

Firming renewables

A commercial perspective

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Introduction

Renewable energy is a success story

- Wind costs at record lows - less than new build coal or gas
- Reached 20% renewables – new target is 50% by 2030!

Increasing renewables has challenges

- Harder for system to absorb more renewables
- Wind and solar curtailments hurt owners
- MLFs?

Firming will create new opportunities

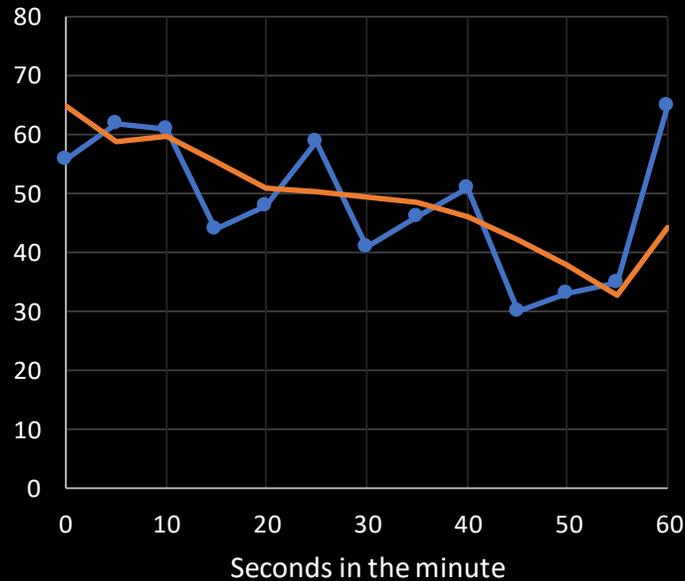
- Proven and emerging firming tech is available
- Will help increase revenue sources
- Relevant for new customer channels (Corporate PPAs)

What are the lowest cost options to firm renewable energy capacity?

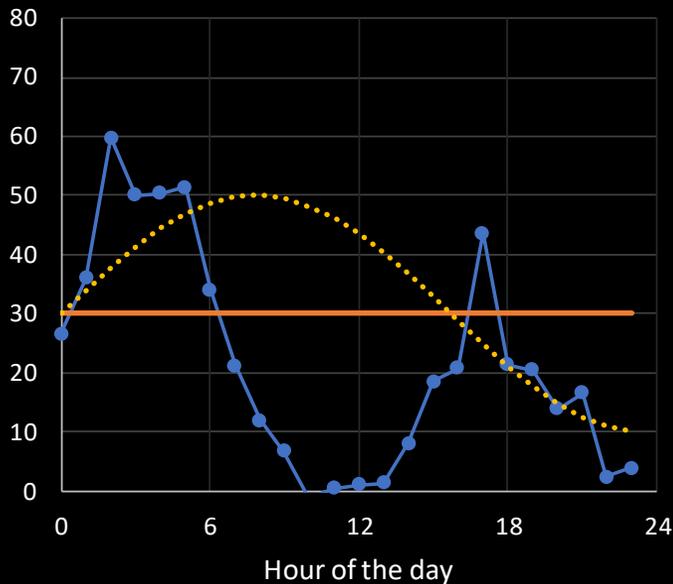
What do we mean by firming?

Maintaining the output from a variable, intermittent power source, such as wind or solar, for a committed period of time.

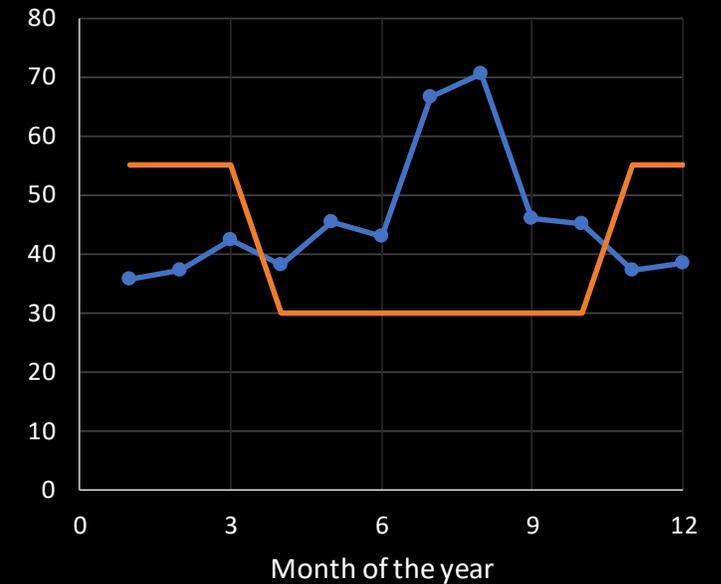
Firm over seconds to minimise FCAS user pays costs



Firm over a day to better match a corporate PPA

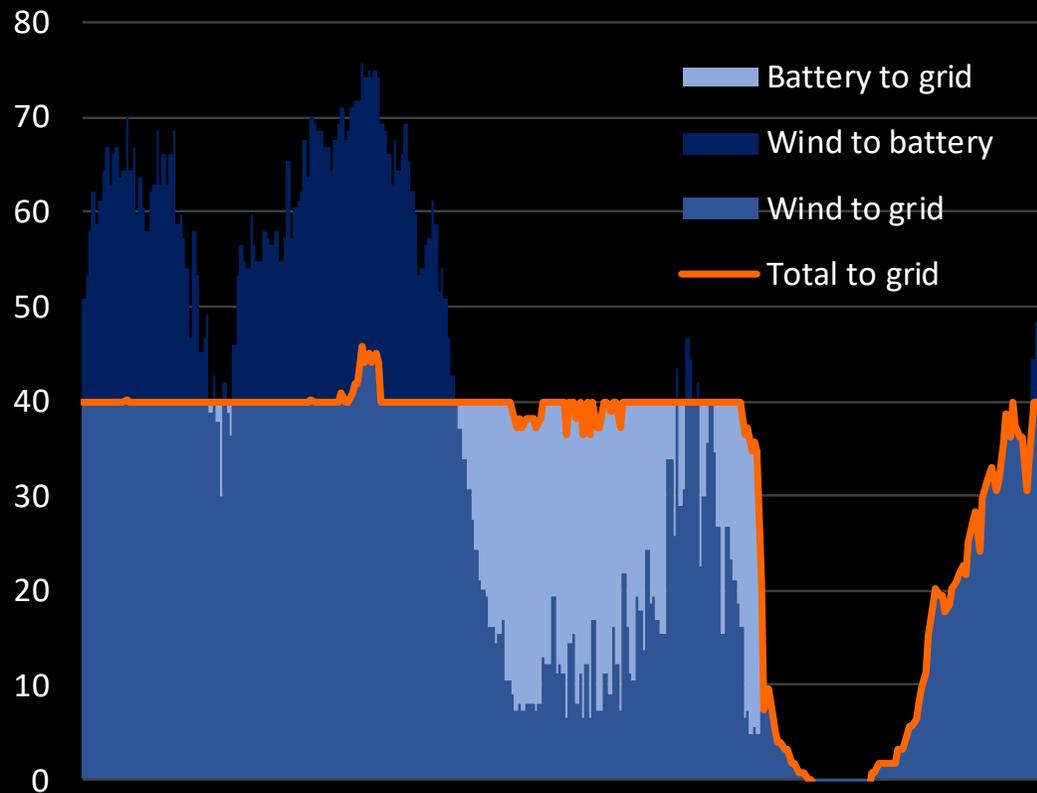


Firm over the year to better match portfolio requirements



Why firm?

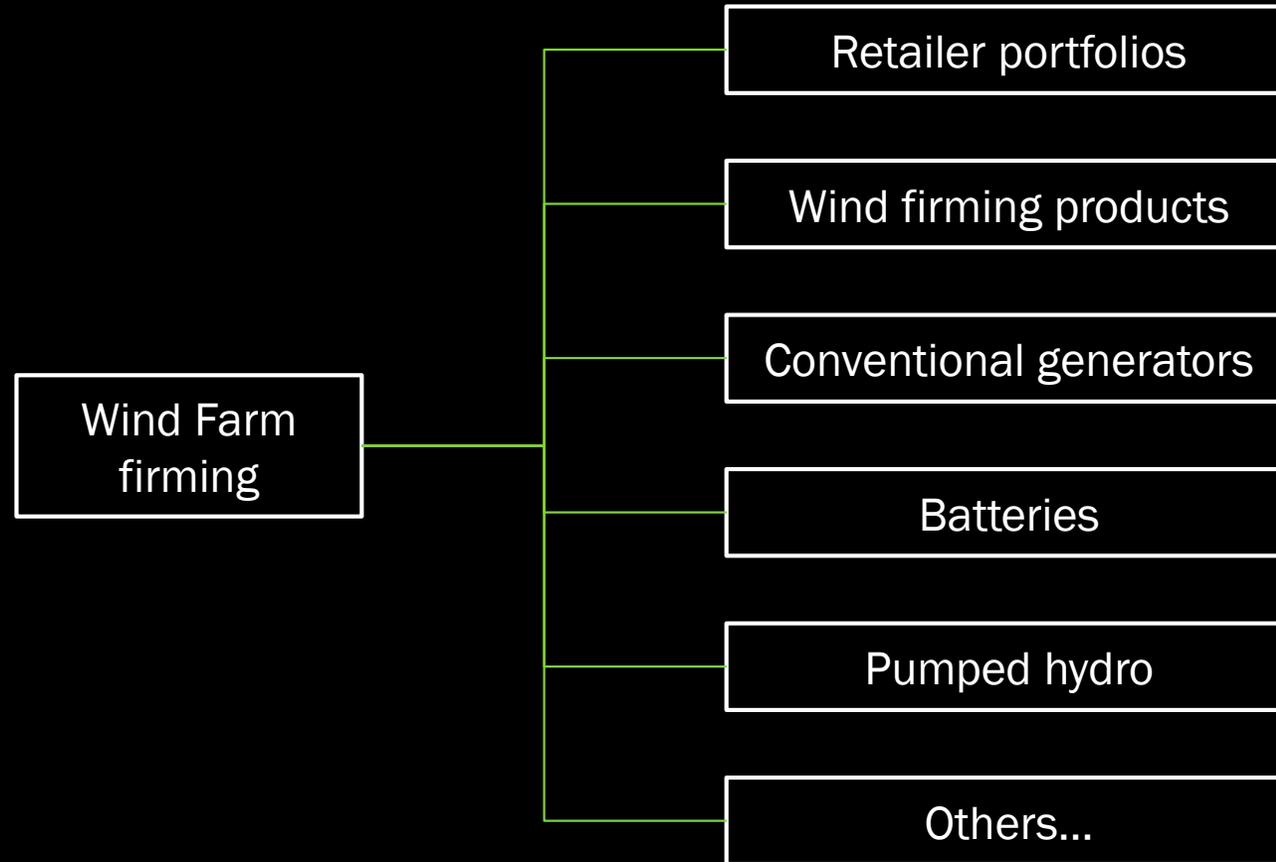
Wind firming simulation for a 100 MW
wind farm, 30 MW, 4 hour battery



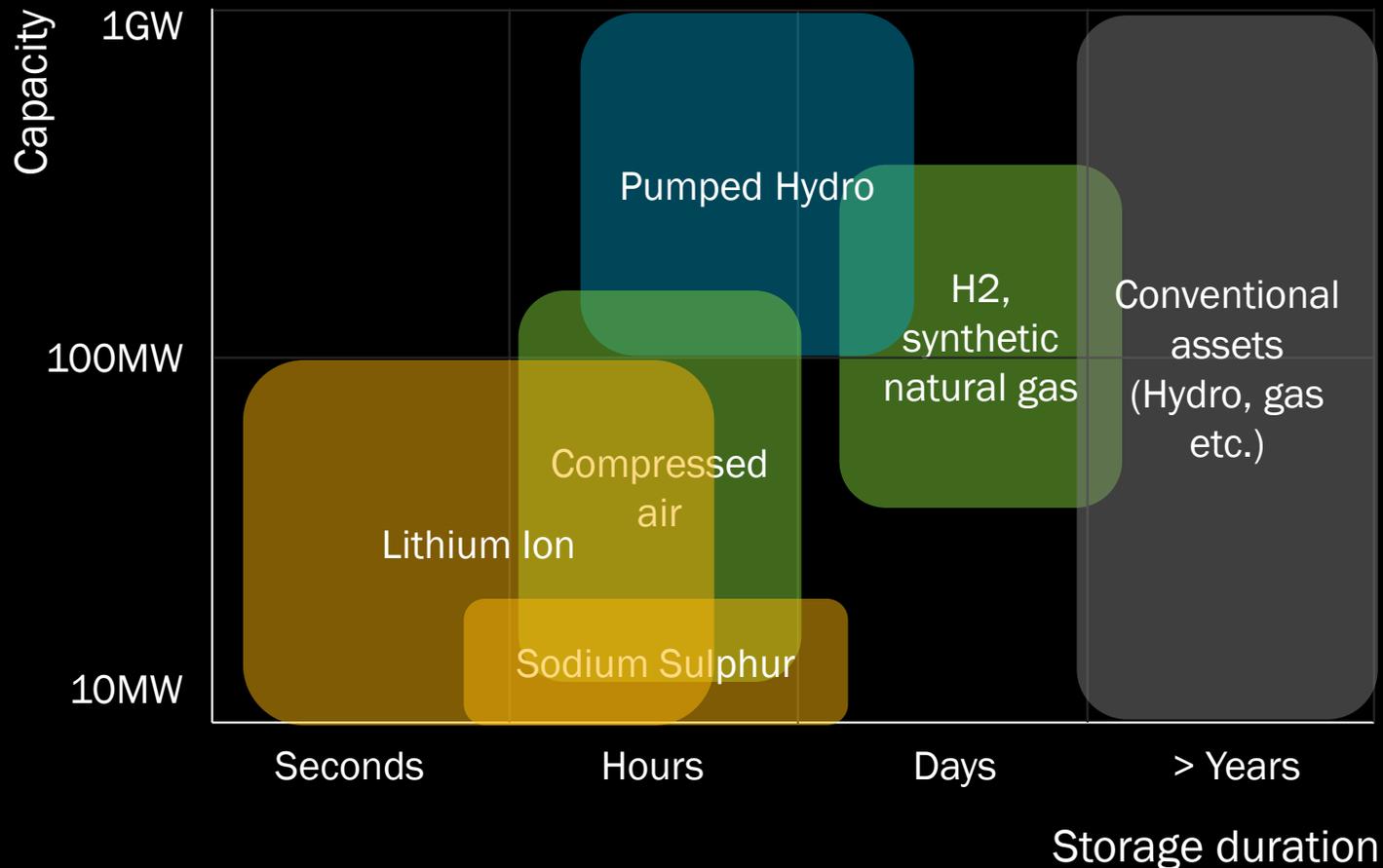
Source: EnergyAustralia analysis

- Optimise within system constraints
- Minimise costs (user pays FCAS)
- Shift energy to higher value periods
- Better match customer loads
- Promotes increased renewable penetration.

Firming options



Multiple firming solutions are required to firm renewables

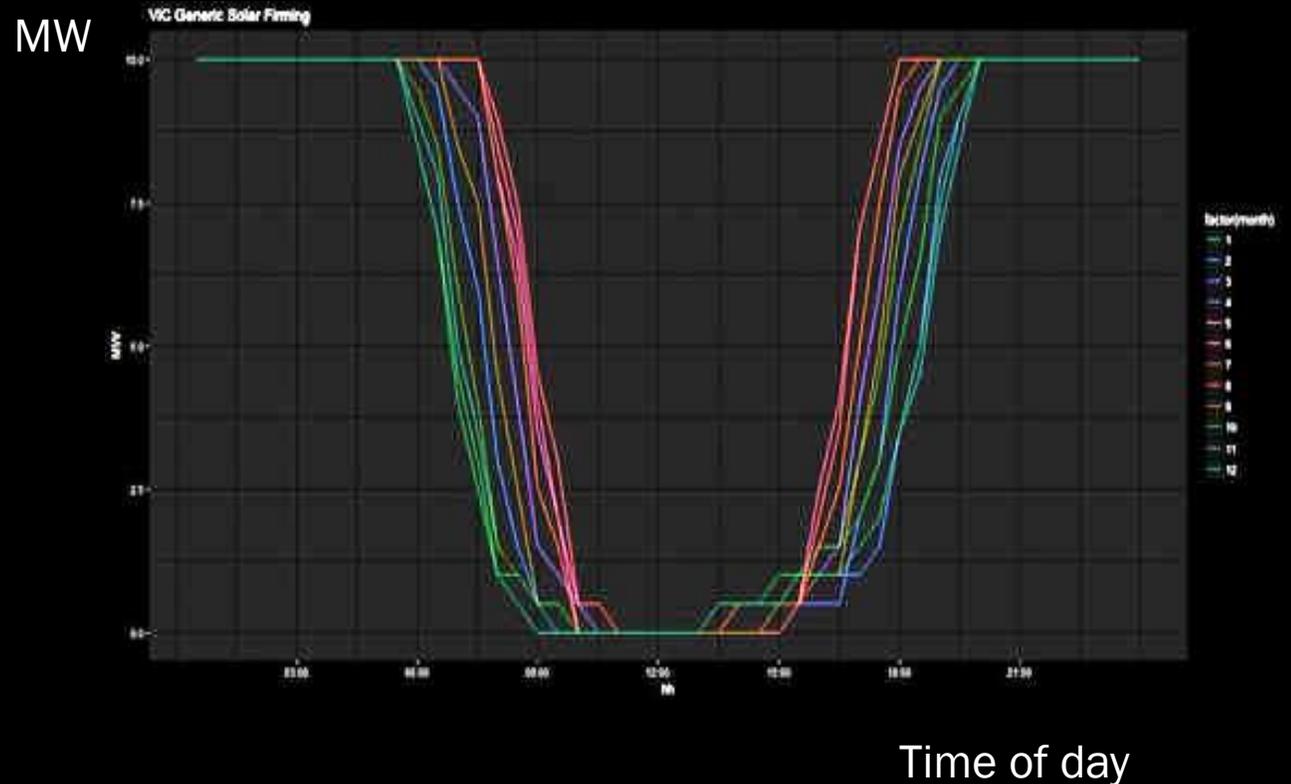


- Some are even commercial
- All have pros and cons
- Lithium ion and pumped hydro are the most practical
- All have relatively short storage durations (<24 hours)
- Longer duration (>24 hours) still requires hydro, gas and other traditional generation.

Innovative new firming products are opening the market to new entrants

- Examples
 - AGL's Wind Product Firming Unit
 - ERM's solar firming product
 - TFS Green's Renewable Energy Hub
- Easier approach for Corporate PPAs
- Understood to shadow price gas
- Need a trading desk?

TFS Green's VIC 'Inverse Solar' Firming Product



Source: TFS Green, Renewable Energy Hub,
<http://www.renewableenergyhub.com.au/>; AGL; ERM

Lithium batteries provide fast firming for short durations and are quick to build

Gannawarra Solar Farm (50 MW) and Energy Storage System (25 MW / 50 MWh), Victoria



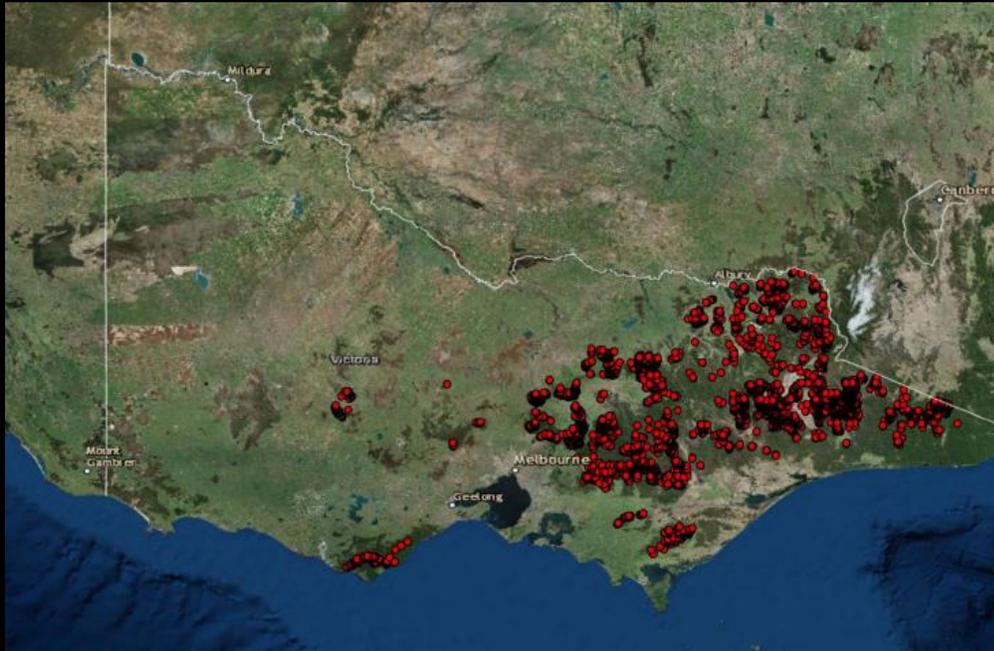
Jointly owned by Edify Energy and Wirsol. Contract EnergyAustralia;
Vendor: Tesla; Capital cost: \$34M; ARENA and VicGovt grant \$25M.

- Can co-locate with asset
- Modular with small footprint
- Very fast response – short term firming, FCAS etc.
- Duration is short (<4hrs max)
- Not presently economic without subsidy.

Sources: EnergyAustralia Analysis, BNEF, ARENA

Pumped hydro's longer storage duration improves firming with better economics

The Atlas of Pumped Hydro sites has identified over 22,000 potential sites across Australia



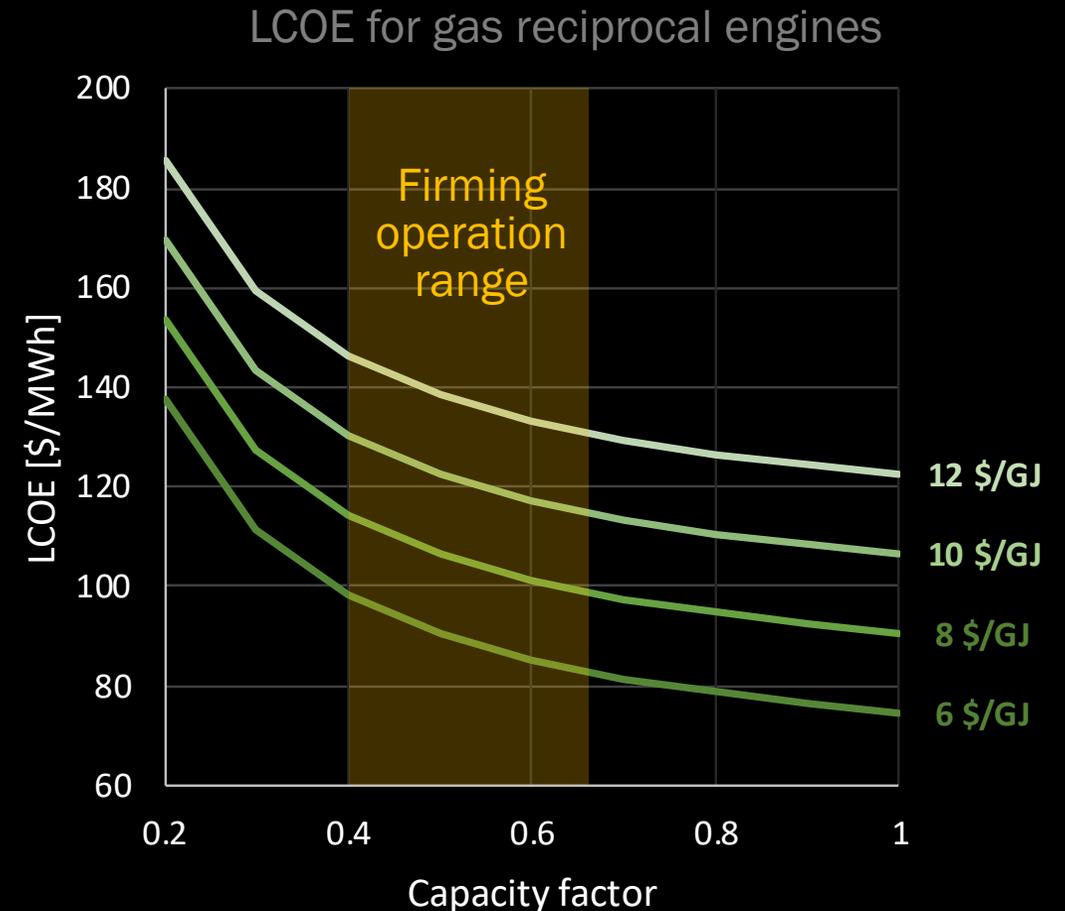
Source: Blakers, A et al, Sep 2017, *Atlas of pumped hydro sites in Australia*, Australian National University.

- Longer duration (typically < 12 hours)
- Well known technology
- Provides inertia
- Very site specific for reservoirs
- Low round trip efficiency at ~70%
- Significant lead time for approvals and construction (~6 years).

Source: EnergyAustralia analysis, BNEF, CSIRO, ARENA

However, modern gas plant works well for firming and will set price for some time

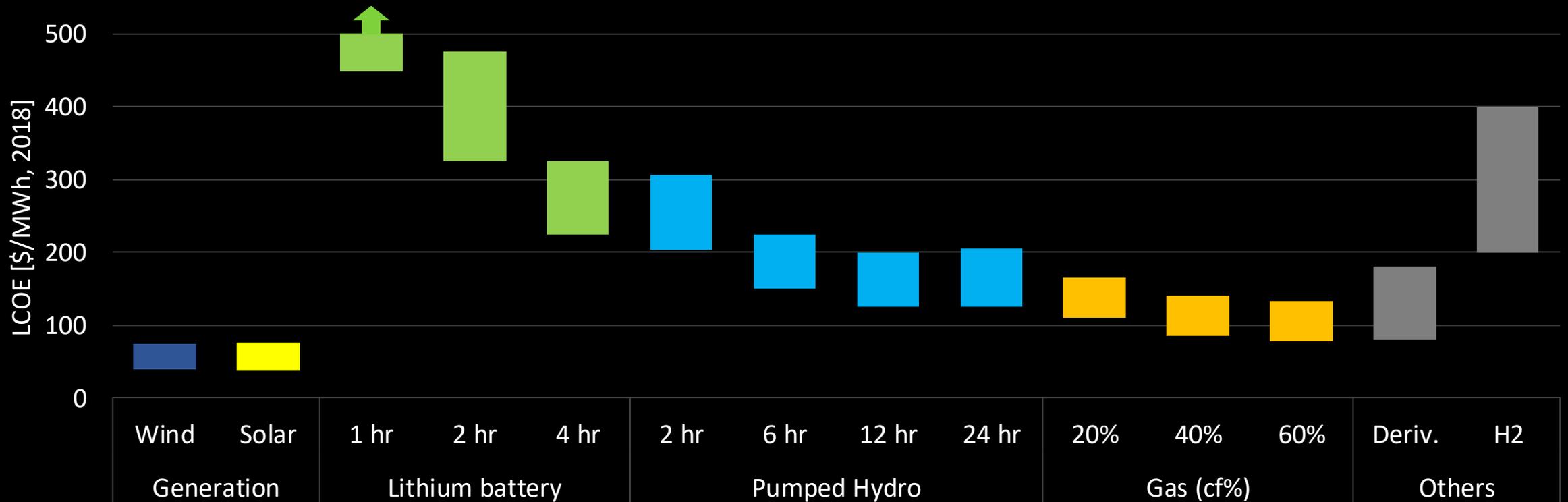
- Effectively unlimited duration
- Fast ramp times but low inertia
- Not renewable
- LCOE 110 - 130 \$/MWh (new) strongly linked to gas price
- Has a role until other long duration storage is competitive.



Source: EnergyAustralia analysis

The costs of firming vary with technology

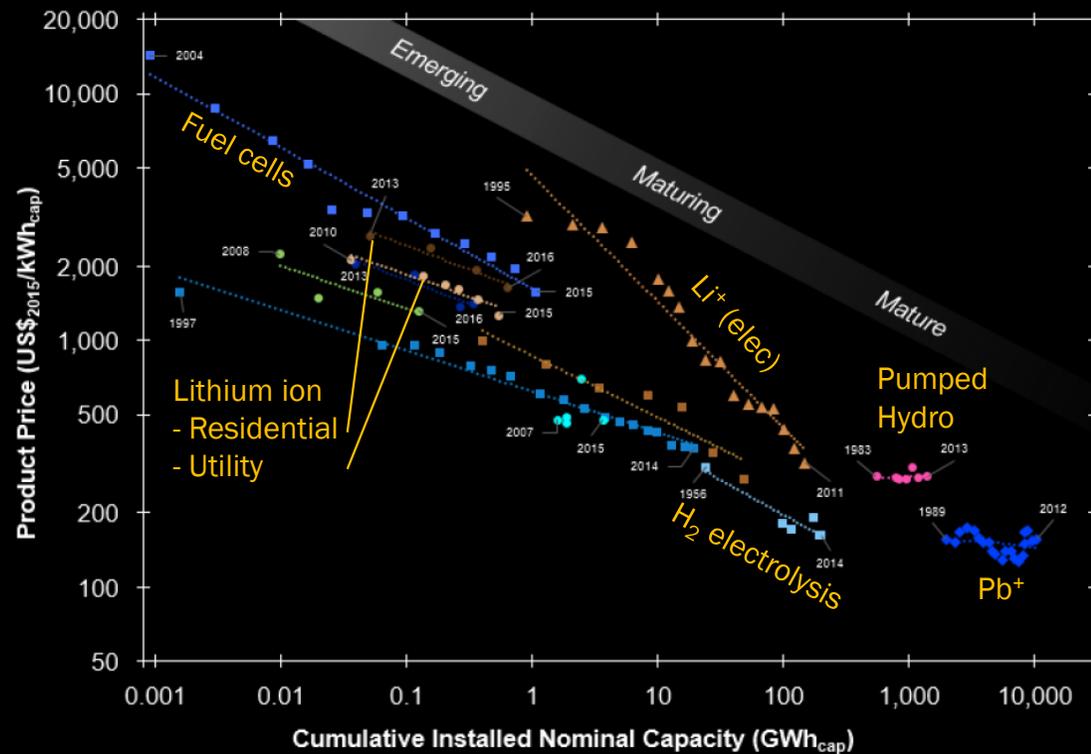
Indicative Levelised Cost of Energy/Storage for different technologies



Source: EnergyAustralia analysis, BNEF, ARENA, CSIRO, Lazard, Entura.

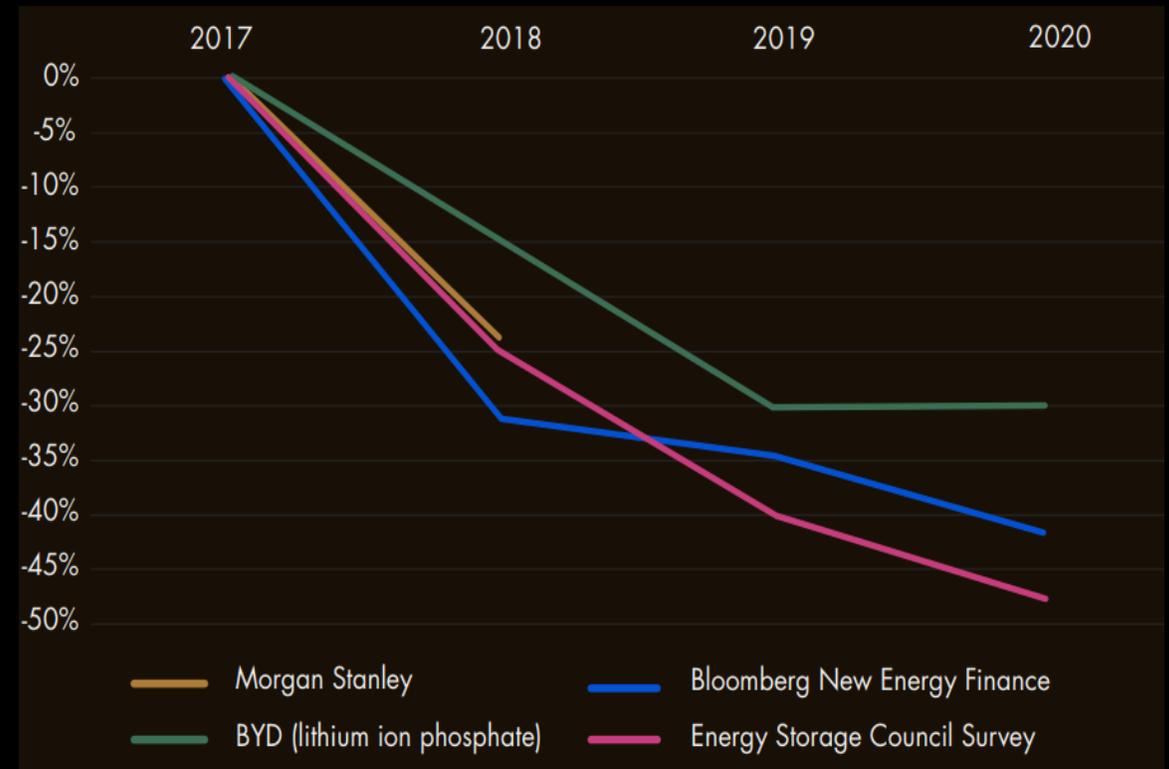
But forecasts suggest the costs of firming will come down

Experience curve cost decline for storage tech



Source: Schmidt et al., 2017, The future cost of electrical storage based on experience rates, Grantham Institute

Lithium ion battery storage system price forecasts



Source: Smart Energy Council, Australian Energy Storage, Market Analysis 2018

Take aways

Lets continue the success story

- Firming is an enabler for increased renewables
- Can you pair up with a pumped hydro?
- A 50% target is likely with \$15B of grants. Apply!!

Some firming is better than none

- Firming to baseload is aspirational and expensive
- Batteries are expensive but costs are coming down
- Pumped hydro will be a part of our energy future
- Gas and hydro have a role to play for longer durations
- Think like a trader.

More renewables means more firming

- Firming has still got a way to go
- 'Necessity is the mother of invention'
- Watch this space.