Bringing ideas to life

Lessons for the wind industry – from Australia

NZWEA Conference, Wellington, New Zealand

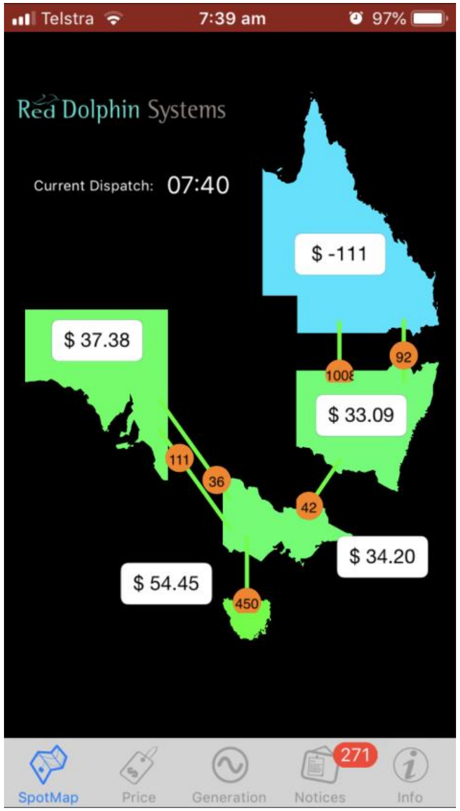
Ashley Grohn

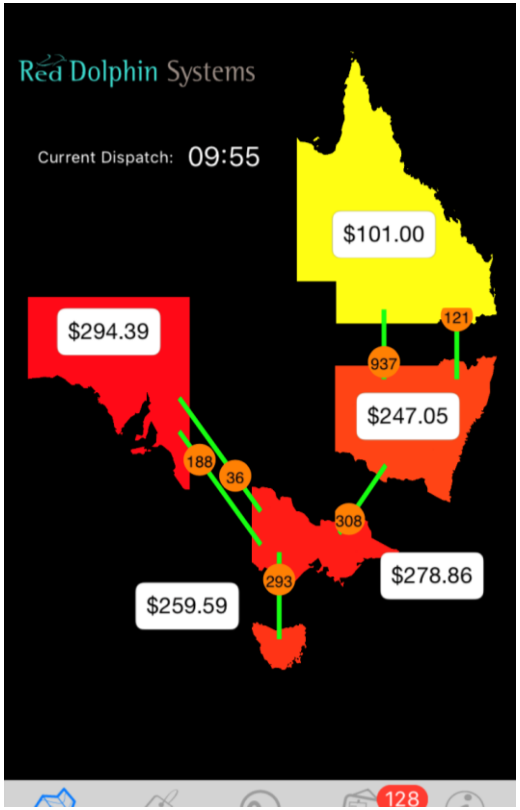
1 May 2019

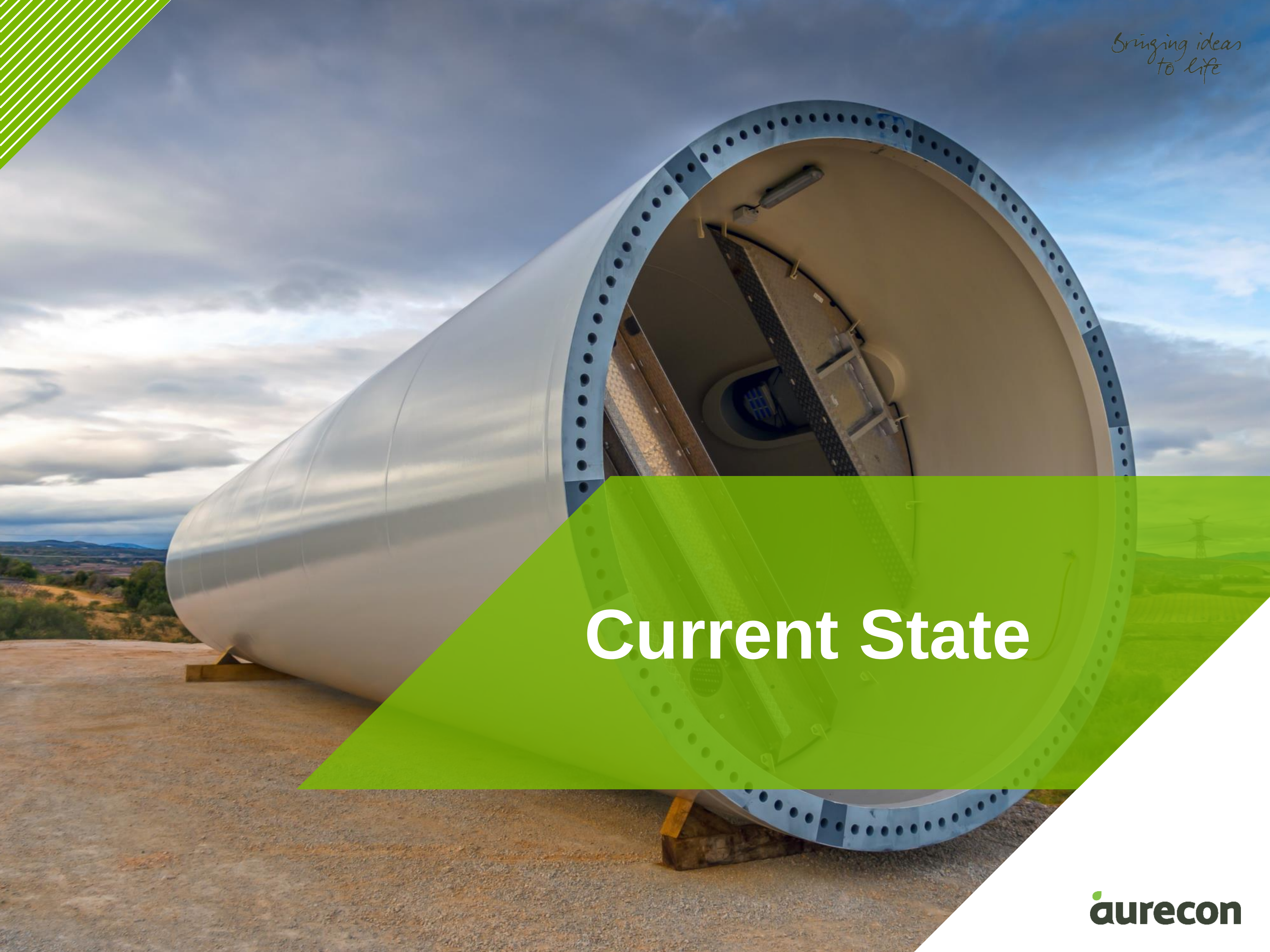
aurecon

Outline

- Current State
- Future State
  - ➢Trends
  - ➢Uncertainties
- Lessons learned







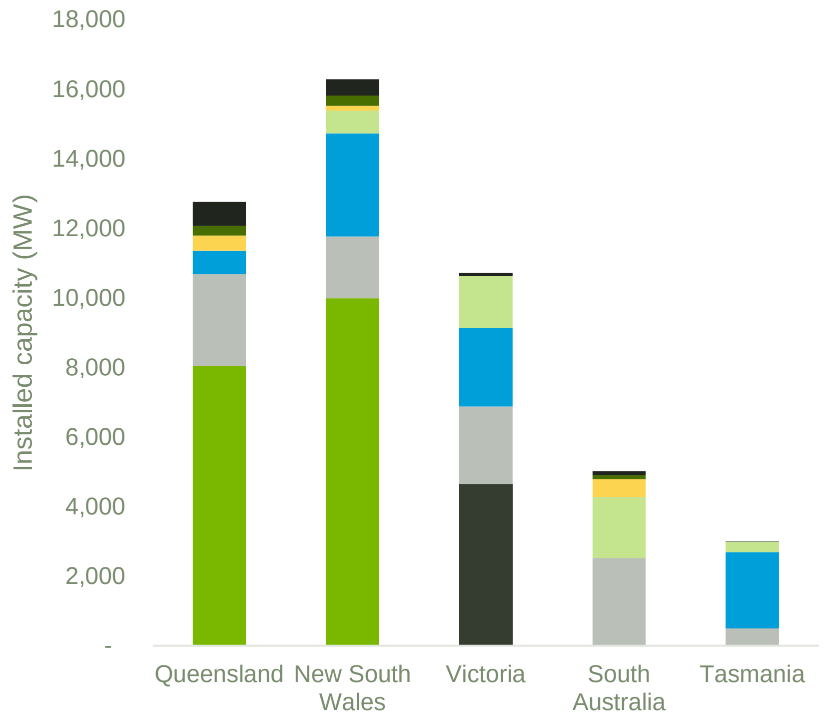
Bringing ideas to life

Current State

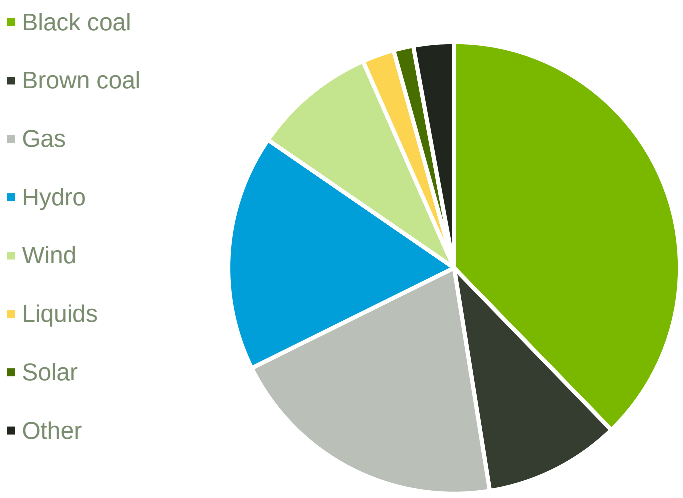
Current state: the National Electricity Market is still dominated by coal fired power generation...

Bringing ideas to life

Installed generation capacity



Installed generation capacity share of market



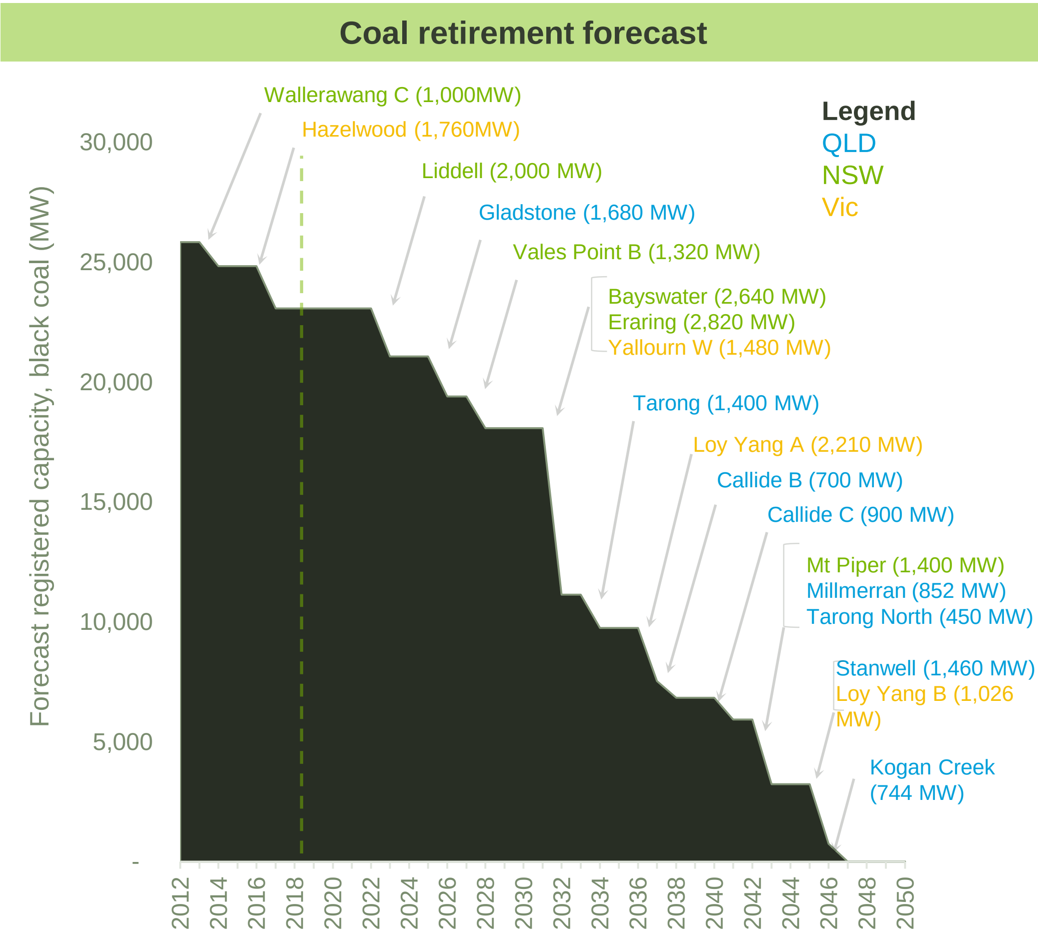
...however the age of the fleet means the next 10-20 years will see ~ 75% of this capacity retire, and the Lowest LCOE is VRE (wind and solar)

Source: Australian Energy Regulator (AER), Sept 2018

aurecon

The impending Liddell exit has sparked debate about the impact of renewables

Bringing ideas to life

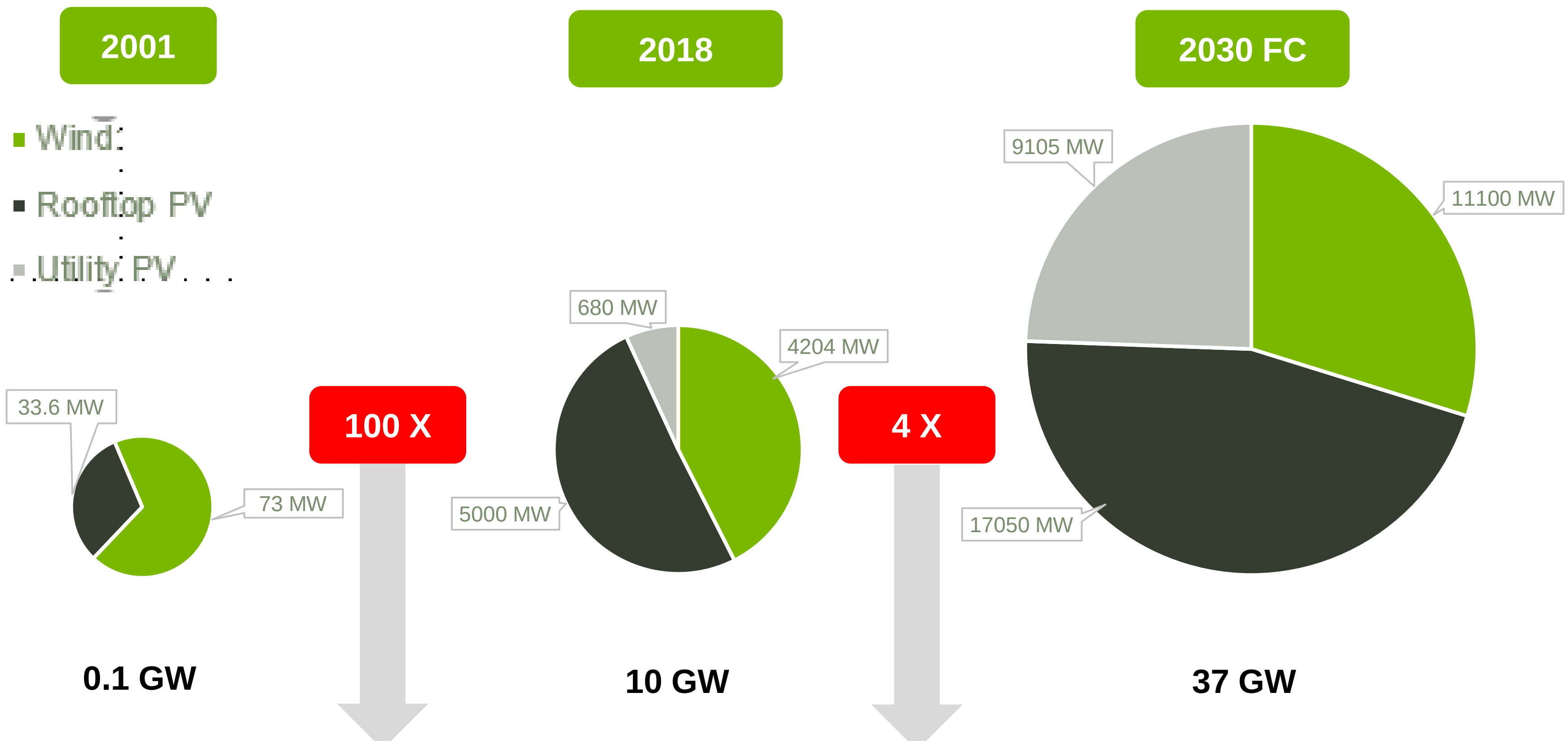


- Queensland coal generators are the youngest in the NEM and despite being more modern, have more limited flexibility to deal with variability of wind and solar
- Victorian brown coal generators are the biggest emitters of carbon dioxide on a per unit output basis
- The impact of coal retirements on wholesale pricing in South Australian and Victoria mean that policy makers are increasingly focussed on ensuring long notice periods for closures

Reductions in dispatchable capacity have driven policy developments to maintain security and reliability, as variable renewables share increases

aurecon

Renewable energy capacity has grown 100 fold since 2001, forecast to quadruple to 2030



Deployment driven by Federal Government renewable target and state based rooftop solar subsidies

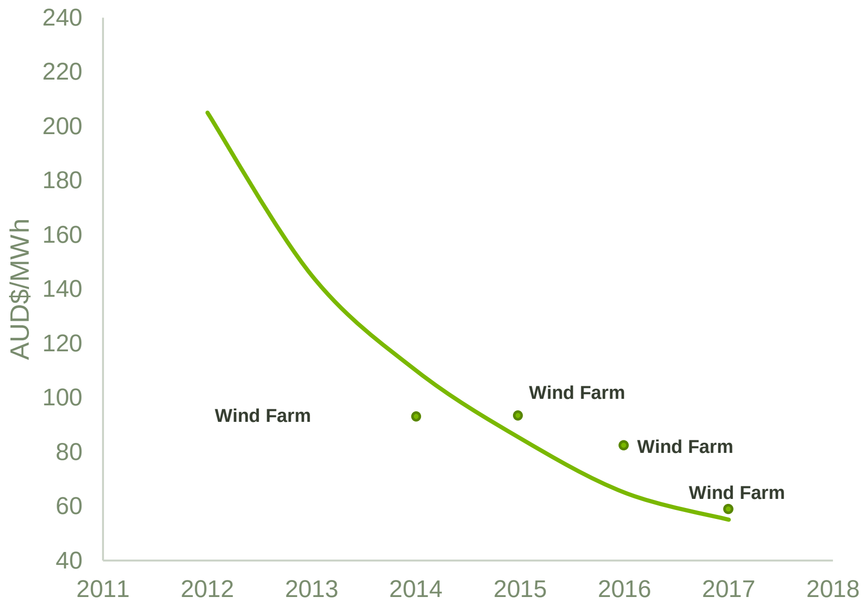
State targets are likely to be the driver of additional renewables deployment (Vic +5GW and QLD +5GW)

Source: All target data from Clean Energy Regulator, www.cleanenergyregulator.gov.au/RET, State targets various State Govt publications
Note Vic and QLD target detailed pricing and mechanisms under development, NSW net zero emissions aspiration by 2050

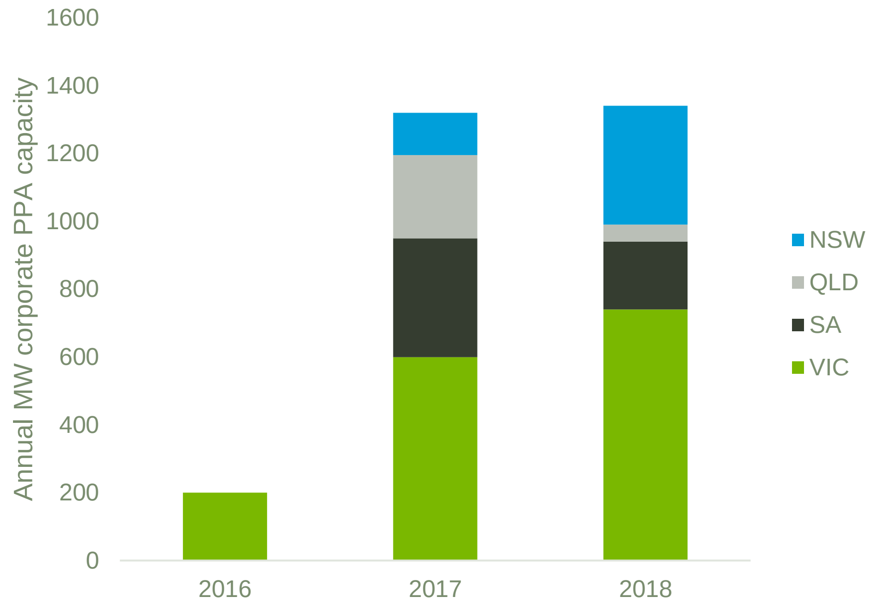
Declining renewable PPA prices and political uncertainty is driving corporates to buy direct

Bringing ideas to life

Australian Renewable PPA Prices



Corporate PPA activity by capacity and region



In the absence of power purchase agreements from the large retailers, corporate agreements enable developers to underwrite new build assets. This in turn is leading should see an increase in retail competition as typically smaller contracts require multiple power purchaser per project

This creates opportunities for large energy users to mitigate price risk

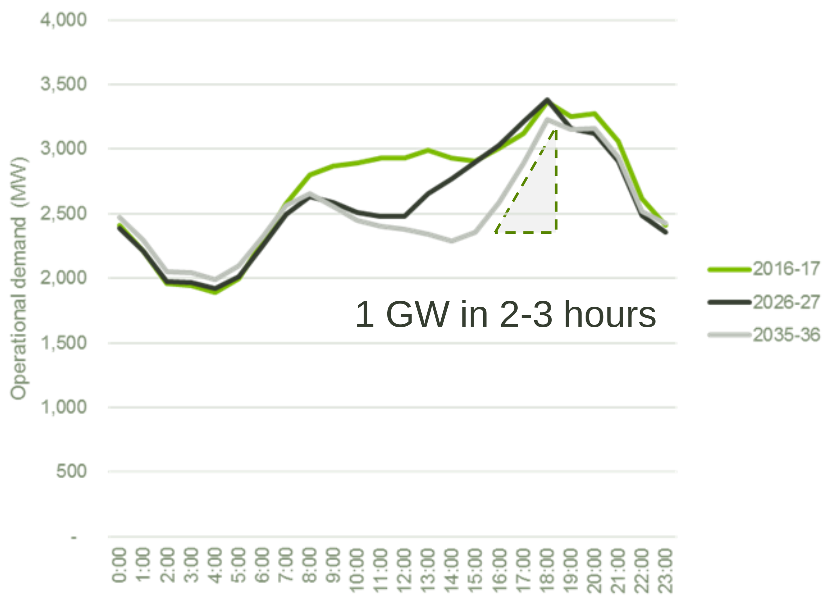
Source: Company announcements, public information

aurecon

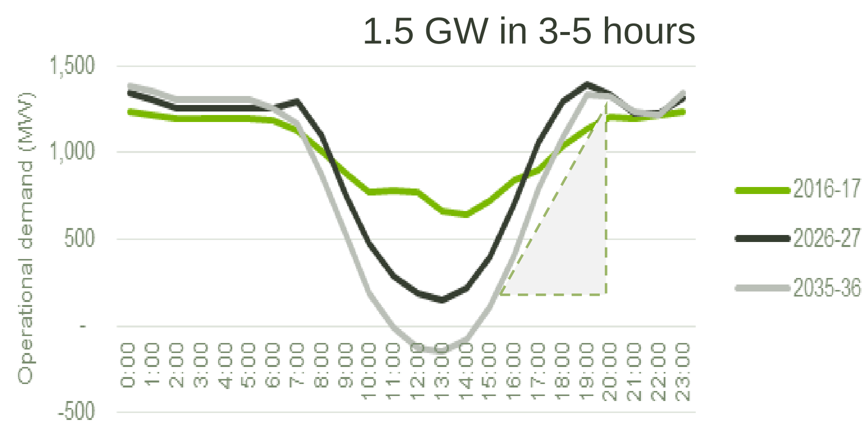
Growth in rooftop solar is likely to further increase this requirement for flexible supply

Bringing ideas to life

Future rooftop solar creates a significant need for a ‘ramp’ period in the afternoon where hundreds of MWs need to come online. Local firming capacity to meet this ramp will come from gas, demand management, and storage.



Maximum daytime operational demand, forecast



Minimum daytime operational demand, forecast

SA will remain reliant on interconnector(s) to meet local net demand profiles without new peaking plant or energy storage

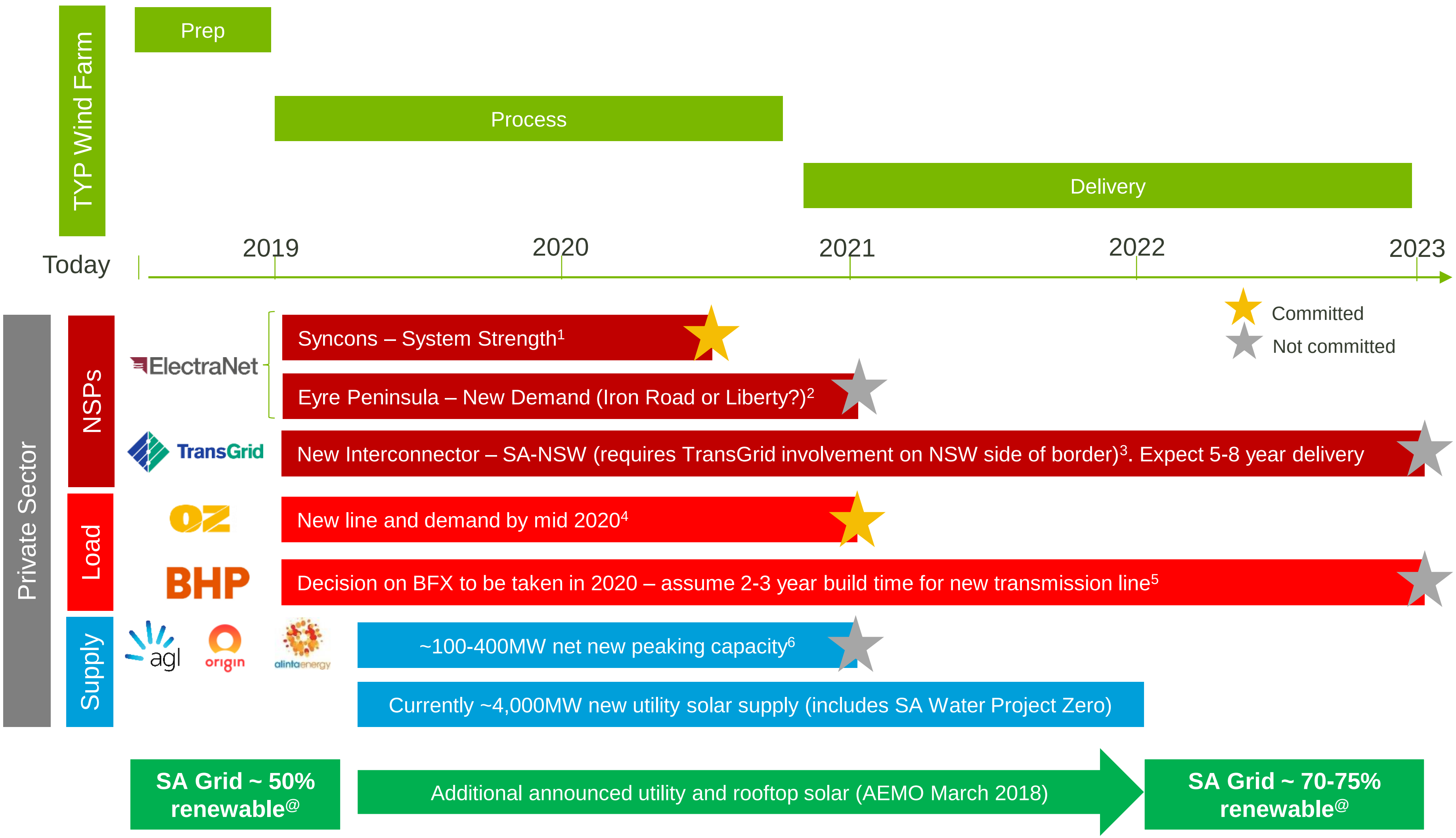
Source: Australian Energy Regulator (AER)

aurecon

SA Market snapshot

Bringing ideas to life

Market activity shown relative to a typical WF development process



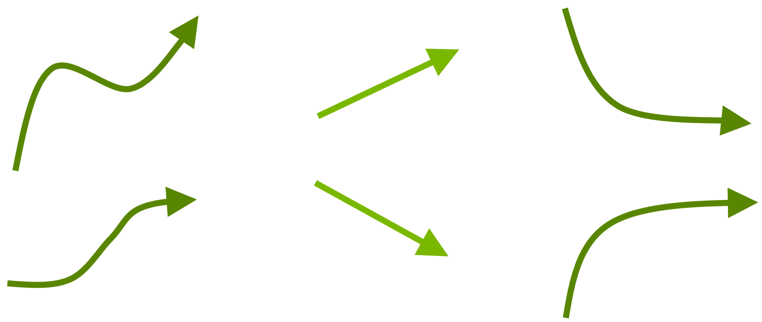
[1] AEMO December network update indicates 18-24 months
[2] Assumes ruling by AER mid CY 2018 with target delivery as per the PACR www.electranet.com.au/wp-content/uploads/2017/04/20170428-Report-EyrePeninsulaElectricitySupplyOptionsPSCR.pdf
[3] Assumes interconnector RITT process proceeds further to the publication of AEMO's Integrated System Plan, to be published mid 2018
[4] OZ Minerals Power strategy indicates new transmission line must be operational mid 2020 www.ozminerals.com/uploads/media/180309_OZ_Minerals_power_strategy_ASX_Release.pdf
[5] BHP has indicated a possible board decision on Brownfield Expansion Project (BFX) to be taken in 2020. Given timing of BHP procurement processes. + 2 year construction time to 2022/2023
[6] AGL TIPS replacement no net increase in capacity. Origin (180MW) and Alinta (300MW) development approval submissions in CY2018 assume 18-24 month construction time from approval

aurecon

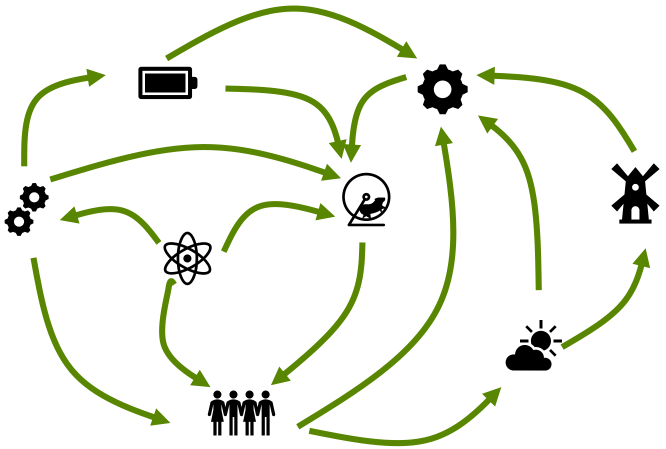
Trends & Uncertainties

The distinction between uncertainties and trends

Trends have clear patterns that move incrementally in a specific direction, you can say something is increasing, decreasing or remaining stable and can make an educated estimate of how it will play out.



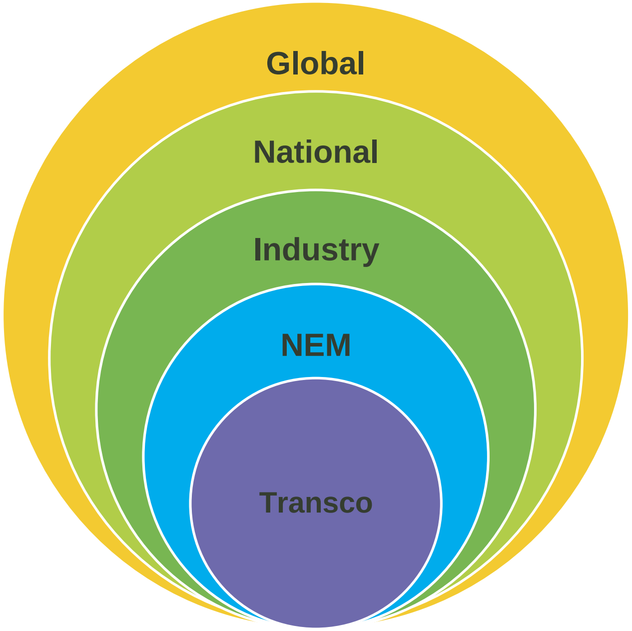
Uncertainties are where feedback loops between trends interact to generate multiple plausible outcomes for how they will develop in the future, they are impacted by decisions yet to be made and unforeseen events.



40 trends acting at multiple scales grouped into 4 key uncertainties that will shape the future of the NEM

- Identified over 40 trends through the stakeholder interviews and review of existing scenarios and research
- Grouped those trends into four main categories of uncertainties

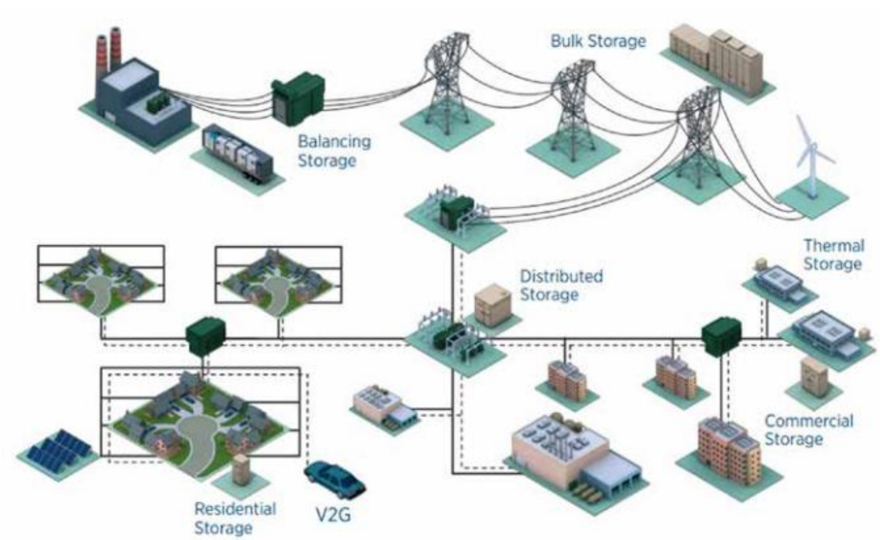
1. **Decentralisation**
2. **Lower carbon future**
3. **Energy consumption (Electrification)**



1 Orchestration of DER is essential

Bringing ideas to life

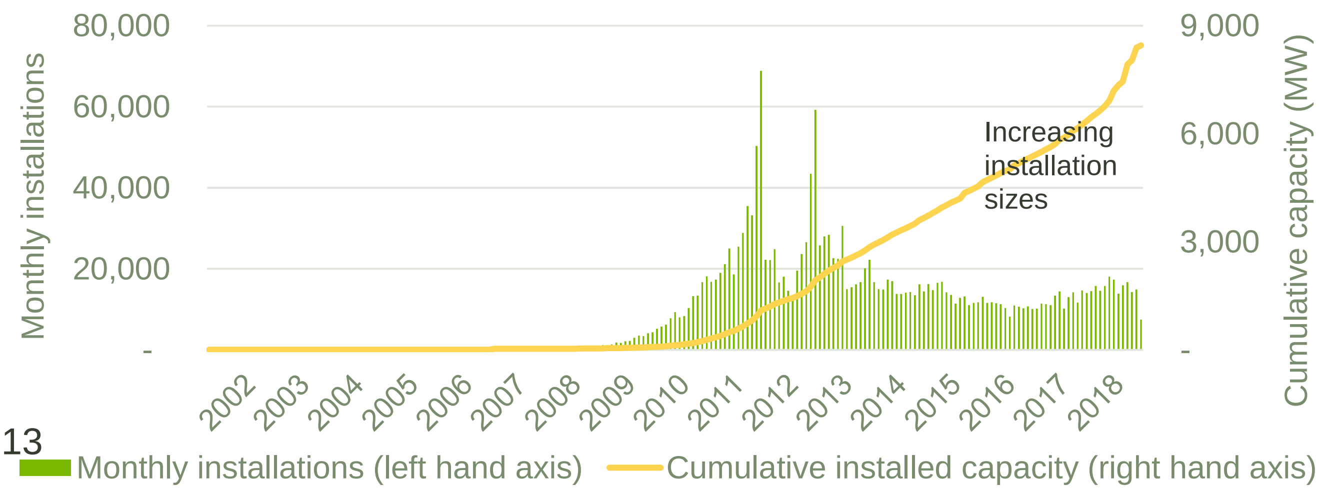
Potential future grid options



Virtual Power Plant Example

- The South Australian virtual power plant has already begun solar PV and battery installations
- The project aims to complete installation of 50,000 home power and battery systems for a total 250 MW capacity. Electricity data will be conveyed via smart phone applications. Generated energy will be first dispatched to the household with excess generation dispatched to the grid.

Solar PV uptake in the National Electricity Market



aurecon

Sources: (APVI, 2018) (IRENA, 2017)

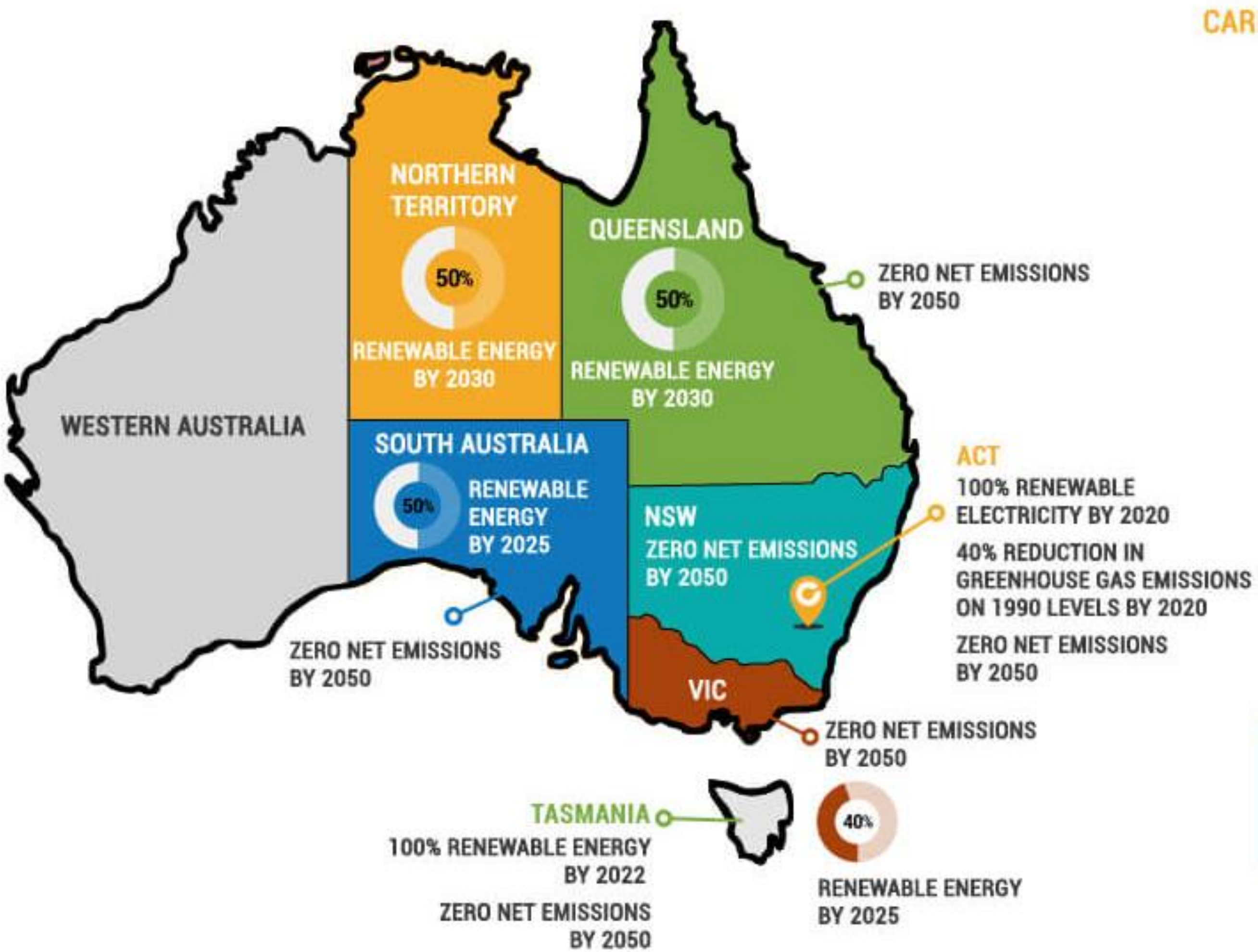
1

Orchestration of DER
Use of AI / Machine Learning brings other opportunities….

Product	Load Forecasting	RE Forecasting	Power Optimisation	Portfolio Optimisation	Price Forecasting	Merchant Trading	Metering Data Mgmt	Digital Twin	Intelligent Asset Mgmt	Edge Integration
DSO	☑	☑	☑	☑	☑	☑	✗	☑	☑	☑
VPP	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Embedded Grid	☑	☑	☑	☑	✗	☑	☑	✗	✗	☑
Retailer	☑	☑	☑	☑	☑	☑	☑	✗	✗	☑
Storage	☑	☑	☑	☑	☑	☑	✗	✗	✗	☑
Gentailers	☑	☑	☑	☑	☑	☑	✗	✗	✗	✗
RE Generators	☒	☑	✗	☑	☑	☑	✗	✗	✗	✗

2 Even in a federal policy vacuum, decarbonisation is a matter of when….

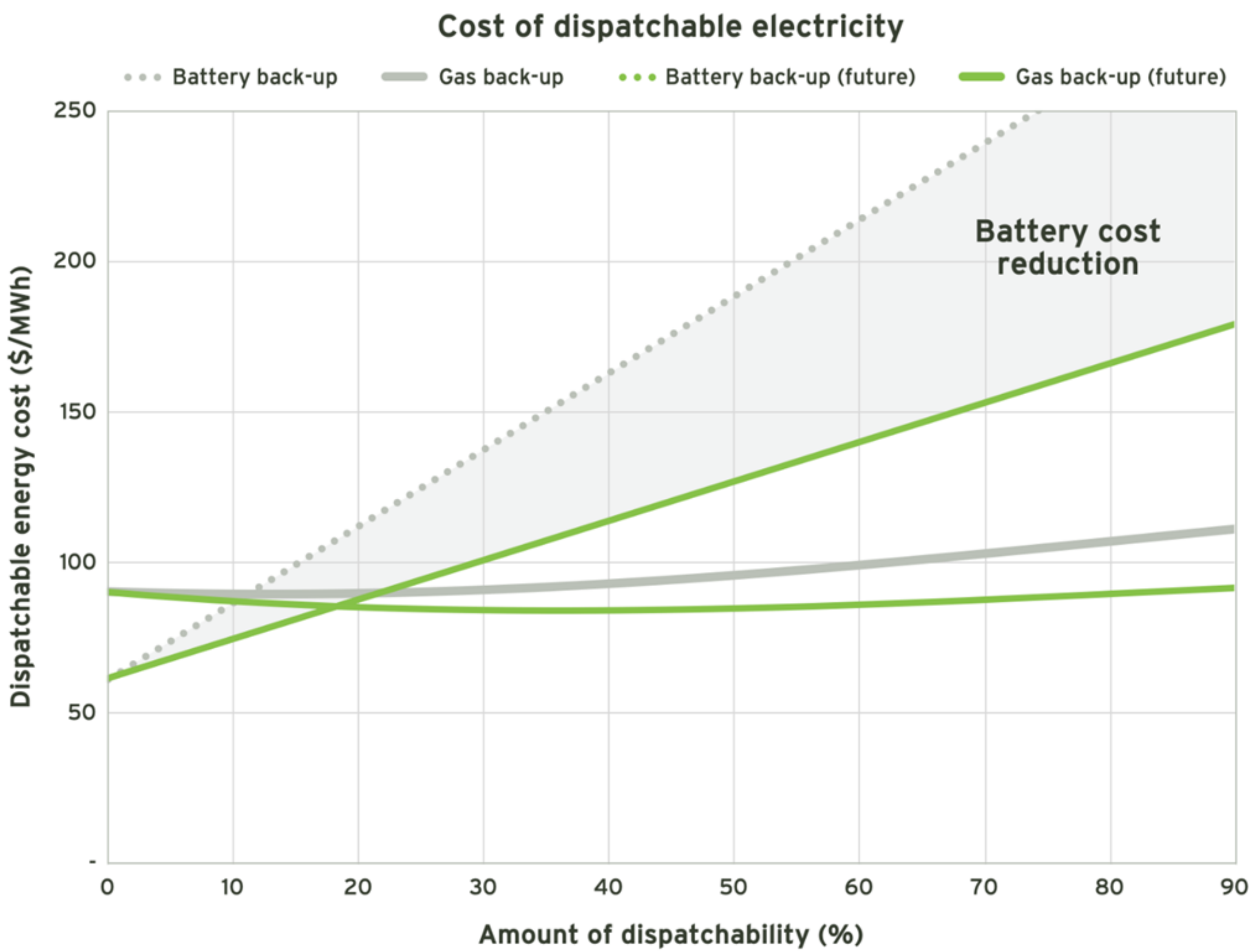
Bringing ideas to life



aurecon

2 Fast evolving energy storage advances give us confidence, but there are limits ….

Bringing ideas to life



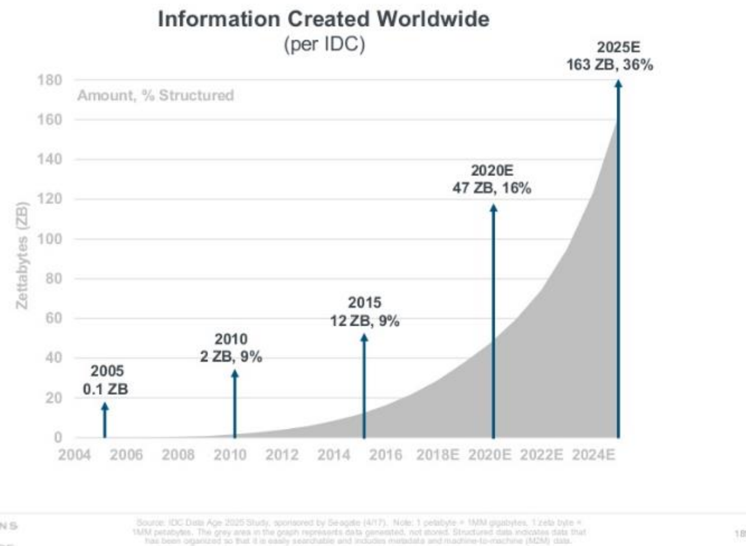
Key assumptions: Today – Gas 10 $/GJ, OCGT capital cost 700 $/kW; Renewable LCOE 60 $/MWh; Battery cost 750 $/kWh; 3000 cycles
Future – Gas 8 $/GJ; Battery cost 375 $/kWh

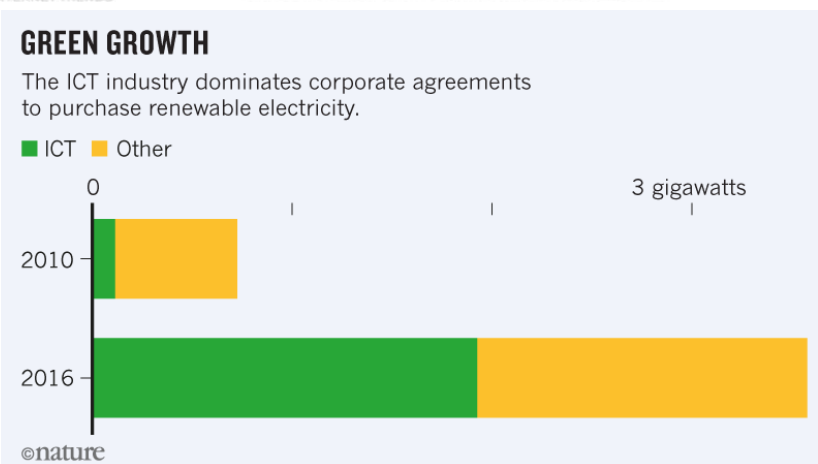
aurecon

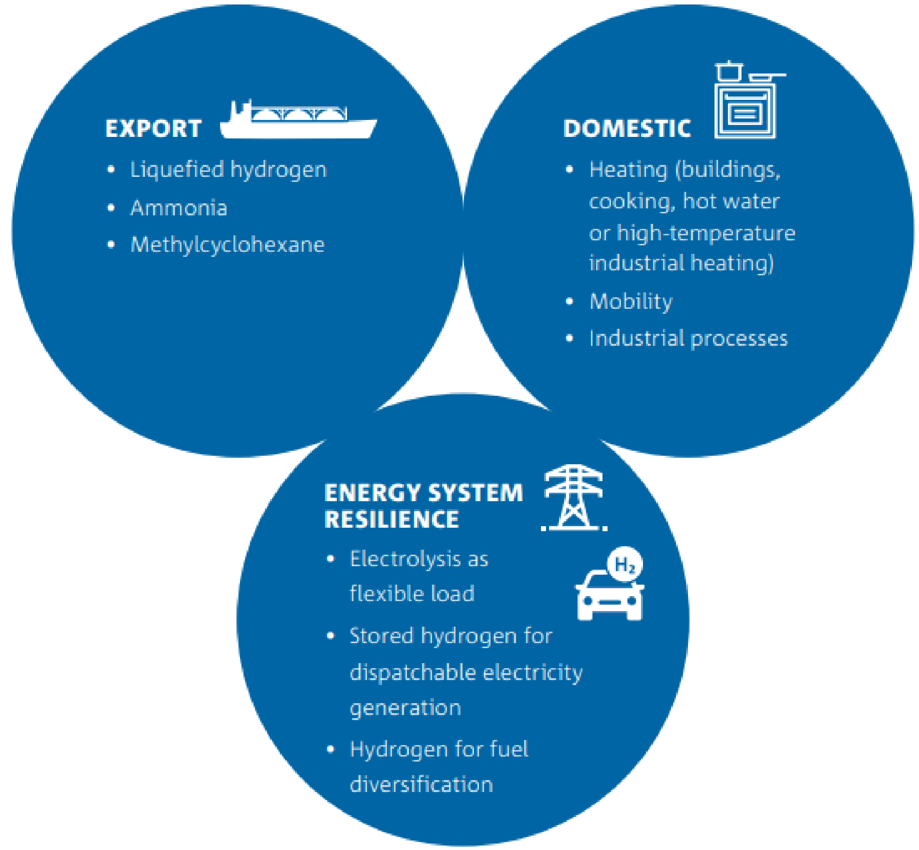
Energy Consumption - Demand growth opportunities

3

Demand growth at Tx scale can come from ICT (eg. data centres) and development of a global hydrogen economy







Source: (CSIRO, 2018)
https://www.chiefscientist.gov.au/wp-content/uploads/HydrogenCOAGWhitePaper_WEB.pdf
https://www.csiro.au/en/Do-business/Futures/Reports/Hydrogen-Roadmap

Bringing ideas to life

Lessons Learn(ing)

aurecon

Bringing ideas to life

MLF - Background

- Large generators increasingly connecting to grid locations **not dimensioned for bulk power supply**
- May result in grid congestion and increased energy losses which **impact project revenue**
- Identifying **causal factors of congestion & losses** supports quantification of curtailment and loss factor risk
- Accurate quantification of these risks increases **investment certainty & supports strategy**

Tomas Keraitis (Aurecon)
CEC – Wind Industry Forum, Melbourne 2019
Using AI to improve forecasting of grid congestion and loss factors
Presentation

aurecon

What makes MLF and curtailment forecasting challenging?

Non-linear correlated complex variables

Study inputs

Generators:
- Buildout scenarios (when and where)
- Retirements
- Generating profiles
- Availability

Market:
- Spot prices
- Bidding behaviour
- Inter-regional (interconnector) power flows
- Constraint equations

Demand:
- New large load connections (e.g. mines)
- Large load retirements
- Demand profile
- EV Uptake

Network:
- Plant ratings
- Augmentation/replacements
- Availability
- Re-configurations

In addition to existing complexity, our energy system is rapidly evolving

Existing approach versus **Machine Learning**

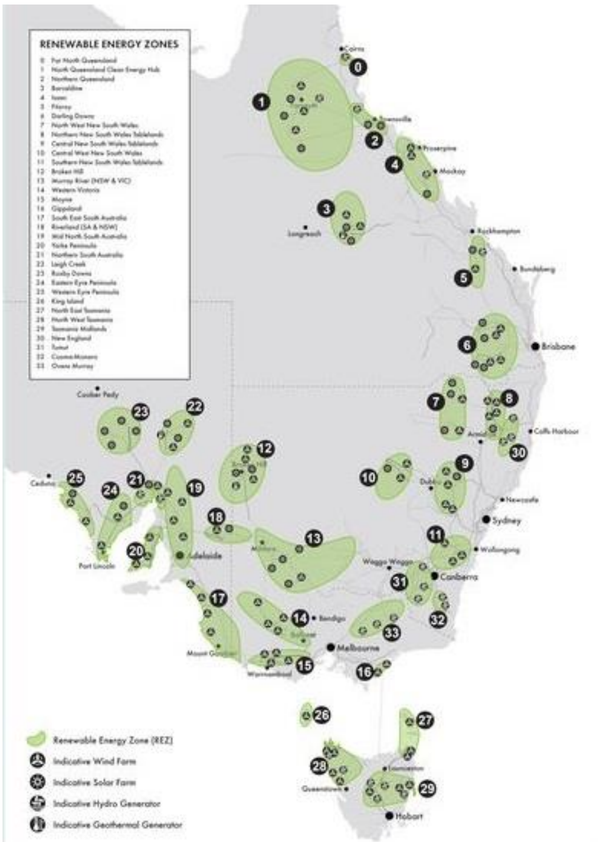
Value Drivers	"Classical" Power System Simulation Based Approach	Machine Learning Approach
Computational Efficiency	Requires high computer processing effort	Less computing power required. Once model is trained, results are rapid
Error Quantification	Calculated manually on the basis of user experience/knowledge	Calculated by the computer on the basis of data and patterns
Flexibility	Restricted to the capability of the software packages being used	Can overlay many dimensions of data potentially supporting deeper insights

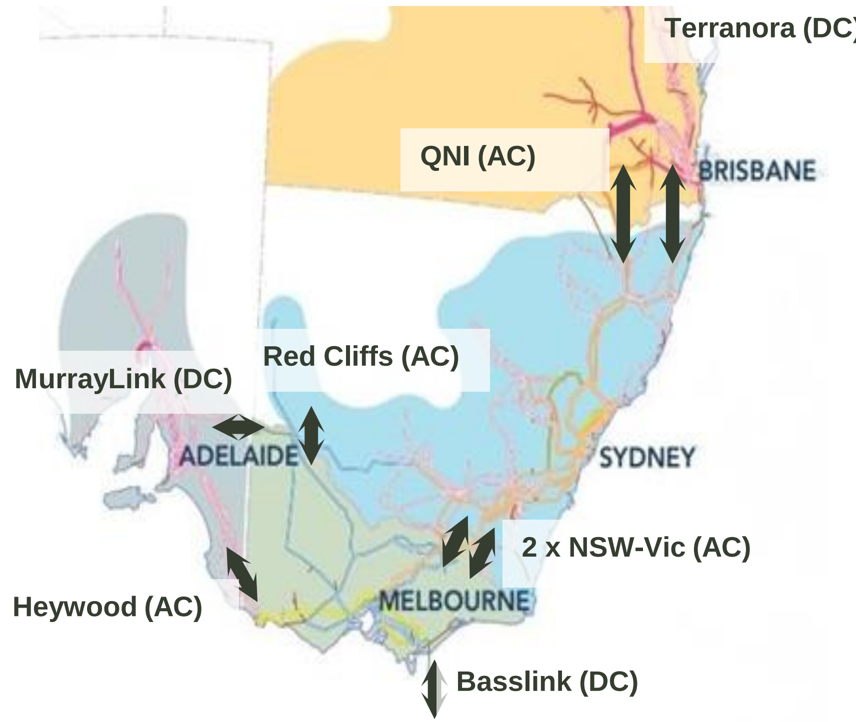
Machine learning techniques require large amounts of input data but provide deeper insights than classical techniques

Significant transmission investment planned

Bringing ideas to life

ISP and REZ's	ISP and NEM interconnectors





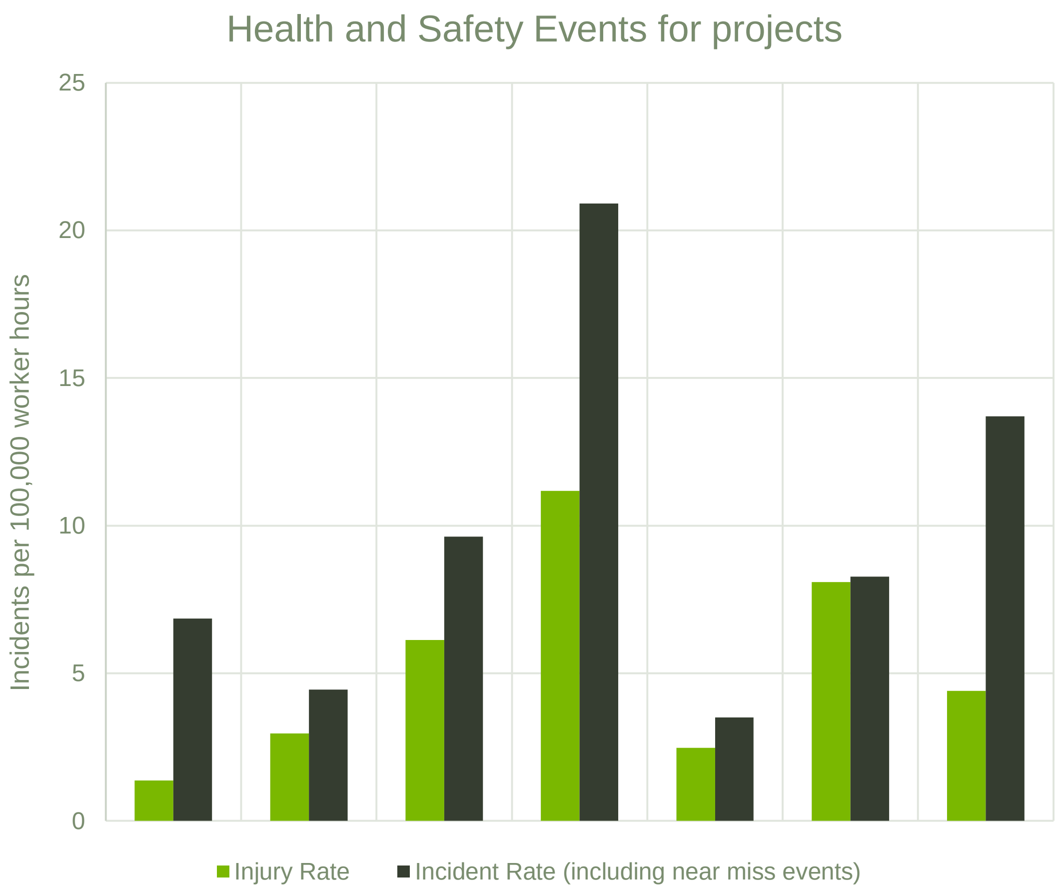
Interconnections are recognised as a key 'enabler' that unlocks value for intermittent renewables by diversifying the generation and load pools

 Source: AER, AEMO Interconnector Capabilities Report. AEMO Integrated System Plan (AEMO) 2018

Construction / Implementation

Site Safety Performance

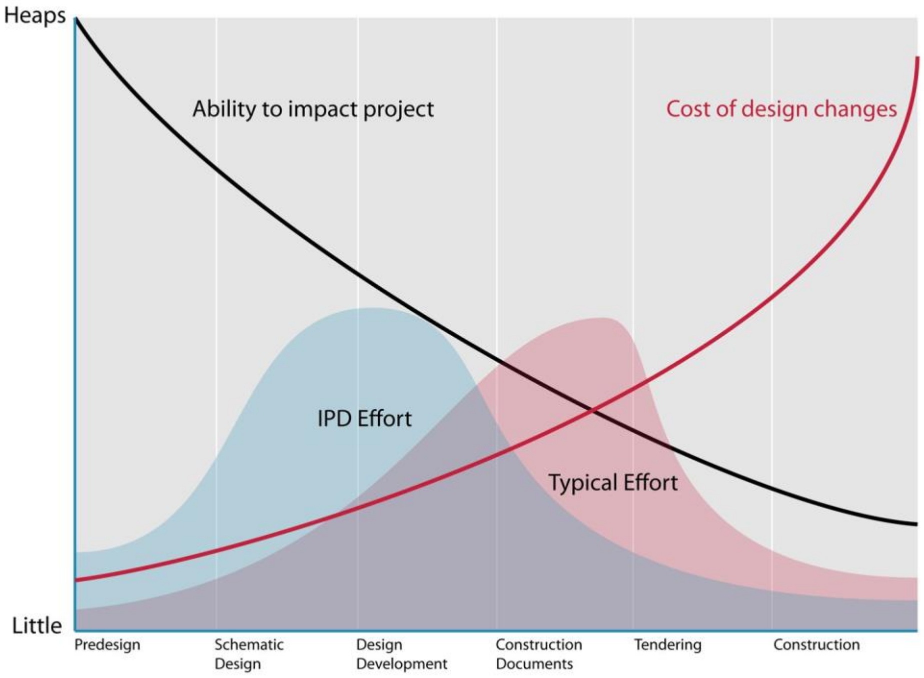
- Widely varying levels of performance
- Owner & Site Team > Contractor
- Early establishment of culture
- Make it personal ……..
- Don’t rely on past performances
- Don’t underestimate the value of detailed EPC negotiations pre-FC



Construction / Implementation

Site factors (delays and over-runs)

- Under investment in pre-FC project planning (MacLeamy Curve) – is there a need to shift to integrated project teams?
- Un-finalised project agreements at FC:
  - Generator Registration (AEMO / Rule changes)
  - Local council approvals (roads, landowners, infrastructure, etc)
- Timely involvement of cranage contractor(s) in design process
- Repeat of lessons learned from ~10 years ago …… don't assume knowledge is retained
- Inter-related learnings from utility scale solar



MacLeamy Curve

Ref: https://www.danieldavis.com/macleamy/

Ashley Grohn
Client Director – Energy APAC
+61 491217021

Bringing ideas to life