEM, policy has promoted competition. But fervor for open markets has gradually weakened:
  - Regulation of retail supply (although only default offers);
  - Increasing government ownership (of projects and in formation of new government-owned utilities);
  - Most new (private) investment is subsidised.
- Climate policy (and consequent energy policy) has been politically contested:
  - The current government has a target of 82% renewable electricity by 2030 (from 42% in 2025). The Opposition rejects this target.

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Outcomes

- Decarbonisation: from stored (fossil) to variable (renewable)
- Declining (grid) demand
- The rise of electro-chemical storage
- Subsidies
- De-centralisation of energy but centralisation of power

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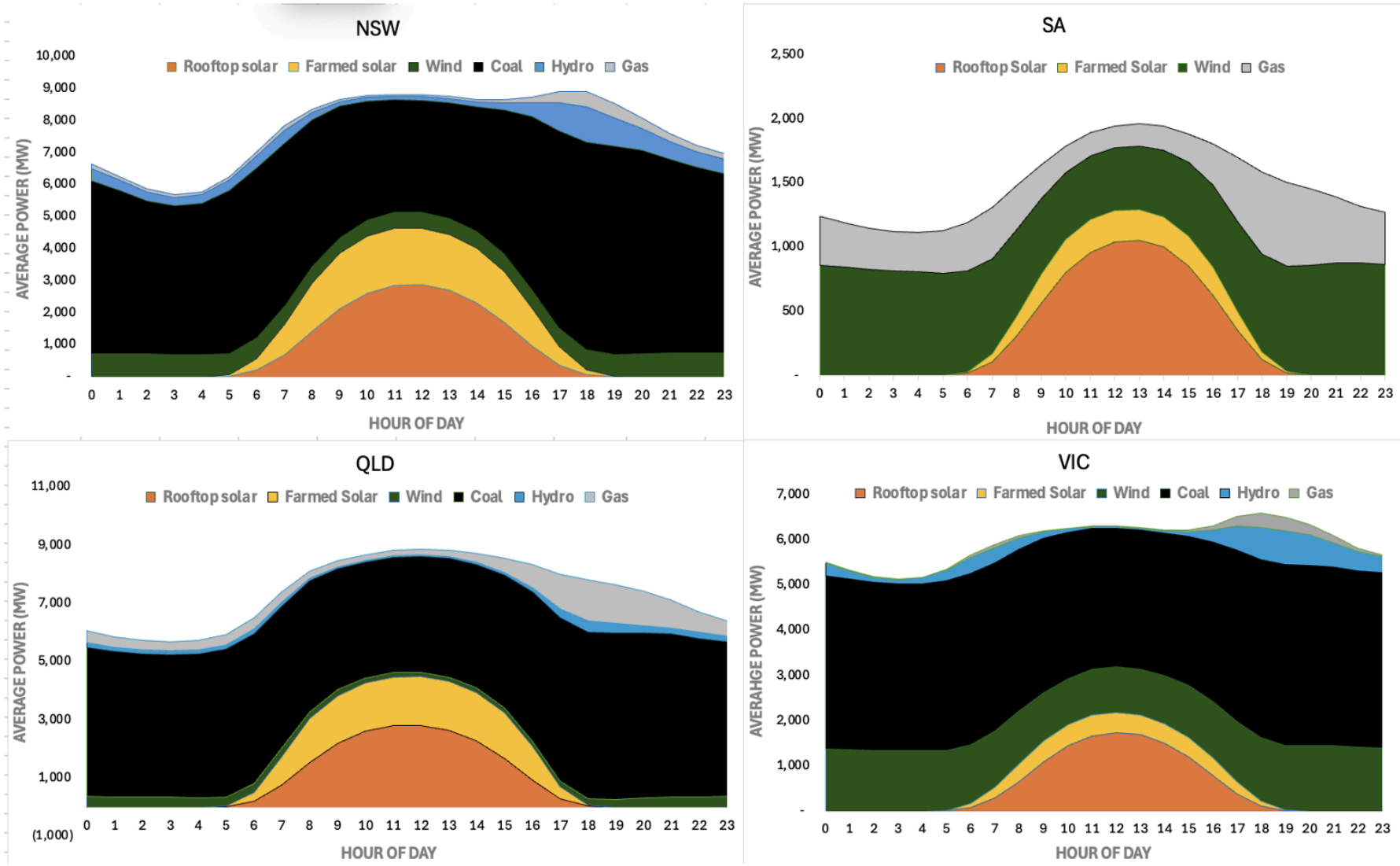
Decarbonisation has greatly changed hourly energy mix

Average power (MW) by fuel type by hour of day in 2024 in mainland NEM regions



Source: www.v-nem.org, author's analysis

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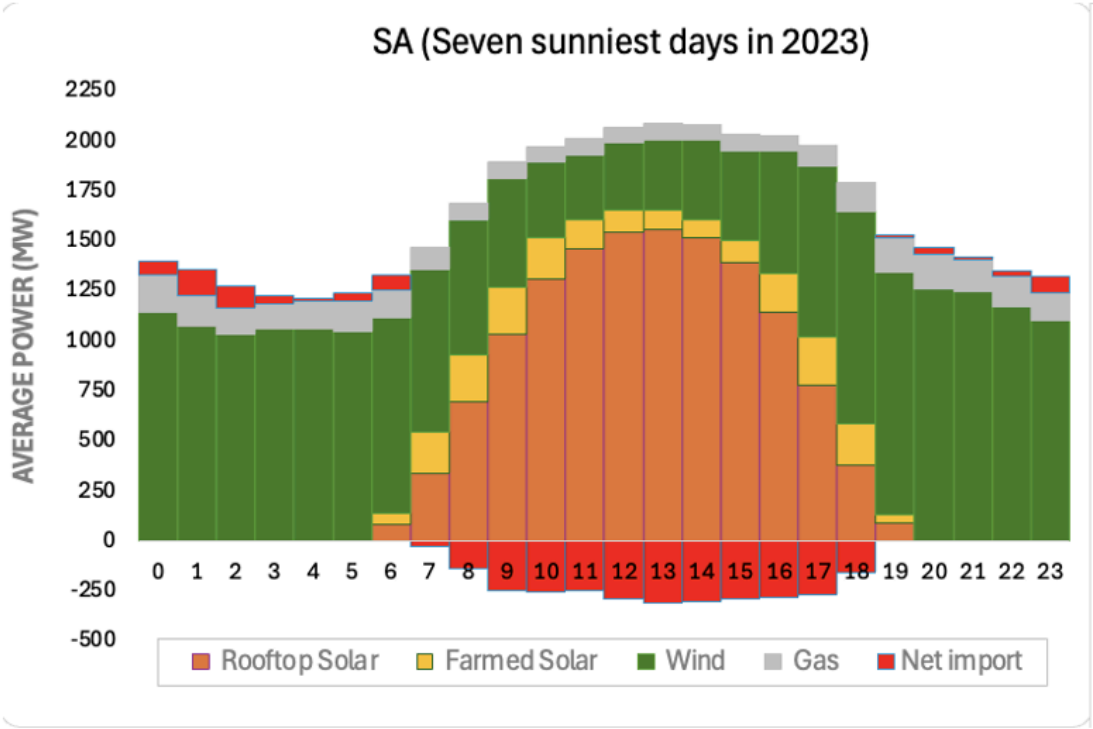
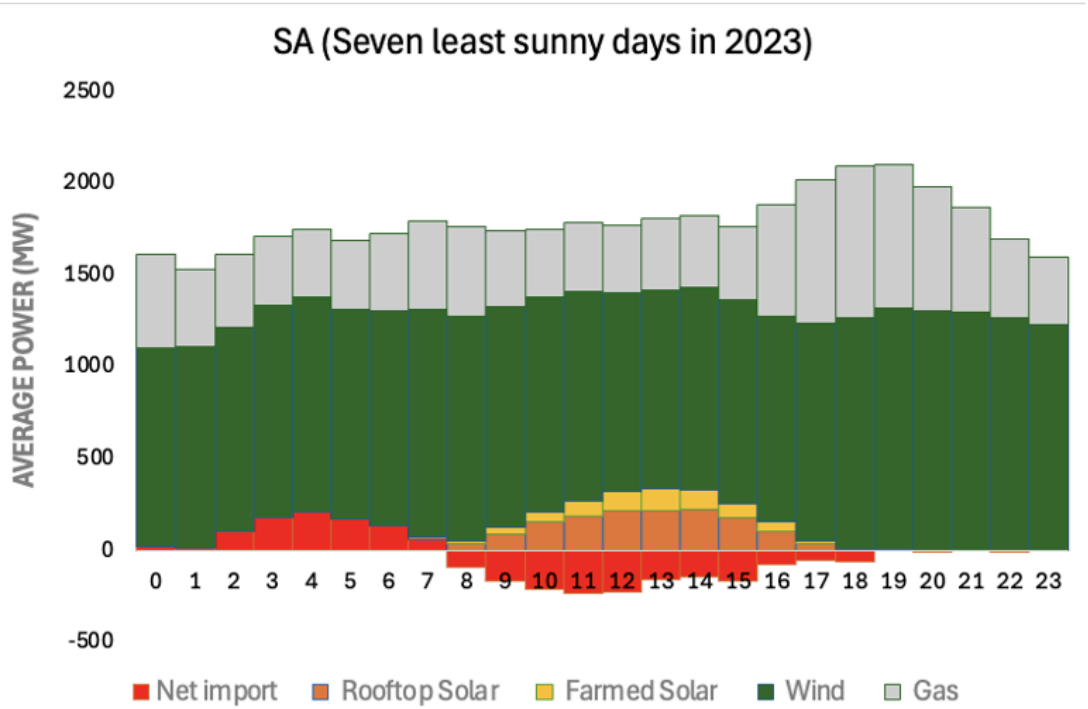
Rooftop solar is not centrally dispatched and so has a huge impact on grid supply on sunny days

Average power (MW) by fuel type by hour of day for the seven sunniest days (left hand) and seven least sunny days (right hand) in South Australia in 2023





Source: www.v-nem.org, author's analysis.

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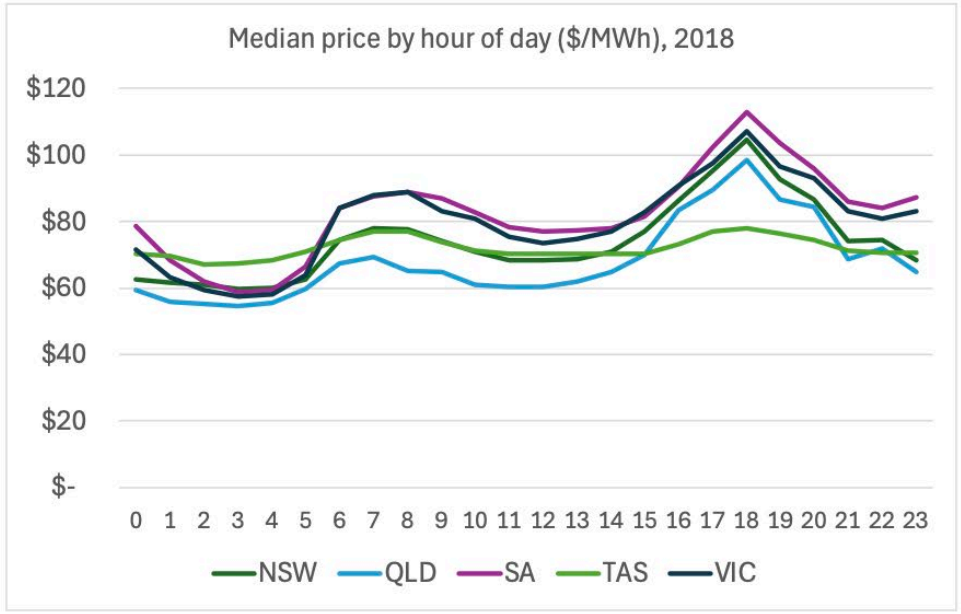
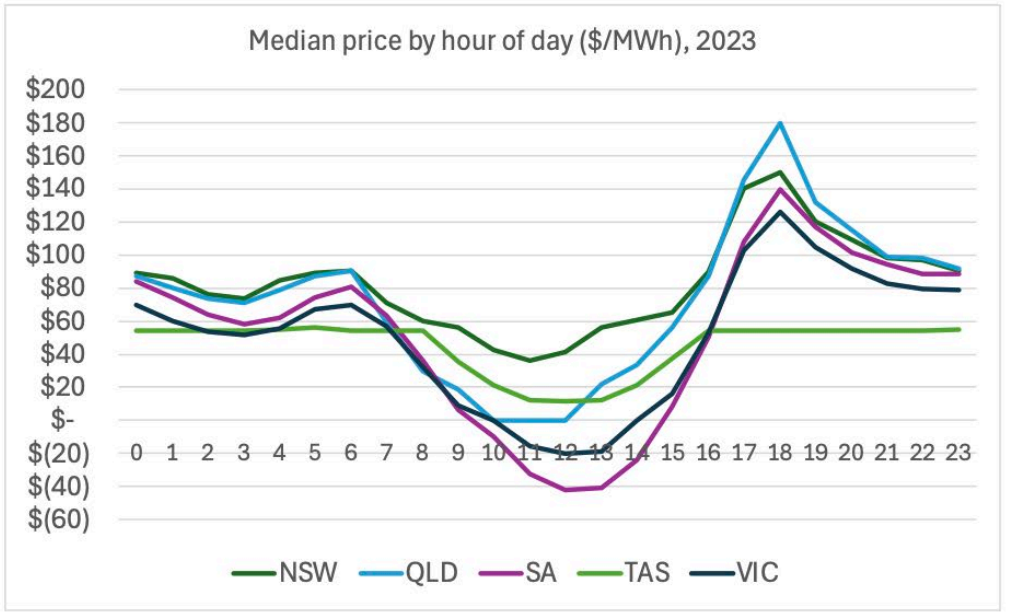
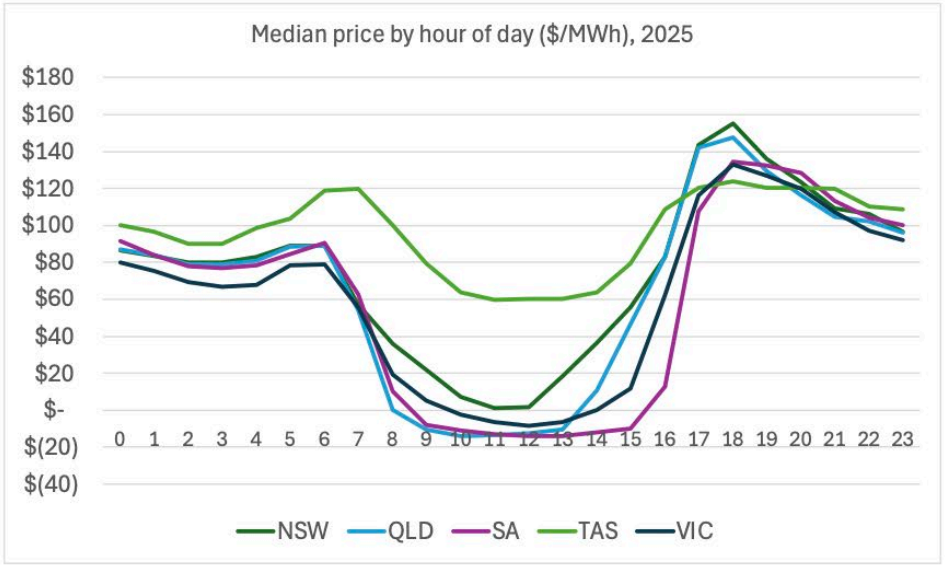
Median spot market prices are close to zero from 9am to 3pm in most regional markets







Grid demand has been stagnant for last 14 years but declined 20% per capita (population has grown 20%)

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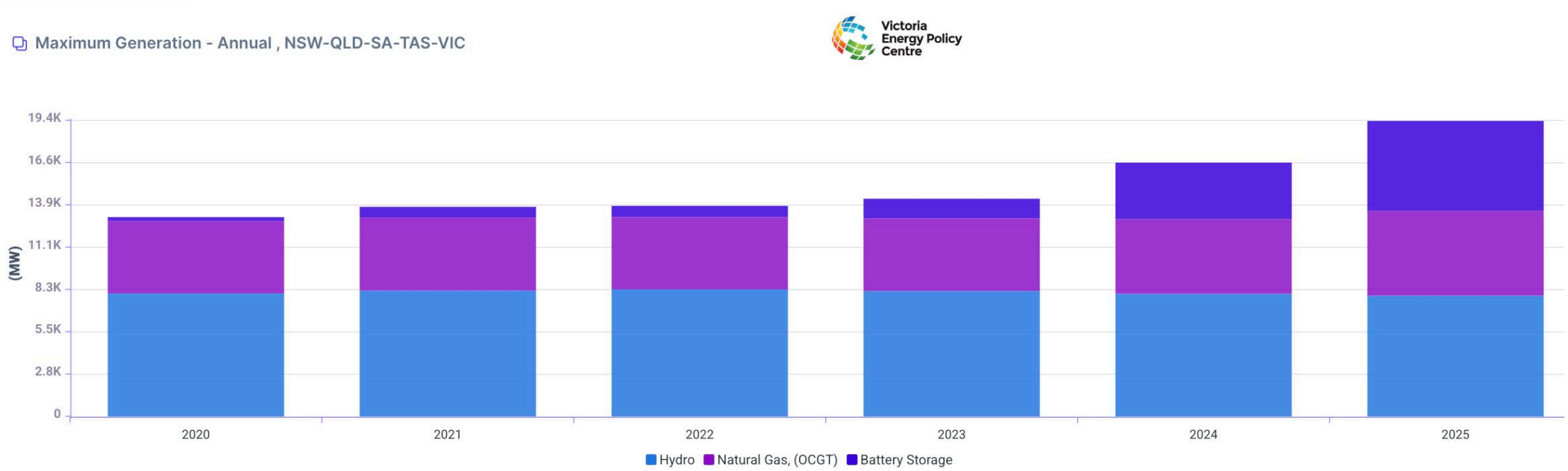
Electrochemical (battery) storage is growing quickly.



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Battery is being dispatched across the day as expected

There is now about as much behind-the-meter battery as front-of-meter battery and it is probably being dispatched in a similar way

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Battery storage is flattening the duck curve in Australia

Peak prices are lower, midday prices are higher

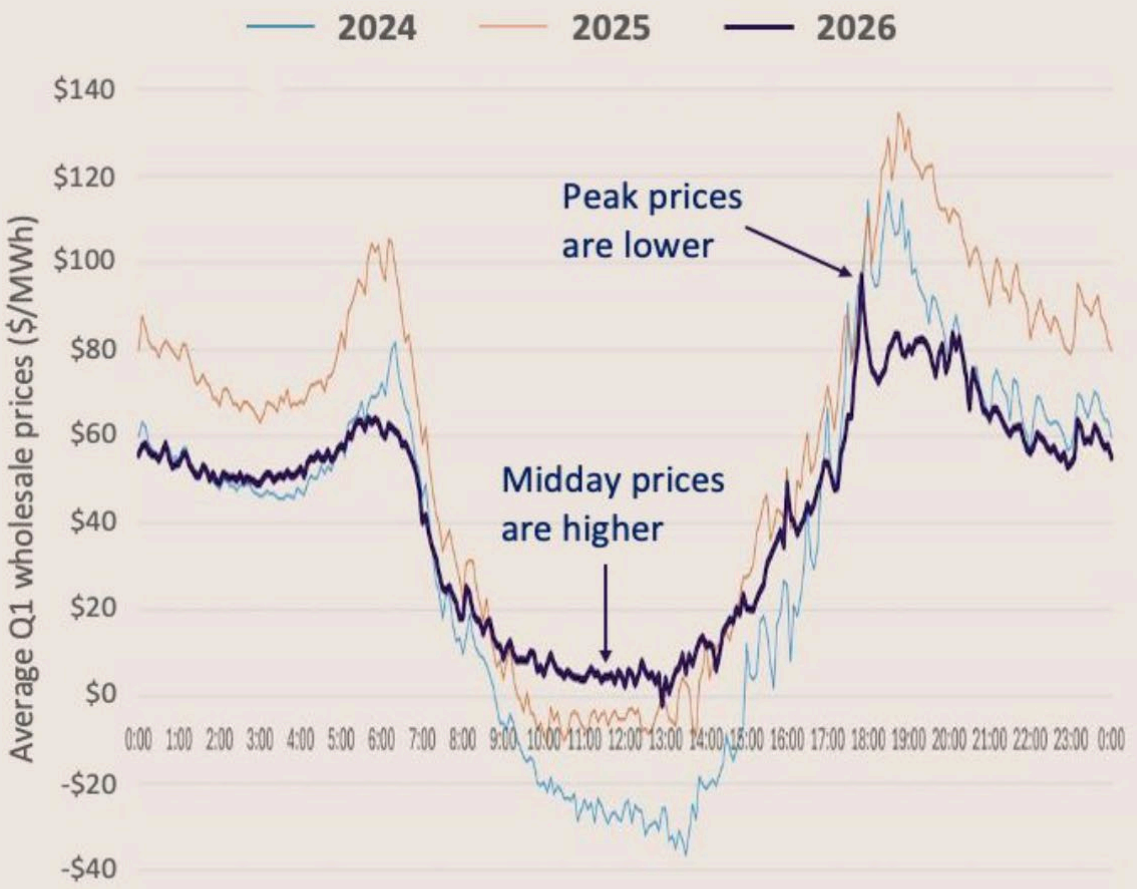

Chart shows average Q1 wholesale prices in Victoria, Australia
Original chart: SEC

@gavinmooney

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Outcomes: retail markets are a focus of much innovation

- Consider my own household electricity bill:
  - Time-of-use rates for grid purchases with free electricity from the grid each day from 11am to 2pm.
  - Time-of-use rates for sales to the grid.
  - Incentive payment to not purchase any electricity from grid from 6pm to 9pm.
  - Incentive payments if let my retailer control the operation of my battery.

Outcomes: Energy supply is de-centralising, but power is centralising

- Capacity, production and storage has grown behind-the-meter (often in response to policy support) much more quickly than front-of-meter. Yet, “power” (political and administrative) is centralising because the federal government is the main source of the subsidy that it thinks is needed to deliver its decarbonisation plans.

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Lessons: uncertainty in demand and supply

- Technology changes have been rapid and unforeseen:
  - Renewables relative to fossil fuels;
  - Solar relative to wind;
  - Rapid declines in electrochemical storage costs.
- The economics of renewables-dominated power systems is still heavily contested:
  - Redundancy (curtailment) has to be paid-for;
  - The economics of storage (if not highly utilised) is unattractive.
- On the demand-side, the impact of AI data centres is highly uncertain. Even leaving this potential new demand source to one side, AEMO has long been unable to forecast annual demand growth.

Lessons: transmission expansion planning

- Transmission expansion planning has been centralised and AEMO (the planner) has pursued ”least cost” optimisation modelling. But:
  - An important factor of production in transmission expansion (i.e. “social licence”) is local and is not known until plans become evident;
  - Technology changes quickly (last slide) and so long-term least-cost models have quickly become inadequate;
  - In markets, production is determined by price, not cost. Least-cost planning is not consistent with price-based production and investment.
  - Big transmission lines with high towers and wide easements attract a great deal of opposition.

Lessons: governance, markets and regulation

- Electricity supply is a constitutional right/obligation of the states, not the federal government. In the NEM, a system of “co-operative federalism” attempts to co-ordinate the policy of the federal and state governments. It worked reasonably well when not under the pressure of rapid decarbonisation and consequent centralisation.
- Under pressure, “co-operative federalism” has resulted in confused accountability and consequential blame shifting as decarbonisation progress falls short of targets.
- Political support for decarbonisation in Australia is perhaps under increasing pressure as some question the promise that decarbonisation means lower bills.

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