How Can Fossil Fuel Power Generation Have Role In A Decarbonised NEM?

MEGS

brought to you by

Gamma Energy Technology
EXPERIENCE THINKING INNOVATION

REDVector

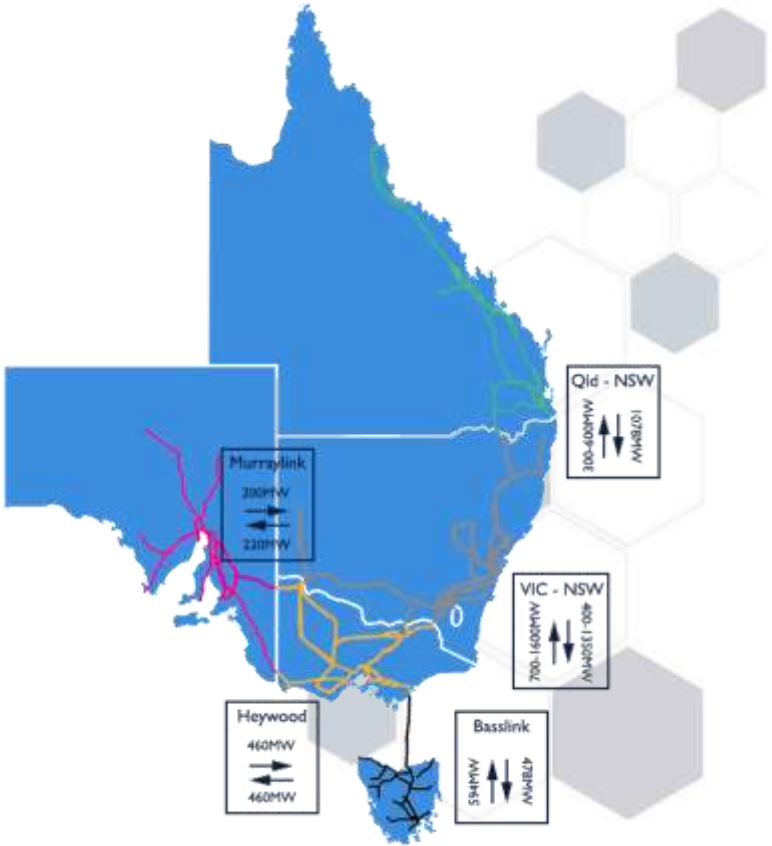
Background – The Team

Geoff Bongers
Gamma Energy Technology
Adjunct Professor @ UQ

Andy Boston
Red Vector

Nathan Bongers
Gamma Energy Technology

Steph Byrom
Currently working and doing a PhD @UQ



The Goal

- **Finding Effective Pathways for Decarbonising Electricity?**

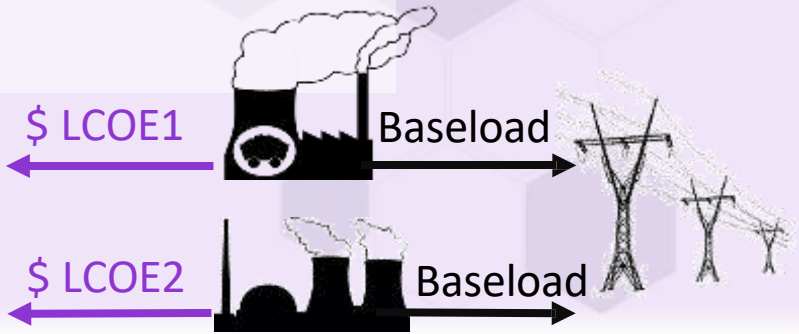
- How hard can it be… surely the answer is wind, solar and energy storage…
- … and now hydrogen!

The Appropriate Use of LCOE

A power plant investor wants to know what price is needed to recover the generator's costs, if energy sales is the only income stream.
The answer is the Levelised Cost of Energy
The LCOE tells the investor what costs will be incurred by the generator.

A very useful metric during PPA negotiations.

- The seller has a benchmark for minimum price
- The buyer can compared potential projects 'like for like'*



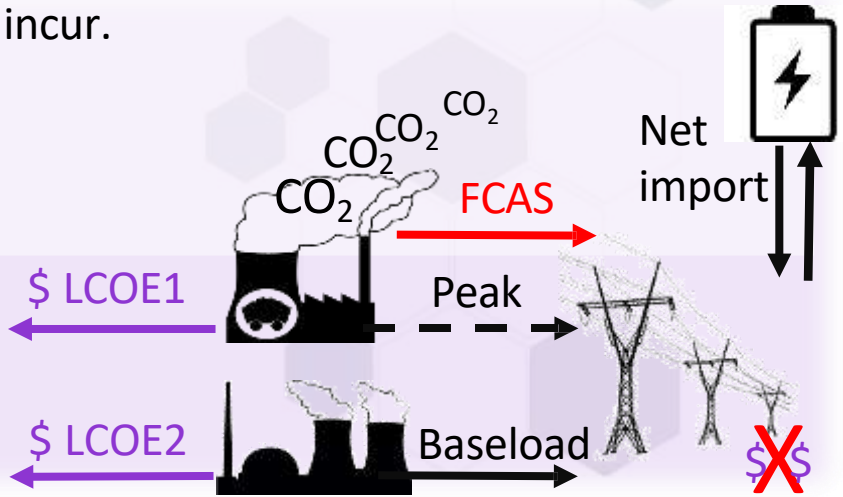
* This only works when the product being sold (e.g. Baseload Power) is the same for each project

The Inappropriate Use of LCOE

LCOE is extremely limited in usefulness:

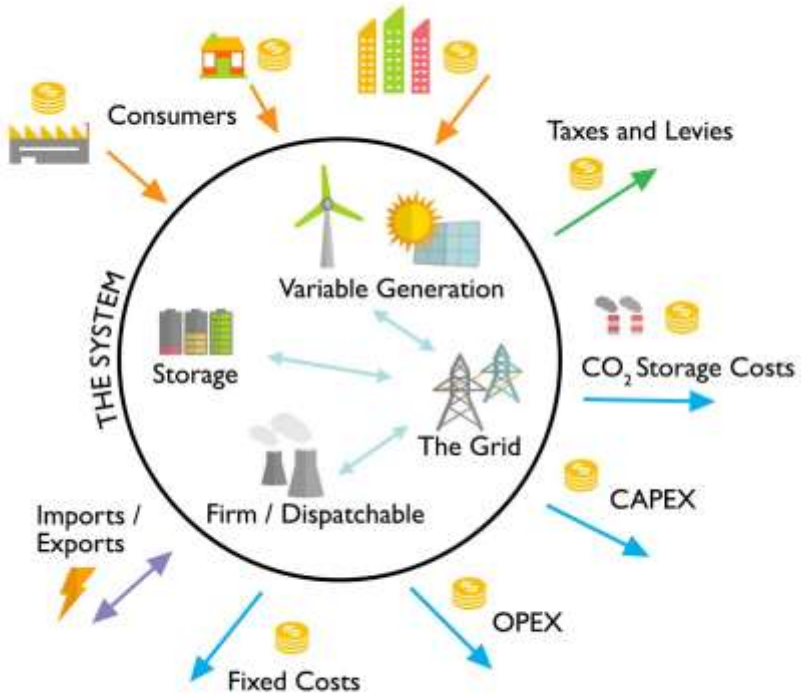
- **It can't compare dissimilar products**. Comparing Baseload plant and Peaking plant LCOE makes no sense. The latter will always be more valuable (per MWh).
- **It can't deal with storage.** Strictly speaking LCOE will be negative
- **It can't deal with non-energy products.** It ignores the value of grid services.
- **It ignores any costs not incurred by the power plant owner.** An investor is not interested in extra costs that the grid operator or consumer incur.
- **It ignores externalities like CO_2 emissions.**

The first point is key. LCOE ignores the **value** of the energy provided. The energy from a technology that produces during periods of surplus (e.g. a PV panel in a solar dominated system) is given equal weight to energy produced at times of system stress.



Total System Cost

- Power generation, storage and transmission assets are those shown within the ‘system’ circle, these are the physical elements of the system.
- Costs refer to any payments that leave the electricity system
  - fuel (blue arrows)
  - taxes (green arrows)
- The price paid by consumers (orange arrows) must cover all of these outgoings and hence is equal to the Total System Cost.



MEGS

Whole System Model	Annual Energy Balance	MEGS	5 Minute / Hourly Scheduling	DC Flow Model	AC Transient Electrical Network Model
Broad Models			Detailed Models		
Small No. of Scenarios Complex techno-economic models. Economics: whole energy system (heat, transport, power).	**Many Annual Scenarios** Simple spreadsheet solutions, includes economics.	**100s of Scenarios** Interconnect capabilities. Includes economics and system stability. Medium resolution	**A Daily to Yearly Resolution** Includes economics and unit dynamics (ramping, on-times etc).	**Simple Point in Time** Good estimate of system strength. Interconnect capabilities.	**Single Point in Time** Represents electrical engineering excellently: system fault stability, inertia requirements.

MEGS: Modelling Energy & Grid Services

MEGS is different to most modelling approaches - it minimises Total Systems Cost.

- Energy must balance. — **Conservation of Energy**
- There is sufficient supply of reserve and response services. — **Managing imbalances**
- There is sufficient inertia — **Stability: time to react**
- There is sufficient reliable capacity to meet peak demand — **Keeping the lights on!**

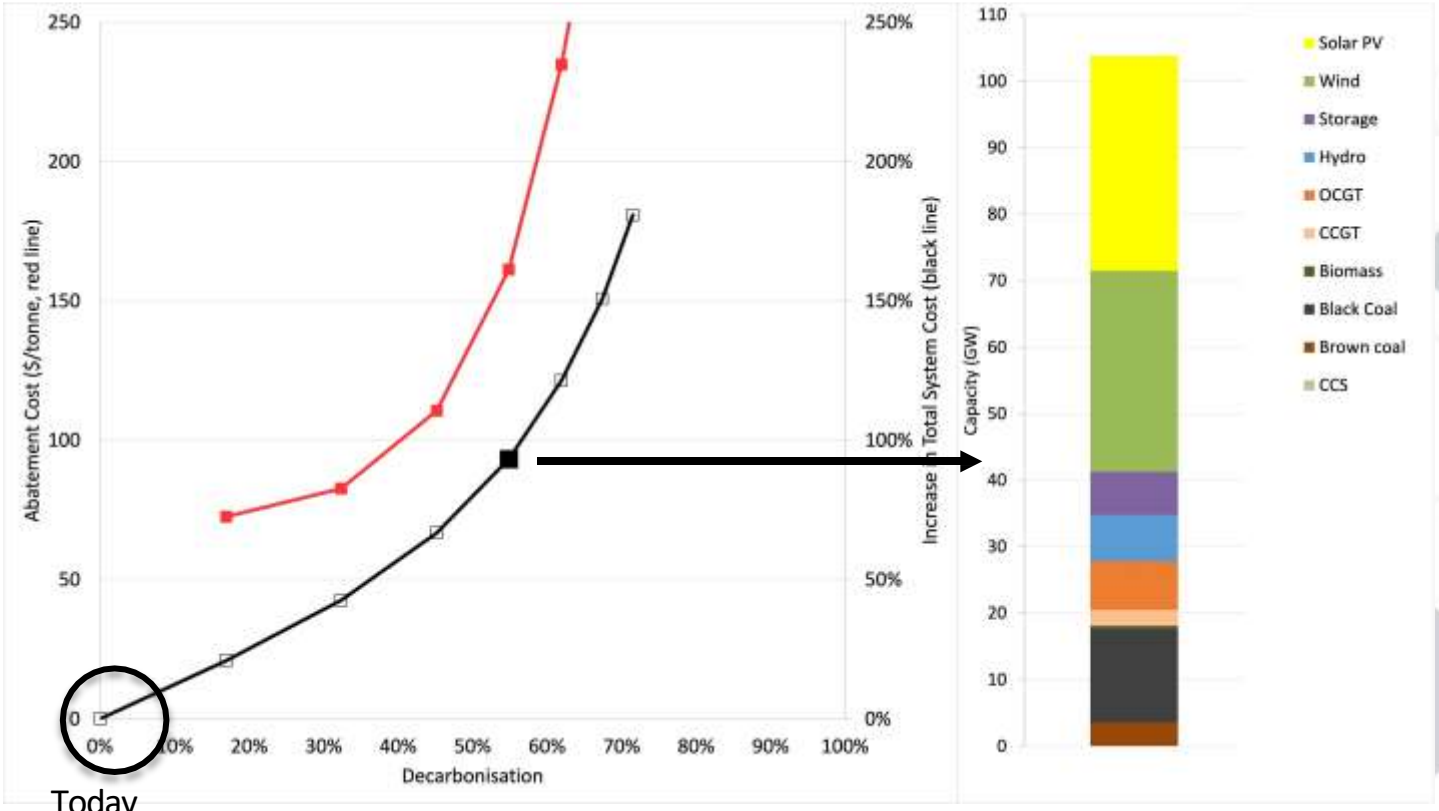
Whilst minimising short run cost
- **Fuel**
- **Carbon Storage**
- **Variable**
- **Start-up**

And optimising storage

Adjusts capacity to maintain Loss of Load Hours

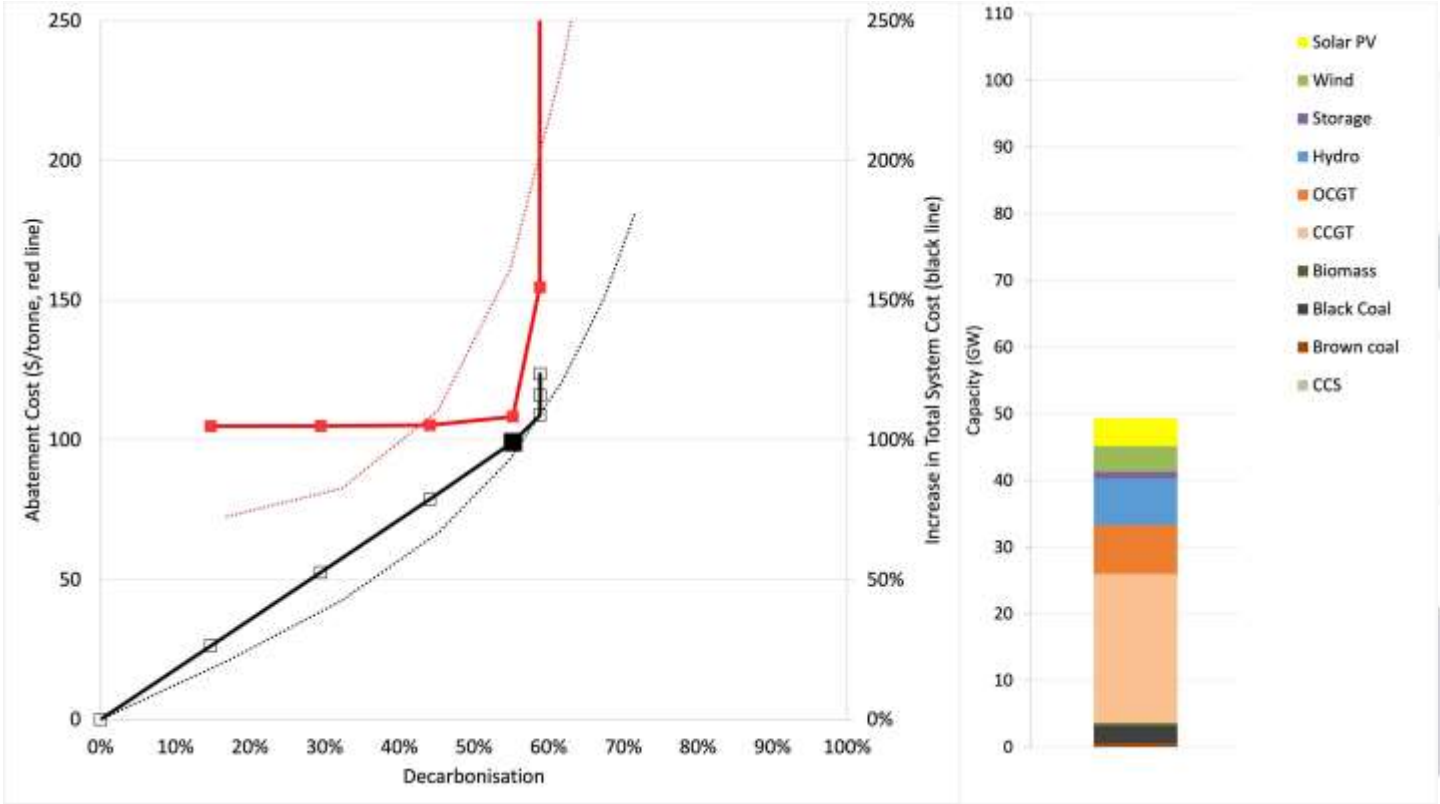
Technology Options - RES

Renewables (wind and solar – with storage) **15GW** steps (+1.5GW supporting batteries)



Technology Options - Gas

Natural Gas Combined Cycle - **5GW** steps

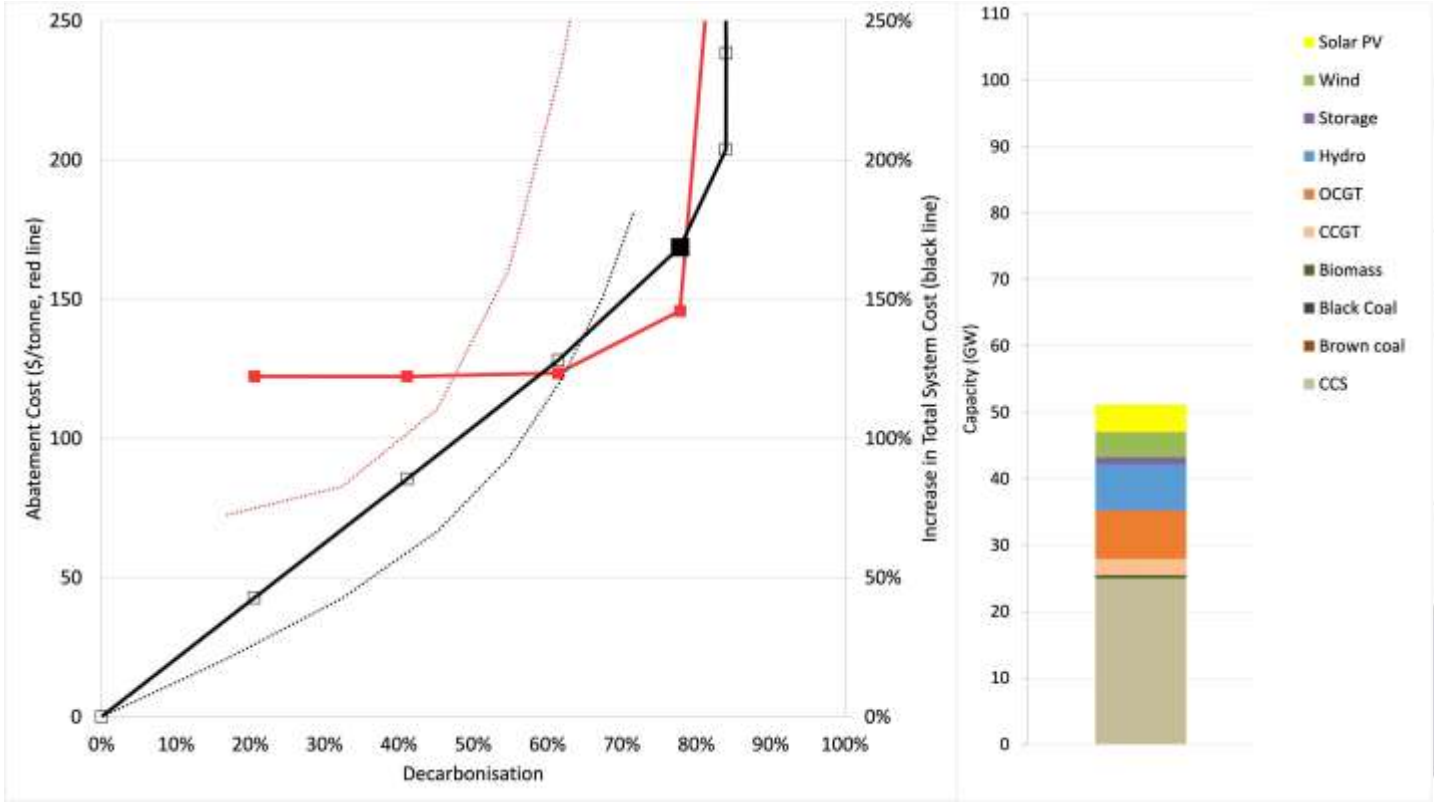


Technology Options - CCS

Gamma Energy Technology

REDvector

Fossil Fuel with CCS – **5GW** steps



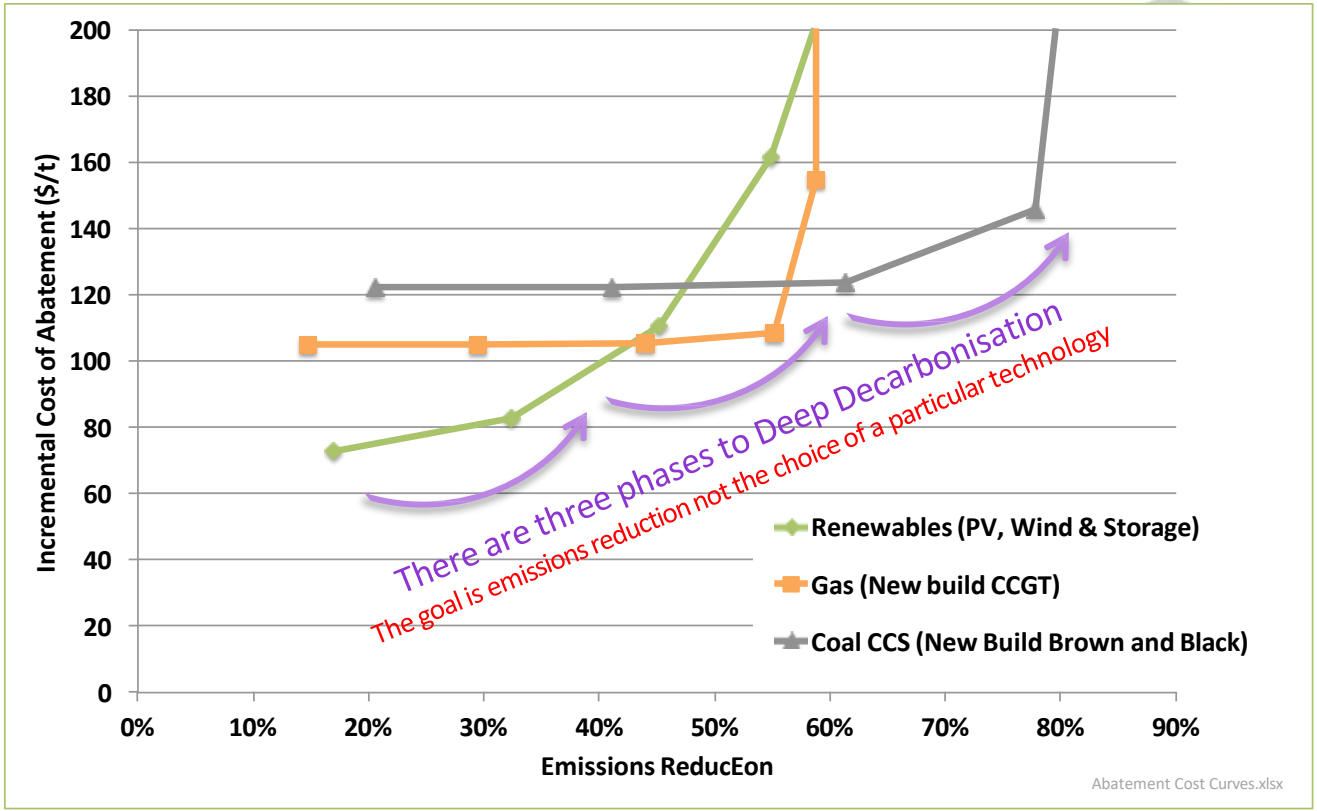
Abatement Cost Curve Comparison

MEGS explored 3 pathways to decarbonisation by either building just renewables, just gas or CCS alone.

The plot shows the ***least cost*** of getting to that emissions reduction on each path.

- Renewables starts low cost but soon becomes ***very*** expensive
- Gas cannot pass 60%
- CCS starts more expensive but can access 80%

All paths need to be worked on together from present day to achieve deep decarbonisation

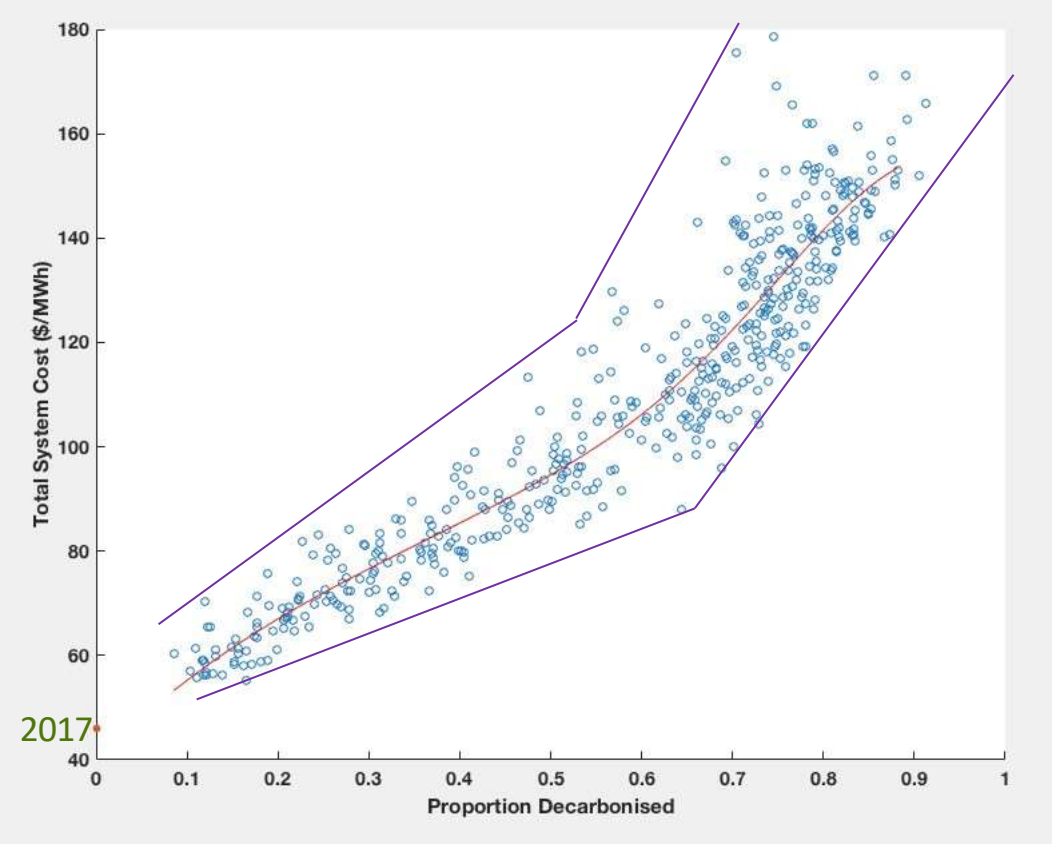


MEGS Monte Carlo Configuration

MEGS

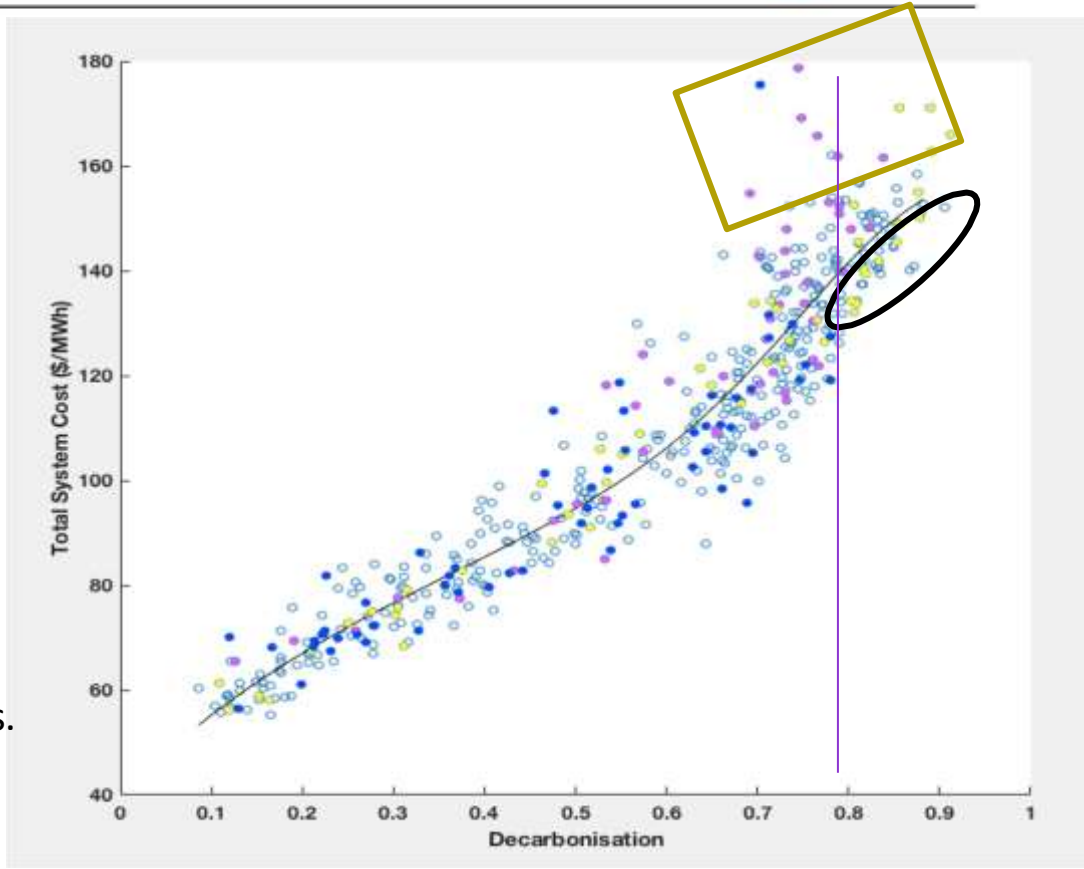
- Can be run in low-res fast mode (5 hour time step) to explore large range of portfolios
- E.g 480 runs randomly choosing
  - 10 weather years
  - Gas price 10% annual volatility
  - Capex with 10% volatility
  - 0-35GW gas and/or coal CCS
  - 0-100 GW renewables
  - Snowy 2.0 in or out

- Note accelerating upwards curve: Decarbonisation implies cost increase



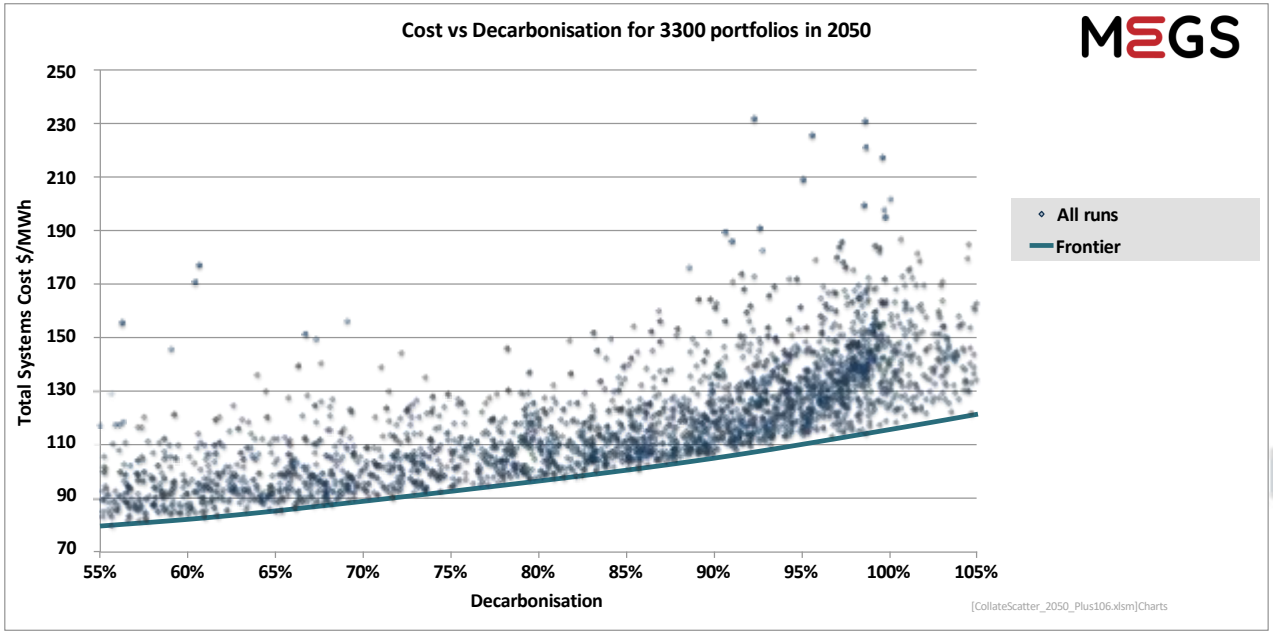
MEGS Monte Carlo – Interpretation…

- Coloured dots are missing one tech:
  - No Renewables (Magenta)
  - No Gas (Yellow)
  - No Coal-CCS (Blue)
- Rectangle portfolios all missing one component
  - **Lack of diversity could lead to very high cost solution**
- 78% line shows there are no scenarios beyond this that are missing CCS.
  - **CCS is essential to get to > 80%.**
- The favourable black ellipse are mostly balanced or with some missing out on gas.
  - **Both CCS and renewables are key to deep decarbonisation.**



A World Without Constraints

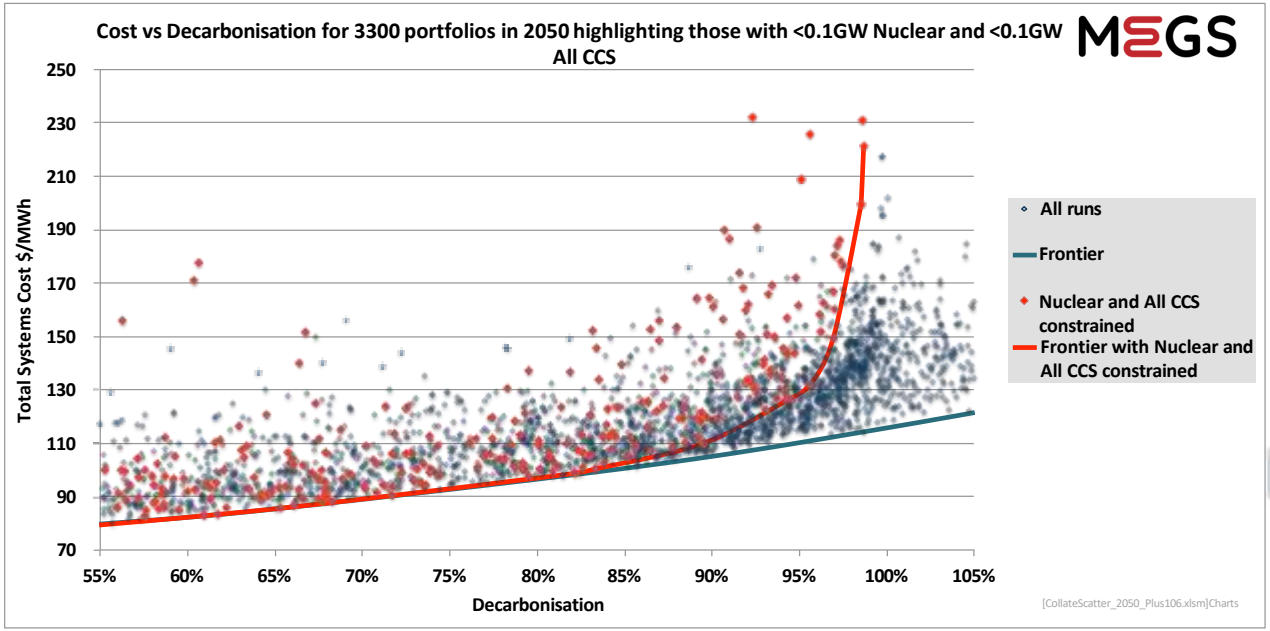
(All technology options are available to achieve net-zero by 2050)



- We can't show you the details on this slide… because… that would spoil the surprise…

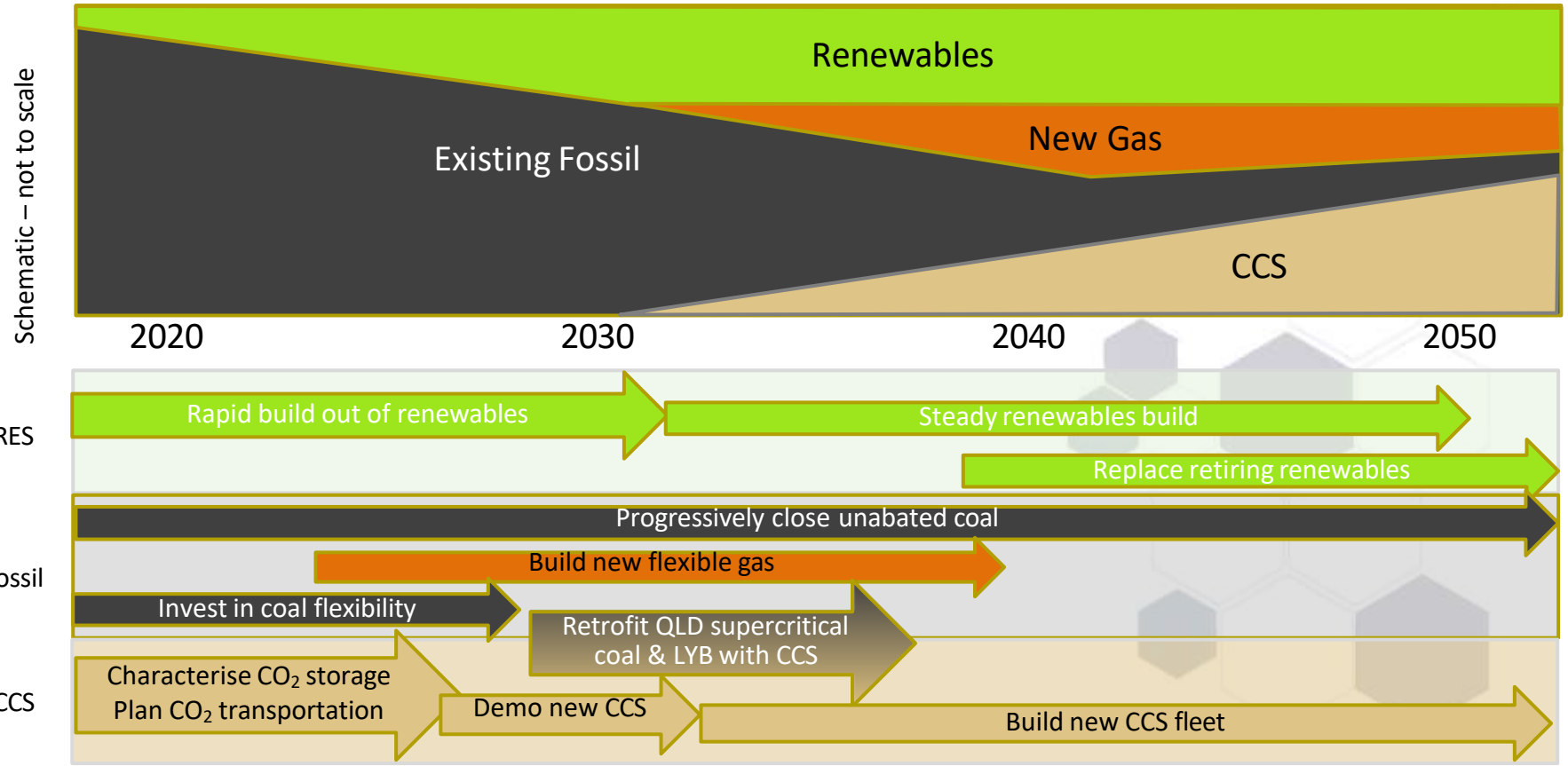
No CCS or Nuclear – not a happy place to be

(CCS & Nuclear technology are excluded as options)

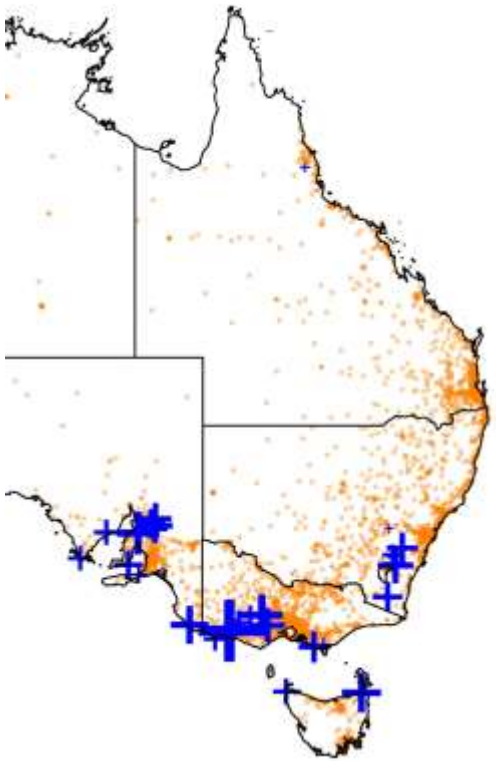


- For decarbonisation targets above 83% either CCS or nuclear needs to be part of the solution to achieve the lowest TSC.
- Realistically, the system cannot progress beyond 95% decarbonisation without extraordinary TSC impacts.

Decarbonisation Timeline



Weather Data Basis



Renewables Ninja takes historic weather records and simulates what wind and PV would've generated in those years

Has been validated against market data for NEM

Known locations marked on map

This project has 10 years of coincidental market and weather data

Anatomy of a Drought

This is 1 in 5 year wind drought for NEM.

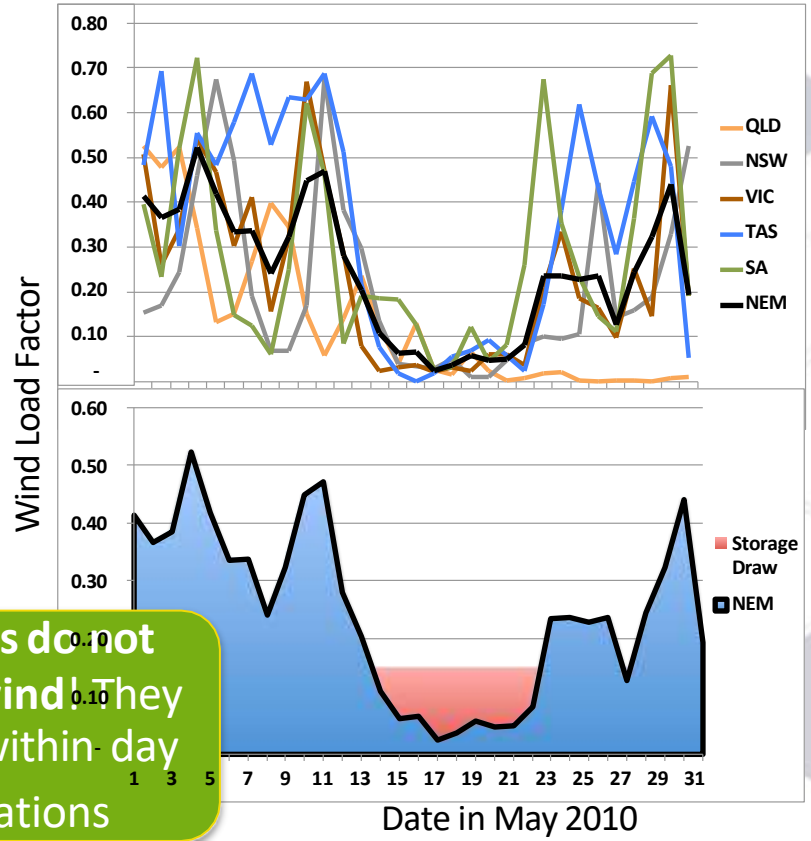
All states went down together for a week.

Assume system is OK with ½ of normal wind level.

Rest is made from storage

Would have to hold 14MWh per MW of wind for 5 years (red area).

So a 1GW windfarm would need 108 of Tesla's biggest batteries to "firm it up".

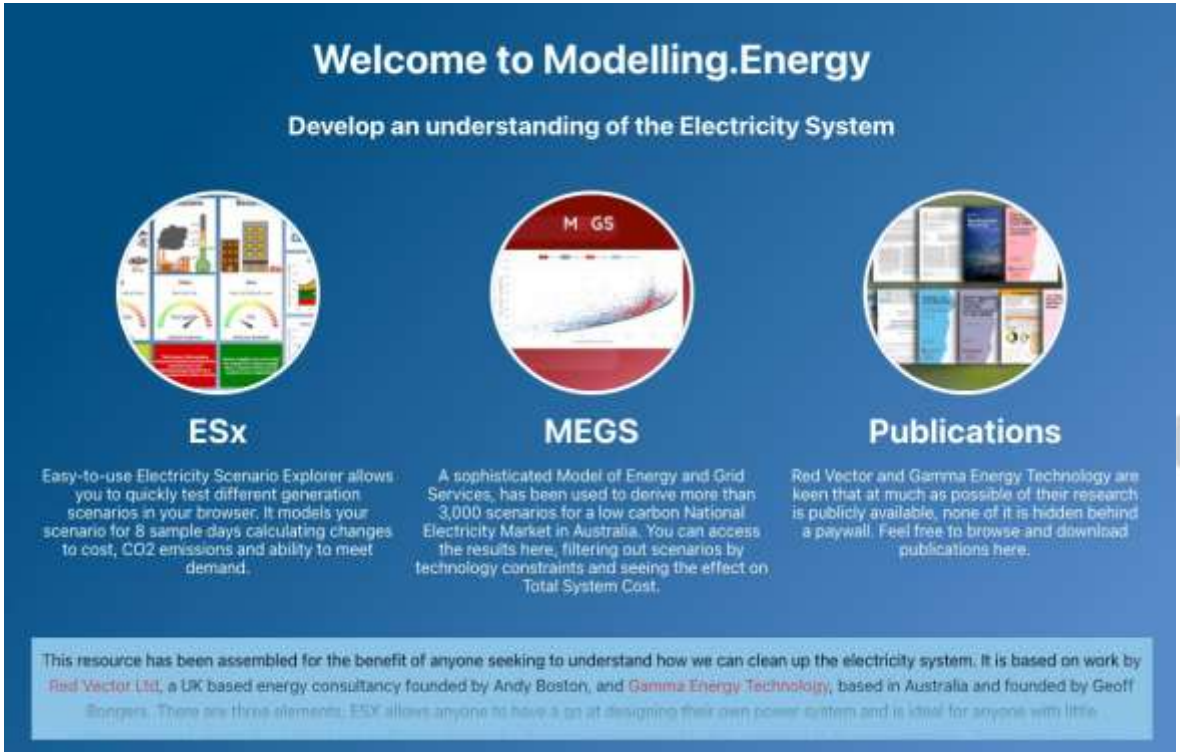


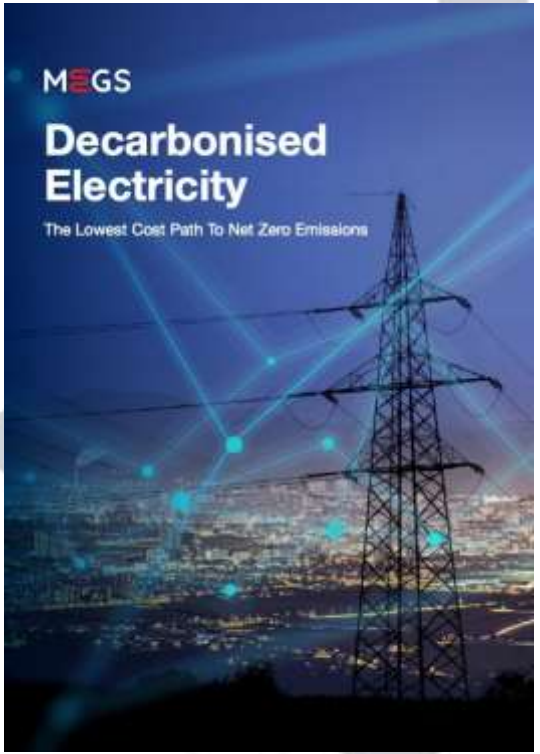
Batteries do not firm up wind! They smooth within-day fluctuations

Results using Total Systems Costs

- ***Only CCS can get to deep (>60%) decarbonisation levels***
- Renewables appears to be cheapest for ***initial*** steps
  - But not for deeper decarbonisation
  - Building gas is cheaper for mid levels of decarbonisation around 50% vs current grid
  - Energy storage increases costs for renewables
- The effectiveness of a technology depends on how much exists already
  - Costs increase in a **non-linear** fashion as they are added
  - Simple metric like LCOE can't explain or represent that behaviour

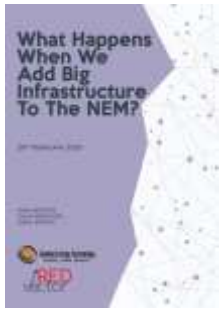
Modelling.Energy &
The Book – Decarbonised Electricity

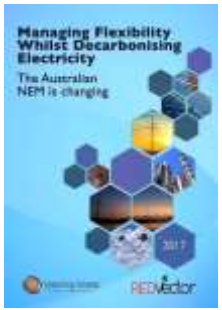


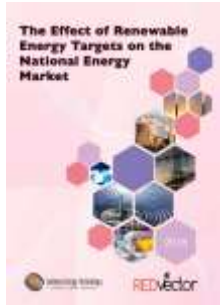


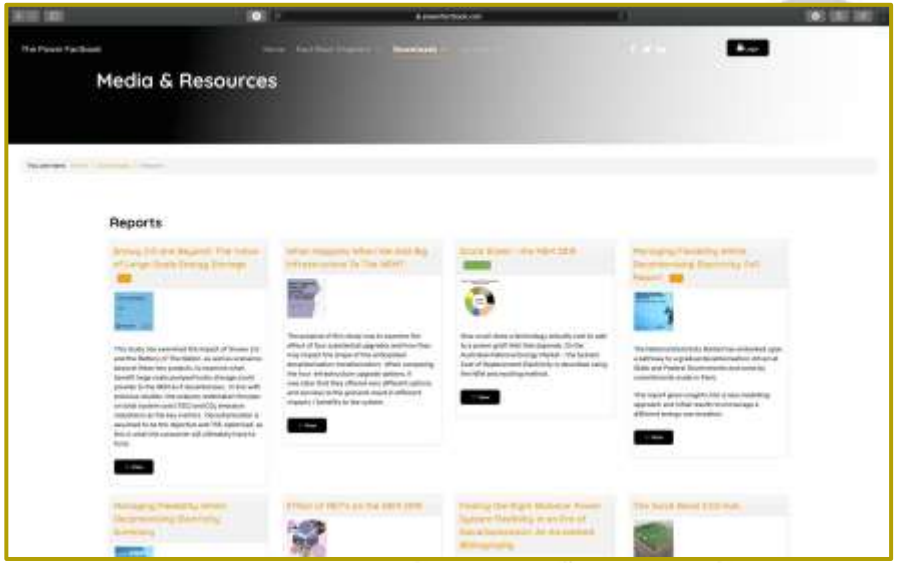
modelling.energy

Our Work to Date









https://www.powerfactbook.com

Follow us

For more details and information…

We are online:

Facebook: @Modelling.Energy

Facebook: @GammaEnergyTech

Facebook: @powerfactbook

LinkedIn: megs-model

LinkedIn: gamma-energy-technology

LinkedIn: red-vector

Twitter: @GammaEnergyTech

www.powerfactbook.com, redvector.co.uk & modelling.energy

END