Scenarios for exit of Australia's coal fired power stations

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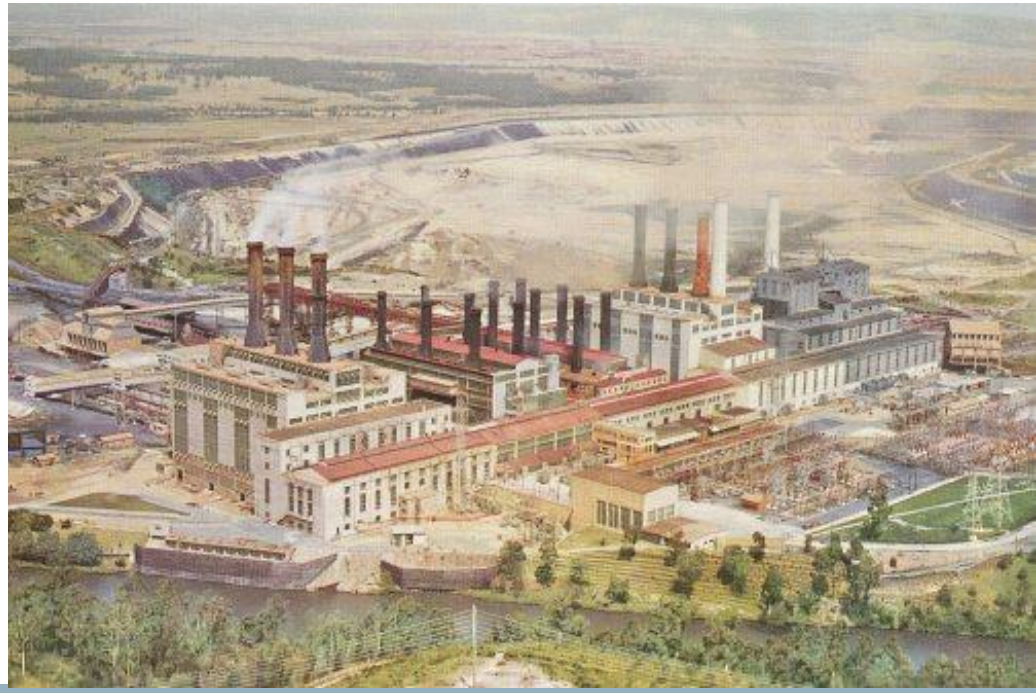
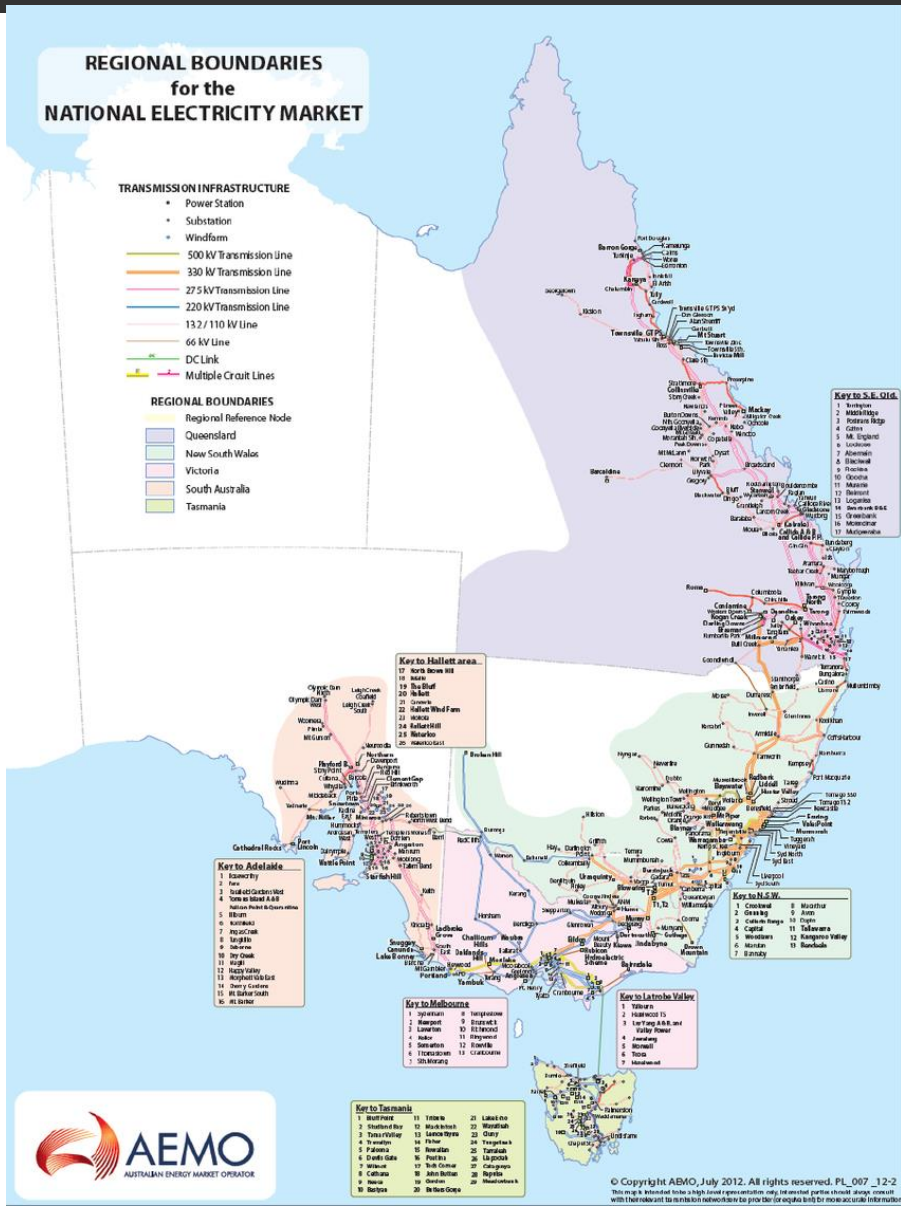


Australia's National Electricity Market

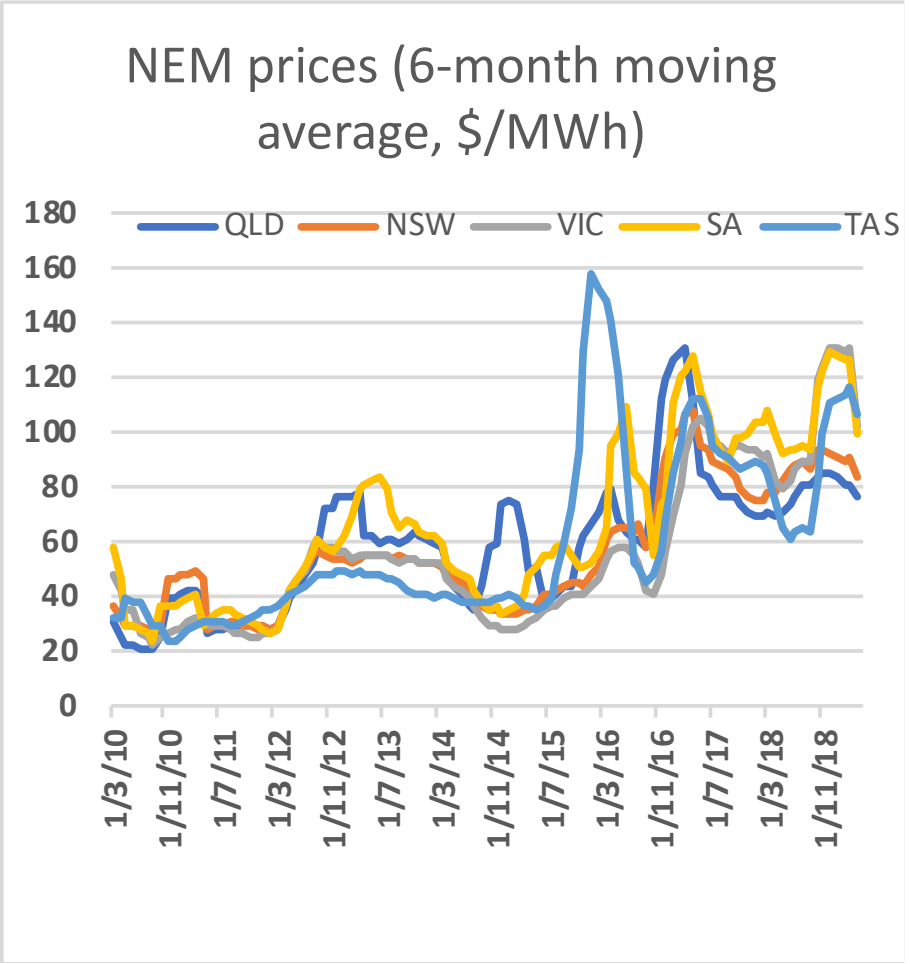
National Electricity Market (NEM)

- Wholesale electricity market QLD-NSW-VIC-SA-TAS
- Energy-only market. Focus: efficient dispatch of existing plants
- Implemented 1998, after construction of large majority of existing capacity,
- Not designed to deal with exit of plants

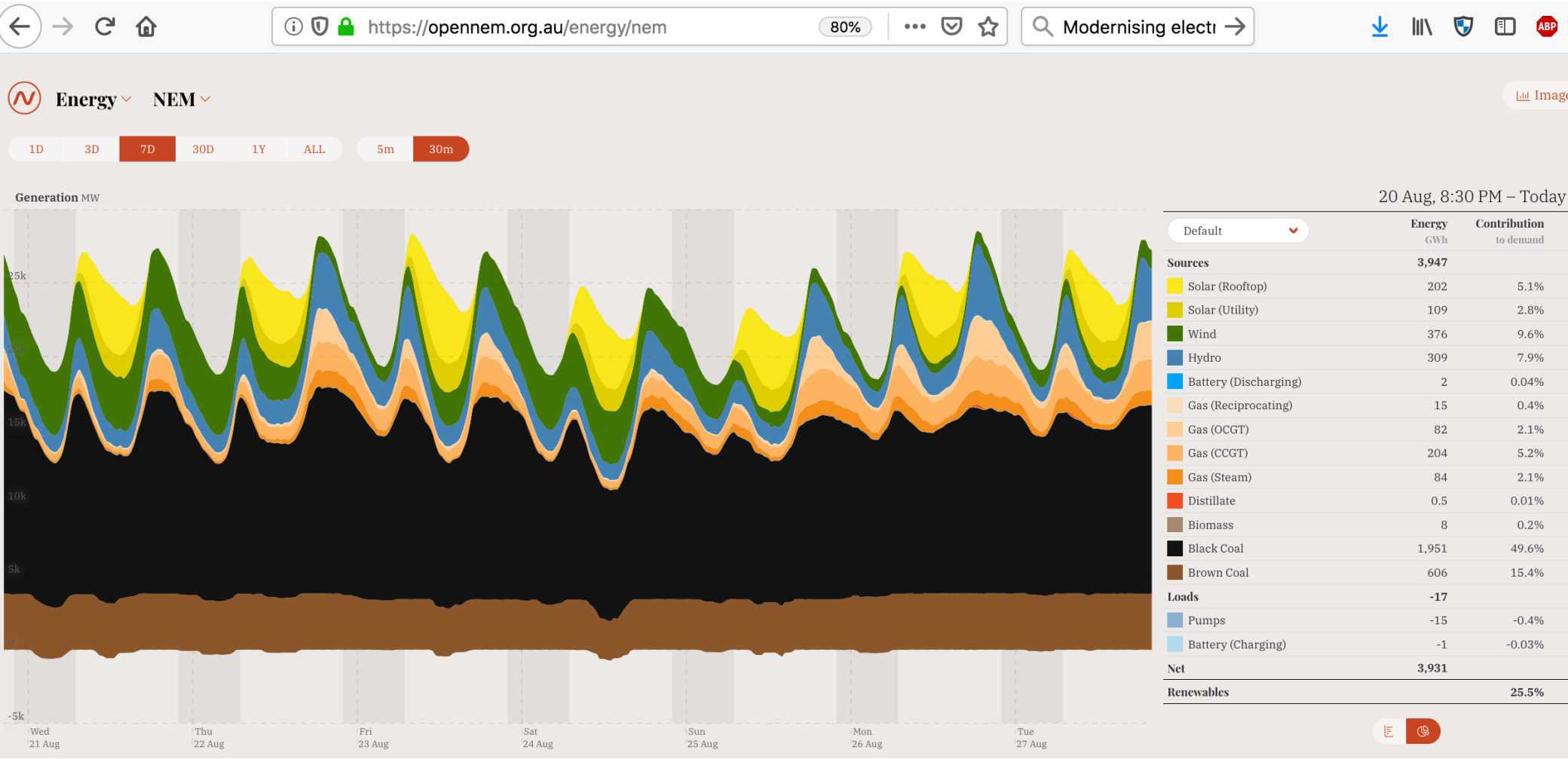


National Electricity Market (NEM)

- Wholesale pricing in 15-minute intervals (matching bid stack with demand)
- Turnover ~200TWh of electricity, $16.6b (2016-17)
- Prices have risen in recent years: gas price rise, coal plant exit



Coal power remains dominant (>2/3)

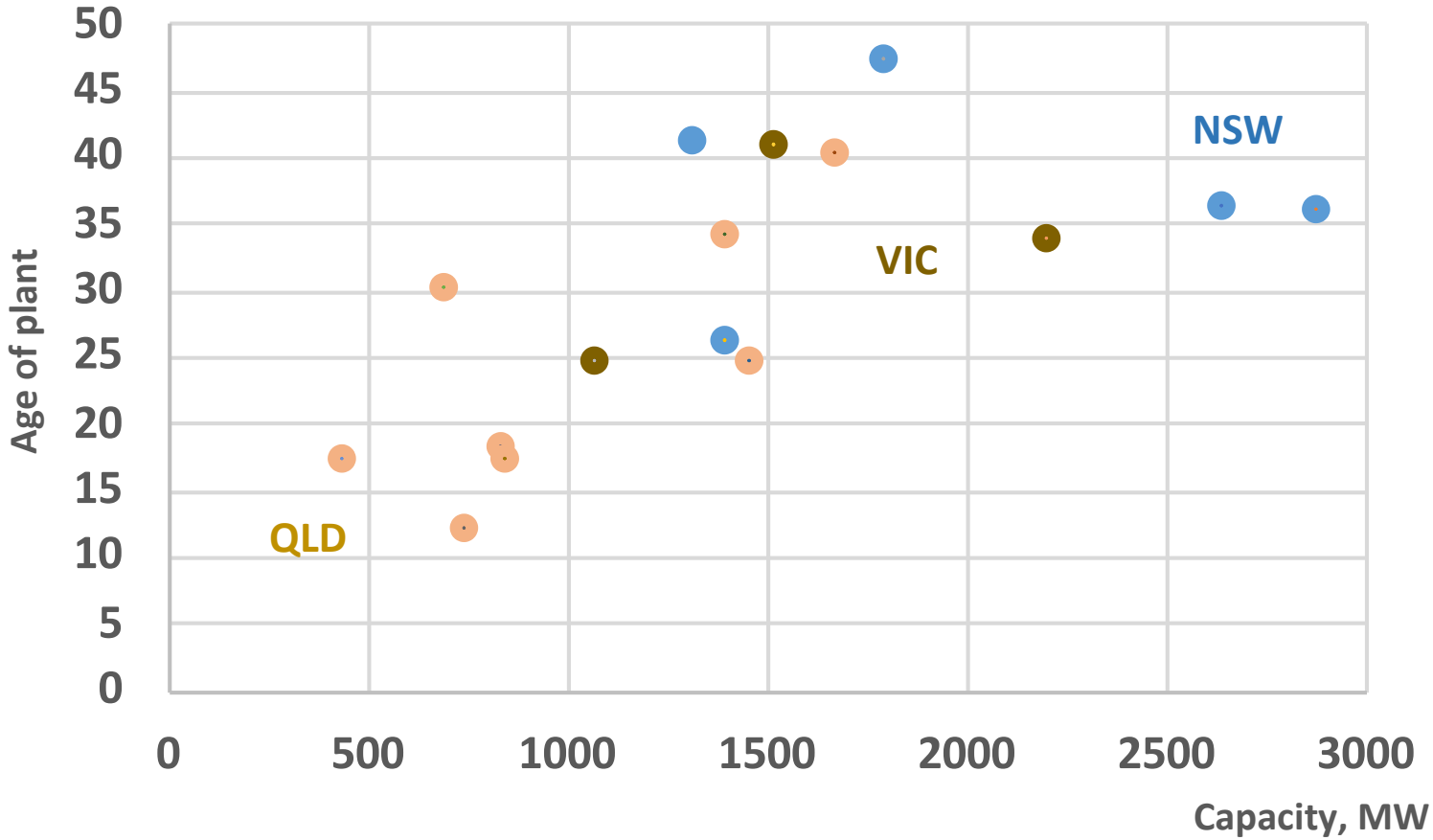


Coal fired power plants in the NEM

Installed capacity: 23 GW, Generation: 146 TWh in 2018 (~70% of NEM generation)

10 closed since 2012 - *Average age at closure 40 (42) years*

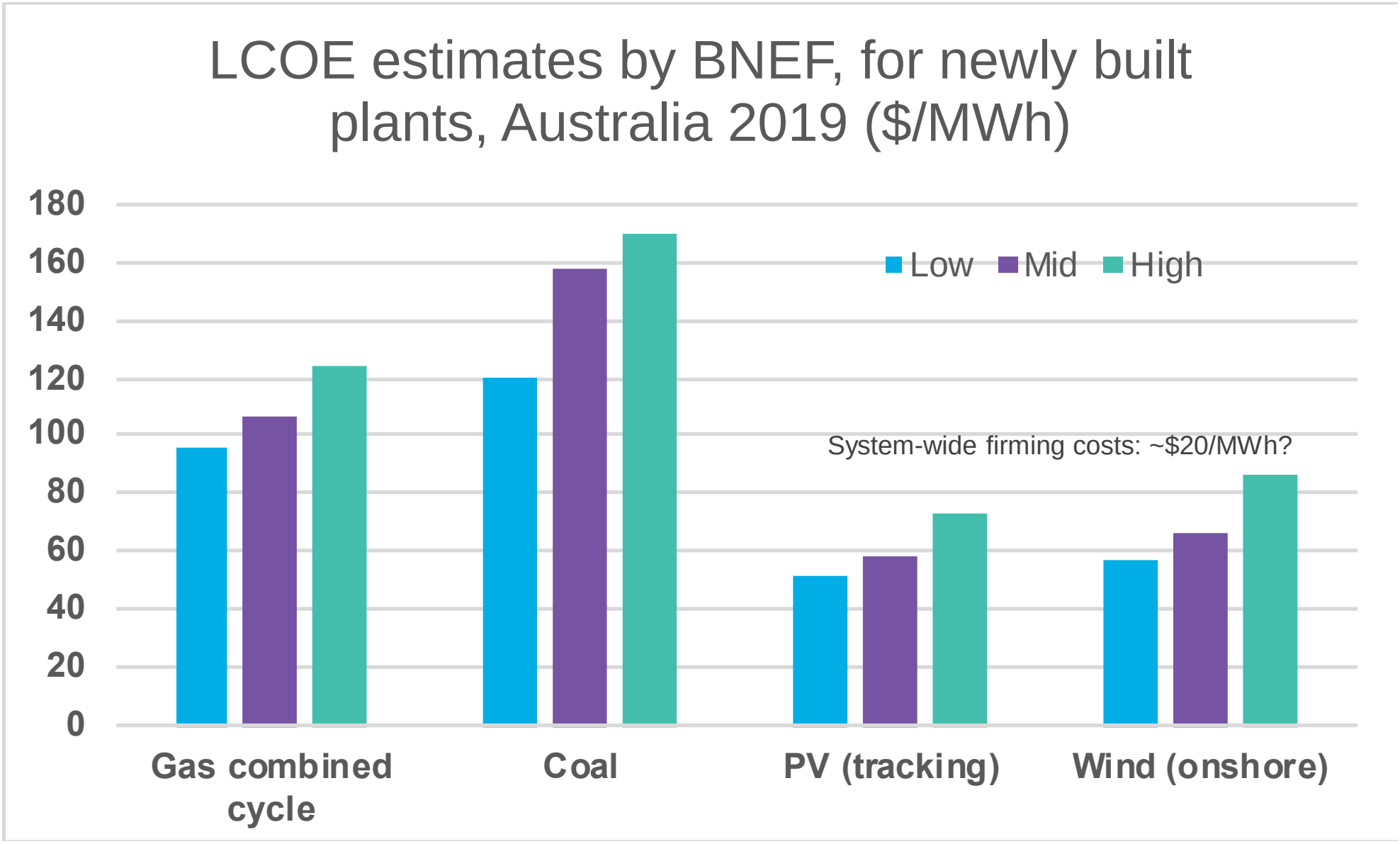
16 plants left - *9 older than 30 years*



The future belongs to renewables

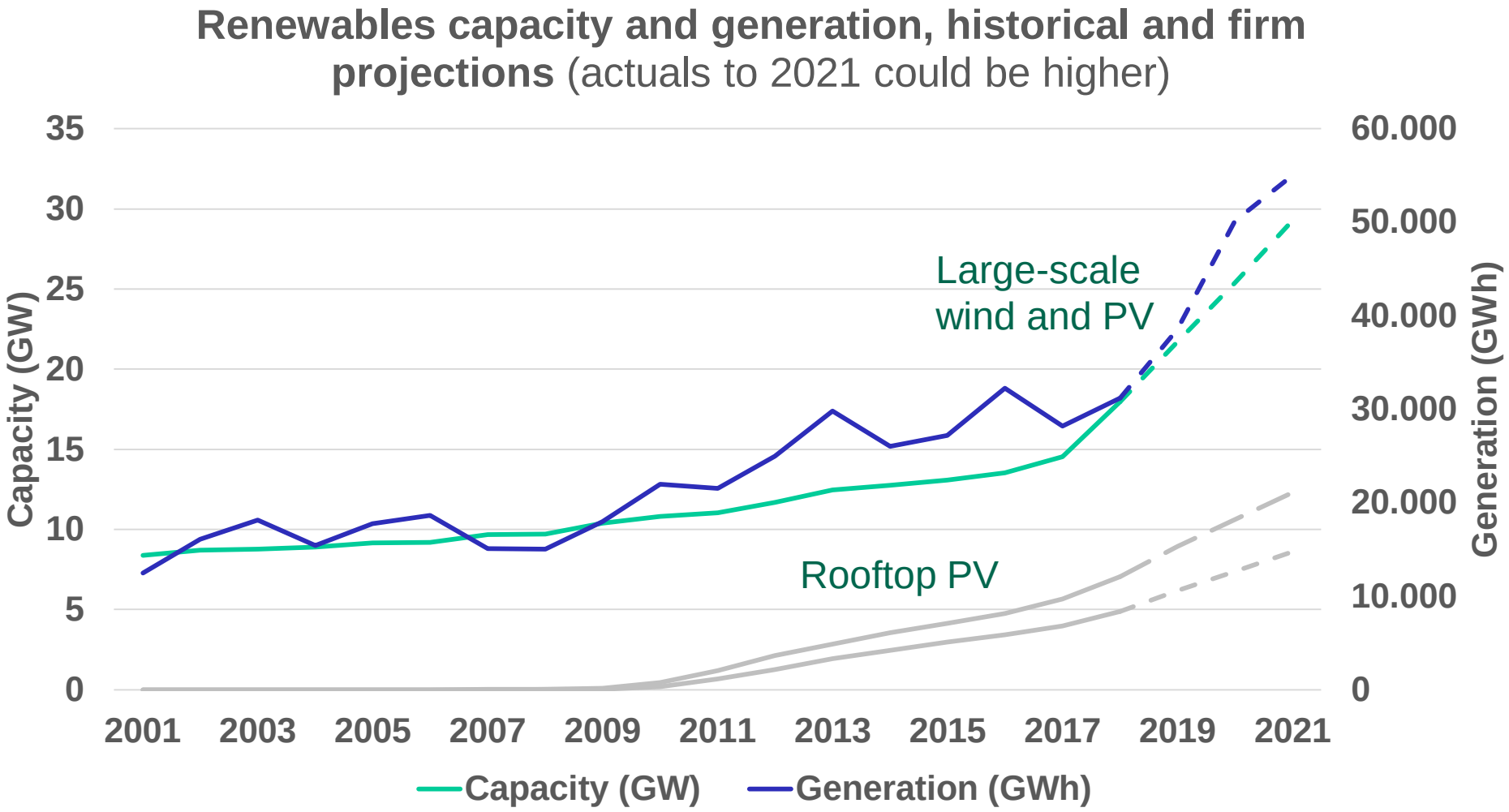
- LCOE for wind and solar PV is far lower than any of the alternatives, including for newly built coal
- …this holds also when factoring in costs of balancing out intermittency in the system overall (storage, extra transmission)
- … and possible future carbon costs rule out private coal plant investment altogether

➢ Practically all investment in electricity generation in Australia is wind and solar



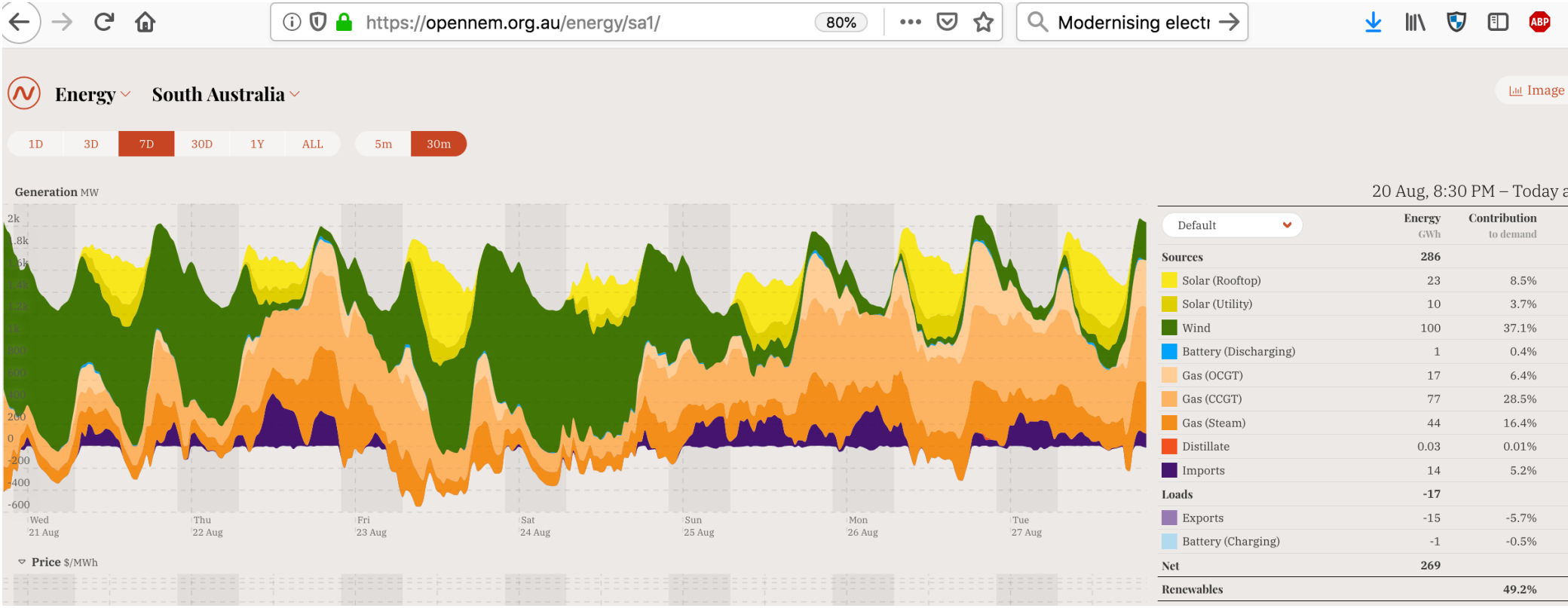
Source: Bloomberg New Energy Finance

The renewables boom



Source: Clean Energy Regulator (Williamson, July 2019 ANU presentation)

South Australia: REN >50% on average



When might existing coal plants become un-economic? When might they exit?

Pressures on coal plants

- Fast rising renewables generation – less demand left for coal plants
- PV erodes prices during the day – increasing need for daily “ramping”
- Prospect of future price on carbon – investment for refurbishment?

Plant exit is difficult to predict

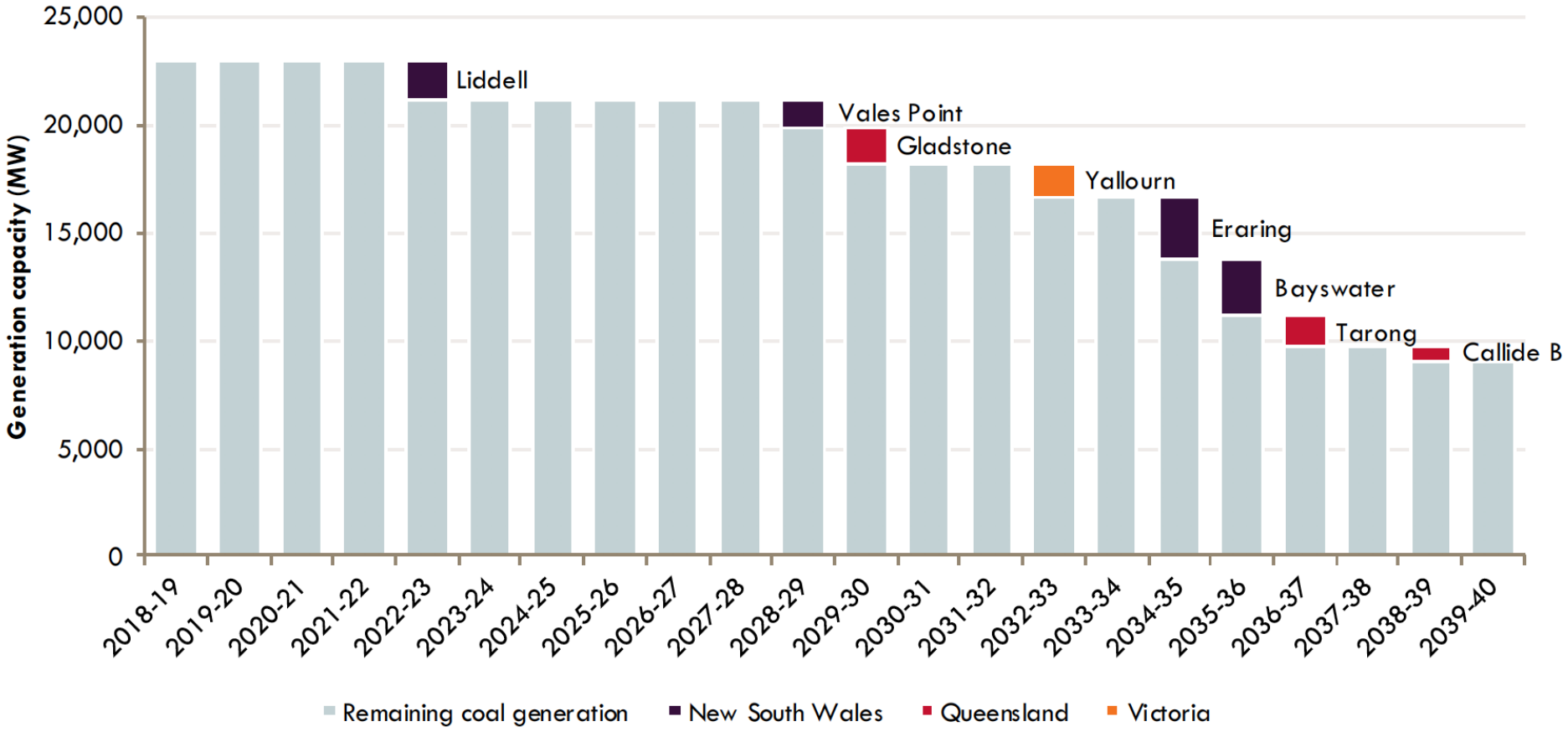
- Model-based singular exit trajectories… will be wrong and risk creating the illusion of predictability

Our (indicative) scenario analysis

- Plant-by-plant, year-by-year scenario analysis for future operating costs – combination of factors
- Trajectories for future prices fetched by coal plants
- Scenarios for coal plant capacity that remains economic

Existing analyses/scenarios typically assume long remaining plant life

NEM coal-fired generation fleet operating life to 2040, under assumption of 50-year lifetimes (source: AEMO ISP 2018) – *this seems highly unrealistic now*



Scenarios

We compute combinations of the following…

Factor	Low	Medium	High
Refurbishment costs & timing	AEMO assumptions	AEMO assumptions	AEMO assumptions
Coal prices	(various, depending on plant)	(various, depending on plant)	(various, depending on plant)
Carbon costs	Zero	ERF: $17/tCO2 (2025), $20/t (2030) rising	EU ETS: $46/tCO2(2025), $53/t (2030) rising
Capacity factors	2025: 49%-63% falling	2025: 55%-67% falling	2025: 58%-76% falling
Capital costs		10%pa	15%pa
Wholesale prices	See below	See below	See below

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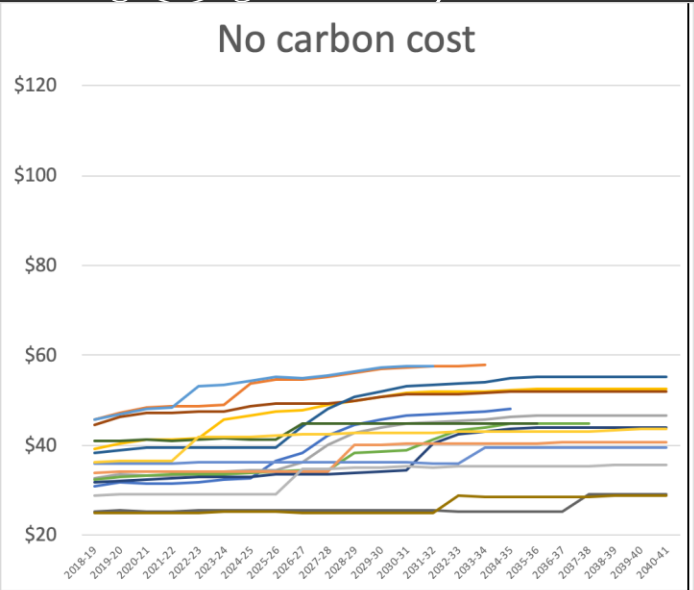
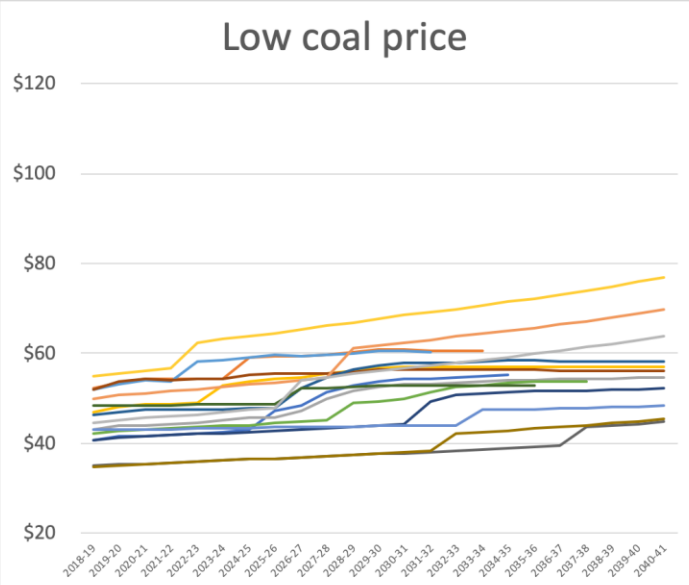
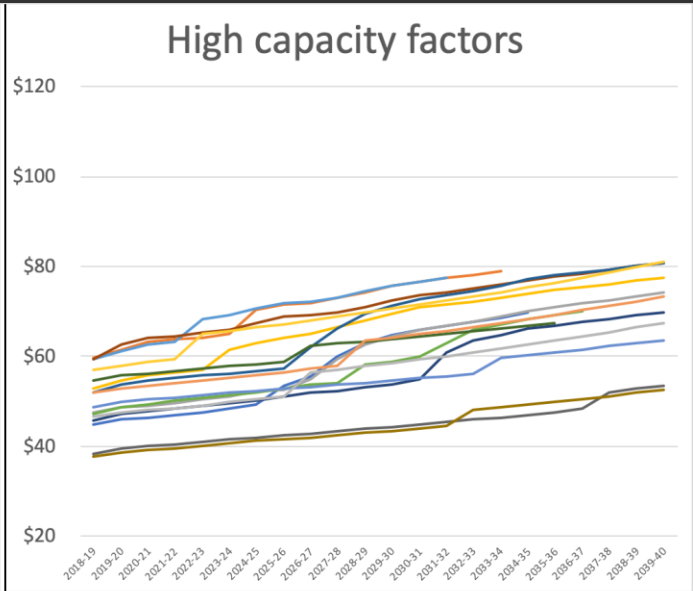
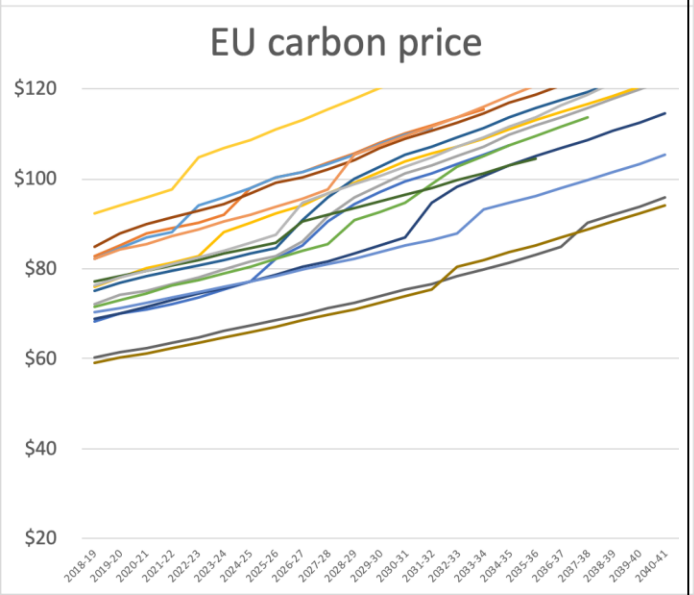
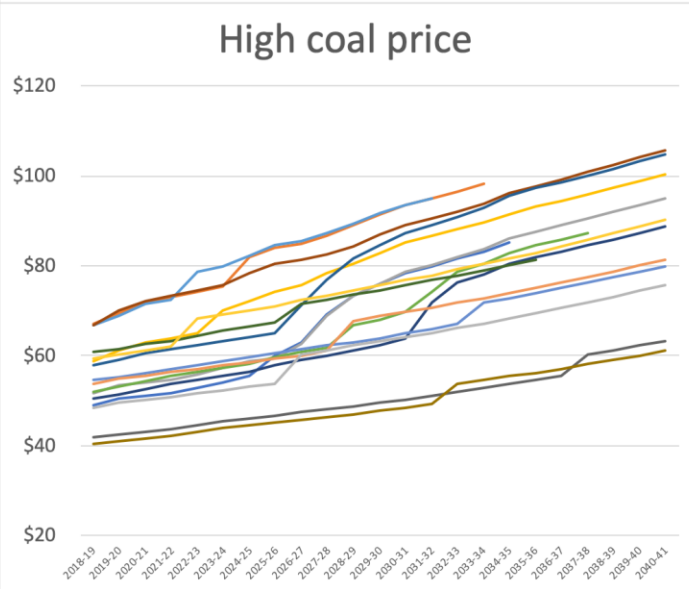
Some selected scenarios

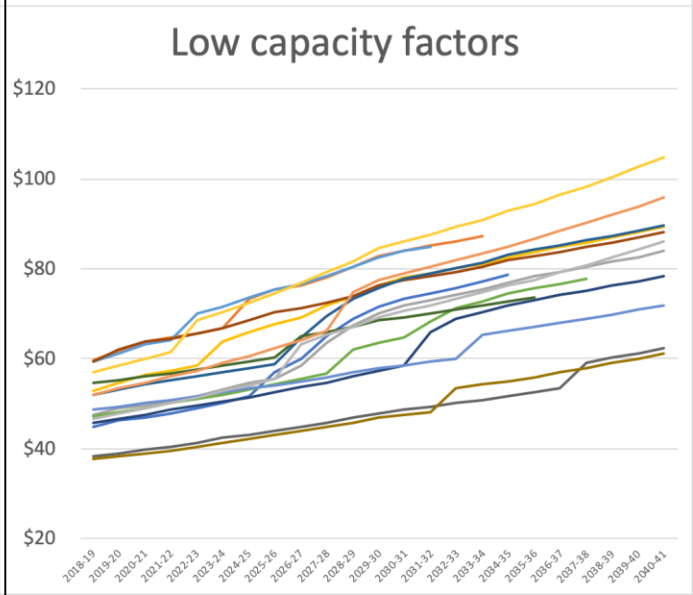




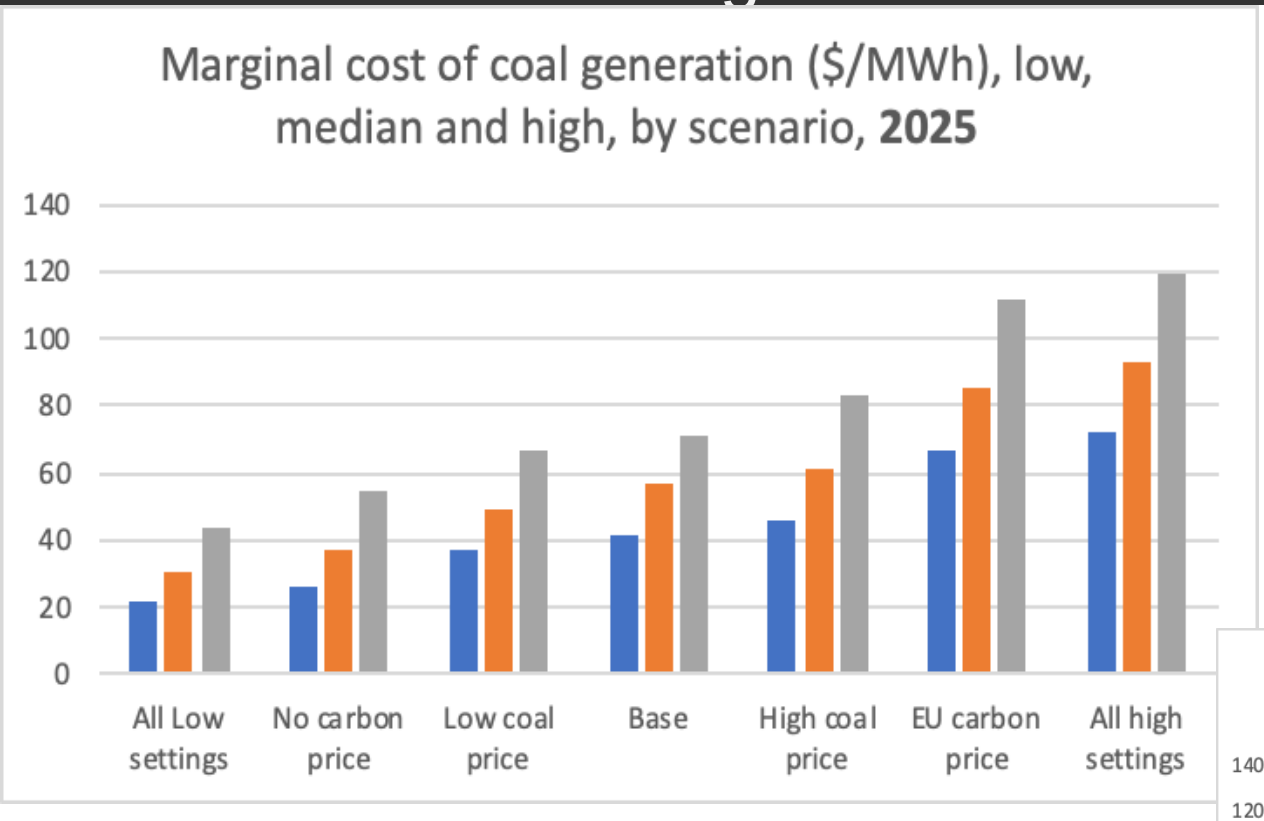


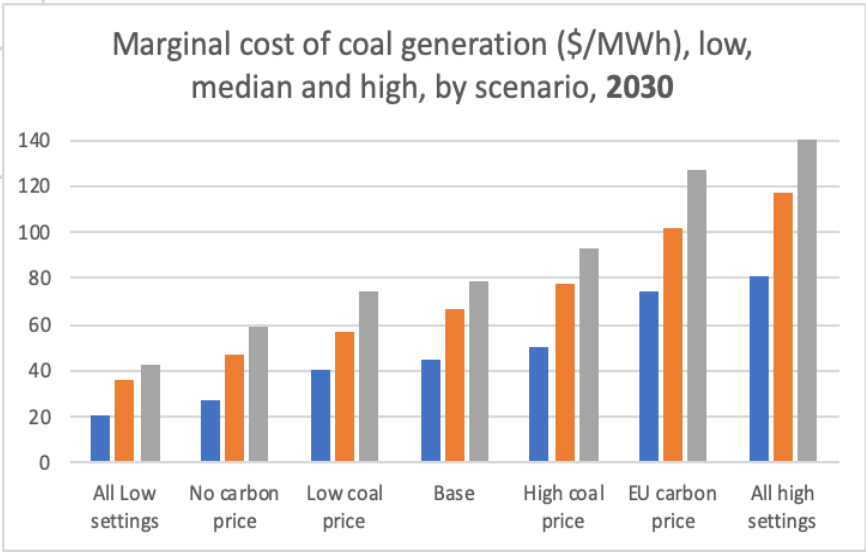






Marginal cost of generation: ranges in selected scenarios





Prices fetched by coal plants depend on …

- Cost of alternatives, eg firmed renewables
- Time profile of operation, eg daily cycling
- Market power, incl price spikes after plant closures
- …

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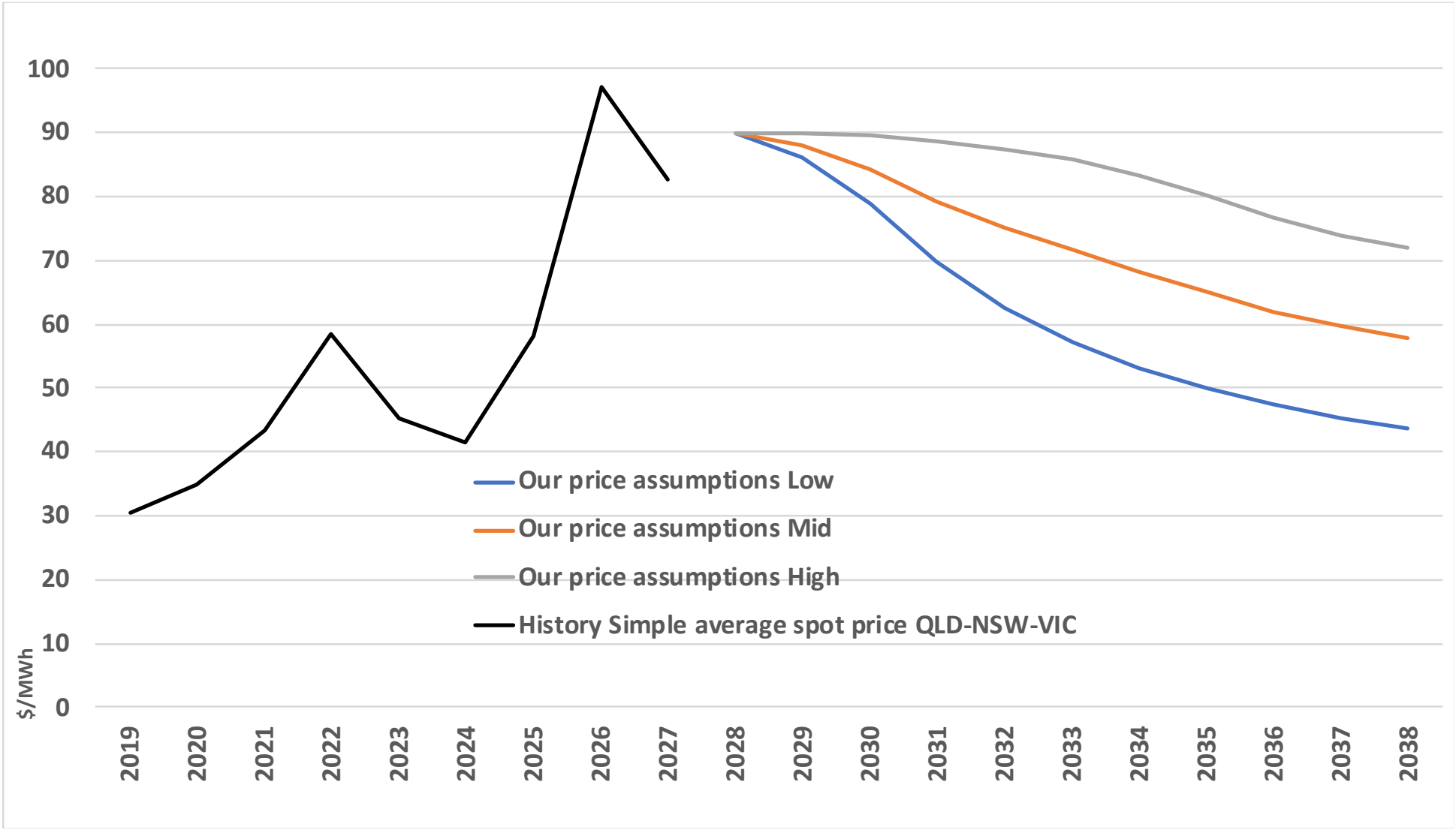
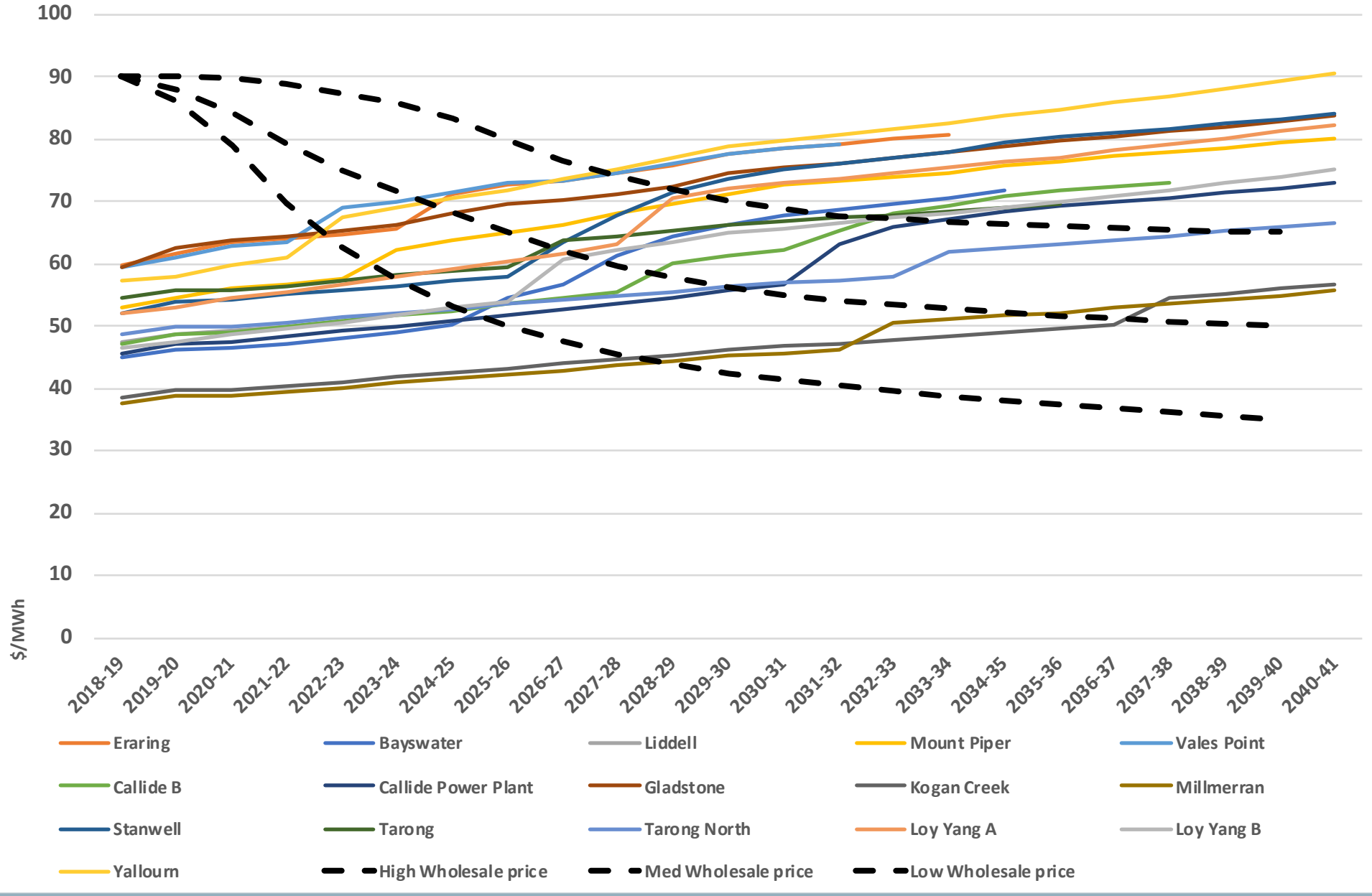
Our wholesale price assumptions compared to BNEF projections for LCOE of solar PV (tracking) with/without full firming



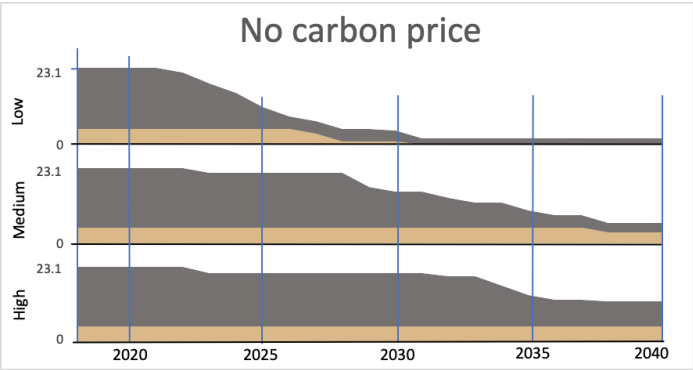
Data source: AEMO via NEMSight

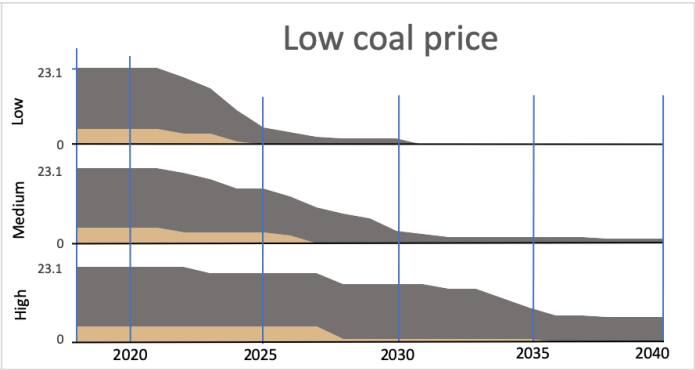
Central cost scenario and price scenarios

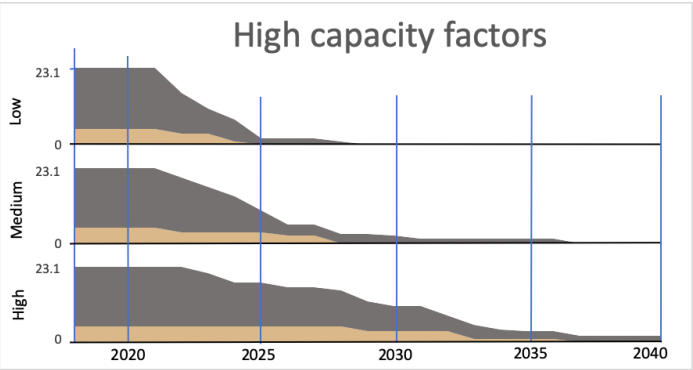


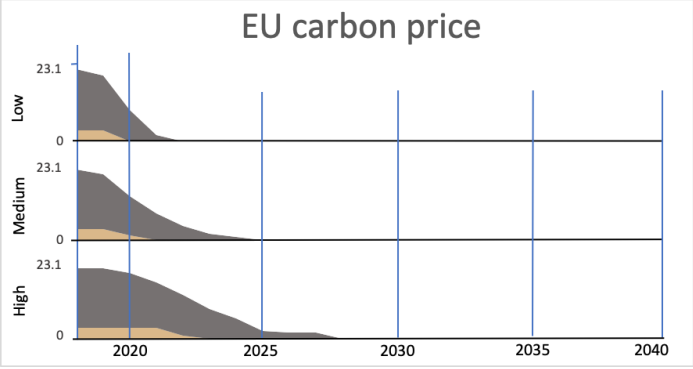
Scenarios for remaining economic capacity – selected cost scenarios

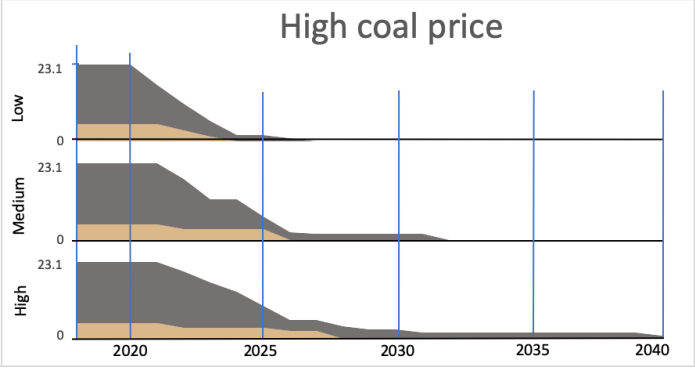
Most important factors: carbon prices, coal prices, capacity factors.

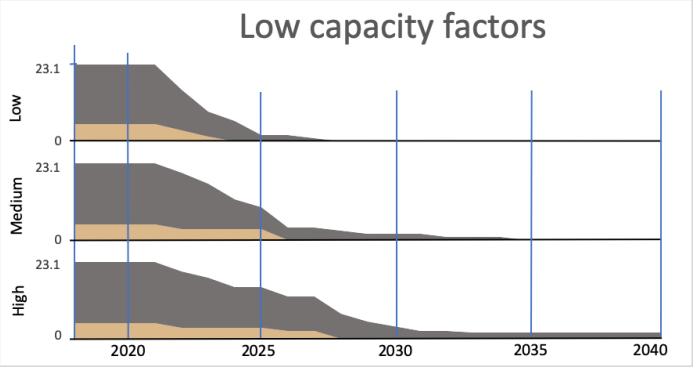






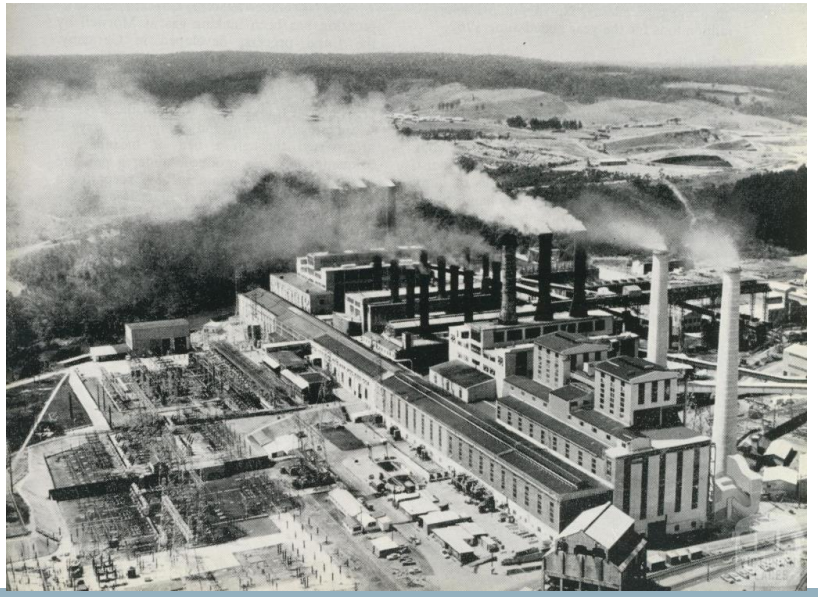






Exit could come out of the blue … and soon

- Our analysis excludes un-planned plant failure
  - eg Hazelwood
- Operators be running plants down
  … and shut down rather than repair/refurbish
- Large, diversified and vertically integrated utilities feel responsibility for orderly, predictable exit
  – eg AGL plans for Liddell plant closure
- Smaller operators may not feel the same
  – and equipment failure can happen everywhere



What is the problem with sudden exit?

Sudden exit of coal plants

Replacement investment

- Lack of replacement capacity – time lag planning, approval, build
- Greater market power for remaining incumbents – high wholesale prices
- Energy supply security – NEM may not adequately incentivize secure back-up supply in anticipation of plant exit

Local economies/communities – a new political flashpoint

- Little time to prepare
- Governments sponsor programs after the event (Hazelwood)
- Societal/political willingness to support coal communities, but inefficient response esp if rushed

Implications for policy

Facilitate predictable exit of coal plants

- **A time-bound pathway for coal plant exit**
- ➢ **Incentivized exit trajectory (eg auctioned exit pathway)?**
- Don't subsidize coal plants – or face a messier, costlier transition

Auctions

Auctions of "exit slots"

Payments could be levied on remaining generators

Allows spatial and temporal planning

Incentivized industry nominated closure dates

Plants nominate exit year

Penalty for earlier or later closure

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