Price discovery under 100% renewable electricity supply

A presentation by Baringa Partners

MDAG
27th July 2021

Agenda

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1. Context

- Broad overview of potential Net Zero market issues
- Price setting in zero-marginal-cost (‘ZMC’) systems – concepts and terminology

2. Potential problem statements

- Framework
- Prevalence of zero/low prices periods
- Role of demand response
- Signals for inter-seasonal shifting and long-duration storage
- Signals for dry year capacity
- Signals for new-build renewables
- Locational signals

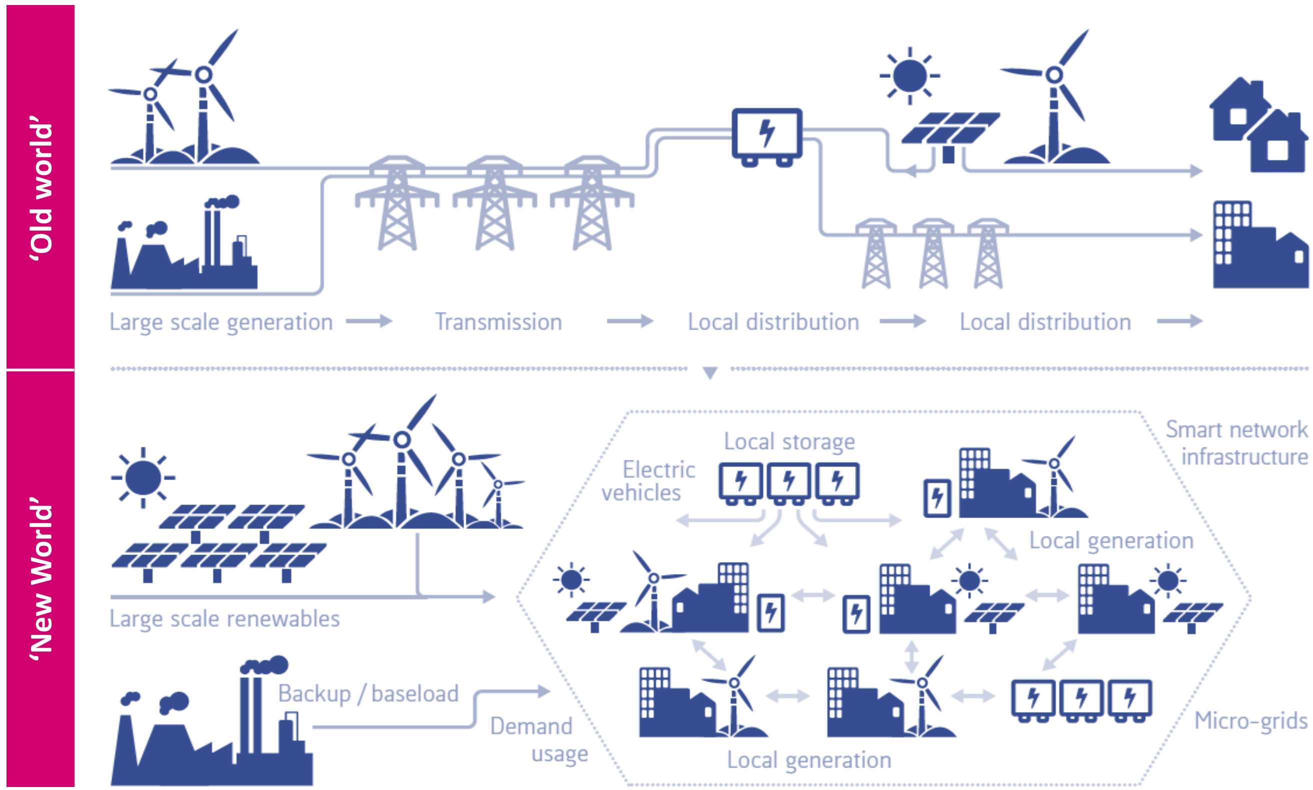
3. High-level approach to options analysis

Context: The electricity system revolution

The transition to net zero will require radical transformation of electricity systems, particularly for more island based systems

In many countries, net zero will involve moving from a highly centralised electricity system based around dispatchable generation and inflexible demand to a decentralised, distributed system with a high penetration of variable renewables and highly responsive demand. The electrification of many other sectors will drive significant growth in demand and have profound impacts on market dynamics.

- Climate Change
- Net Zero
- Mass uptake of intermittent renewables
- Decarbonisation and electrification of transport and heat
- Decentralisation of energy resources
- New technologies and digitisation
- …whilst maintaining customer service and efficient costs



New Zealand's high penetration of hydropower, relatively low inter-seasonal storage capability, and lack of interconnection with other markets (e.g. Tasmania, Nordics) give it some unique features. In this presentation, we will take a look at some of the key problem statements globally, before reflecting back on key possible issues in NZ.

Context: Key challenges and questions

Although we understand what a net zero electricity system could look like, there are a number of questions about the best way of delivering it in practice

Generation & Storage

- Role of regulation vs. carbon pricing vs. subsidies in driving decarbonisation
- Price setting and price cannibalisation in a zero marginal cost (ZMC) dominated system
- Ensuring security of supply in low impact/high probability events
- Diminishing marginal returns for increasing storage capacity
- Route to market for long-term storage

Balancing and system operation

- Ensuring system stability with very high levels of variable renewables
- Managing the interactions between distribution and transmission system operations
- Dealing with large volumes of microgeneration operating outside of the market
- Balance between open data/distributed control systems and critical national infrastructure/cyber threats

Networks

- Co-ordinating cost-effective network build in a highly decentralised market
- Incentivising optimal balance of network reinforcement vs. demand-side measures (e.g. storage, DSR)
- “Last yard” decarbonisation

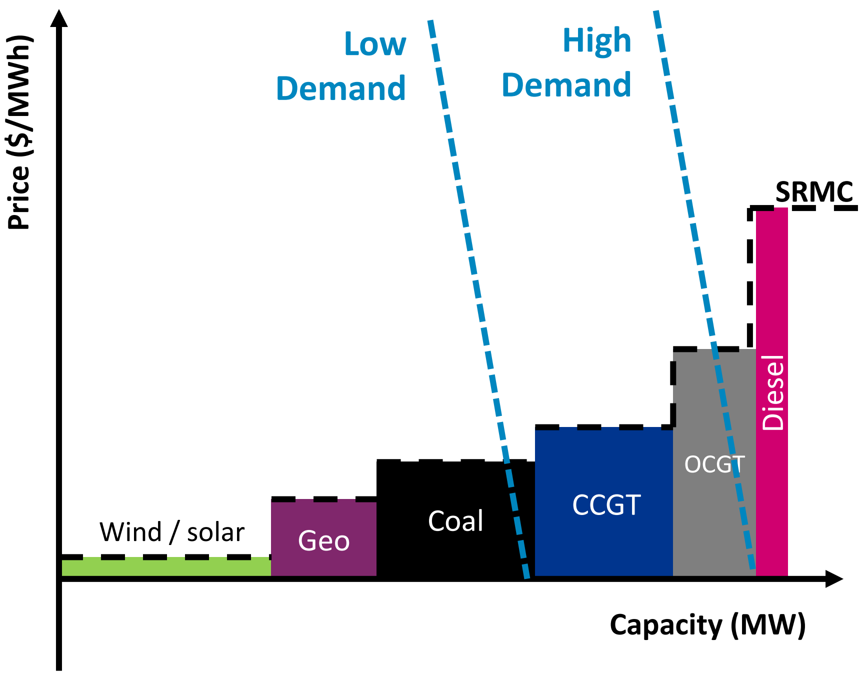
Consumers and prosumers

- Pace of rolling out smart meters and time of use tariffs
- Anticipating changing customer behaviour in response to price signals and new technology
- Protecting vulnerable consumers
- Securing consumer buy-in to the transition
- Efficient collection and security of customer data

Price setting: in gross mandatory pool with thermal

Historically, most spot markets have had significant volumes of thermal plant, setting prices largely based on short-run marginal cost (SRMC). SRMC is relatively easy to project, with scarcity uplifts allowing plants to recover fixed costs.

Relatively smooth supply stack results in price shape over the course of the day



Short-run marginal cost 'SRMC' ($/MWh)

- Cost to the plant of generating an additional MWh
- Below this price, it does not make economic sense to generate, without out-of-market revenue.
- Equally, if supply>demand, plant should theoretically compete down to this level

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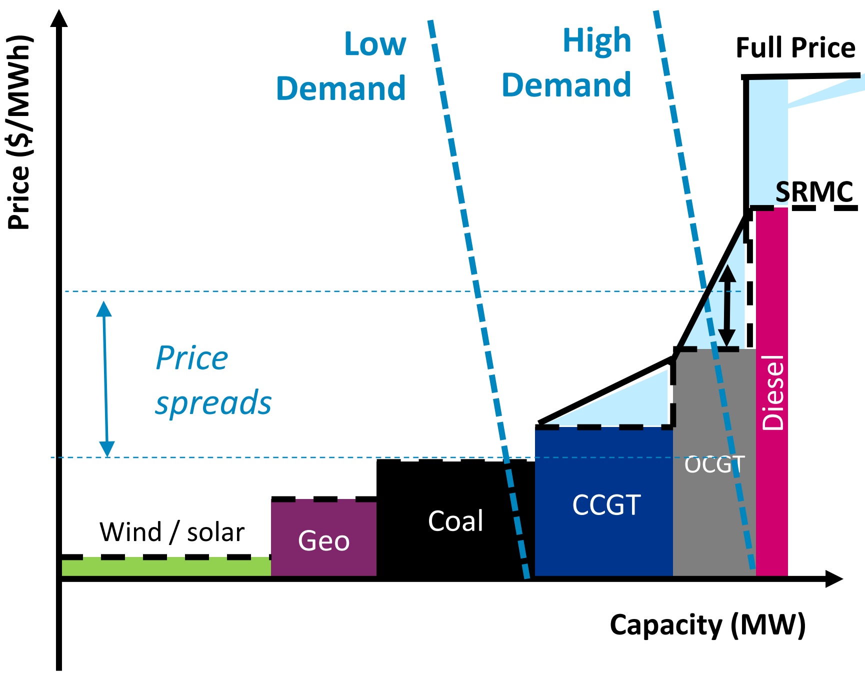


Scarcity ($/MWh)

- Any bid value above SRMC
- Typically bid by plant who expect to be on the margin, up to the level of the next plant or any regulatory cap
- Allows recovery of additional costs (CAPEX, Fixed O&M)

Short-run marginal cost 'SRMC' ($/MWh)

- Cost to the plant of generating an additional MWh
- Below this price, it does not make economic sense to generate, without out-of-market revenue.
- Equally, if supply>demand, plant should theoretically compete down to this level

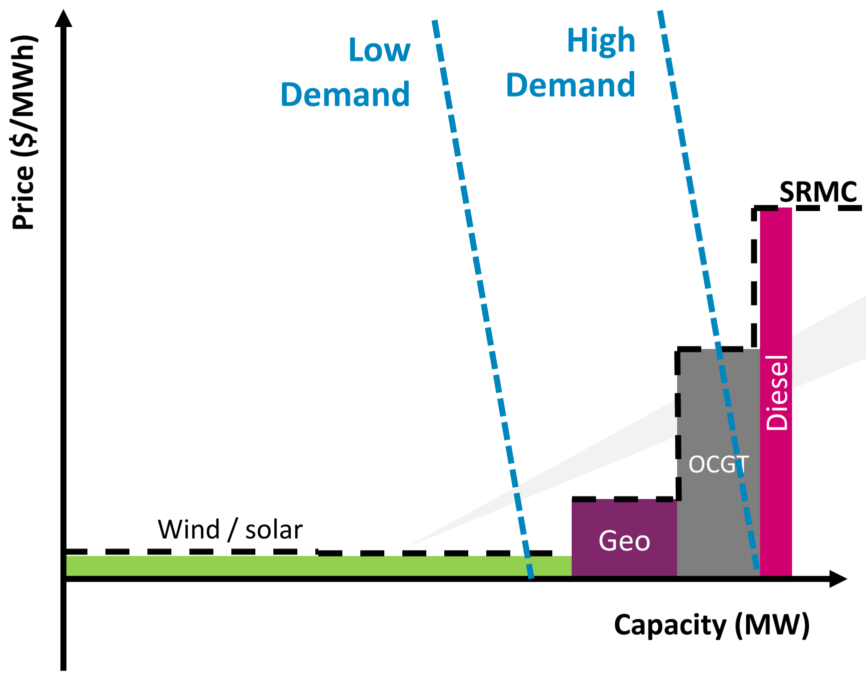
Market features

- SRMC relatively easy to forecast
- Scarcity value significant proportion of revenues for peaking plant, lower for baseload / intermittent renewables

Price setting: in high intermittent RE penetration markets

In markets with significant coincident intermittent renewable generation, we have seen increased volatility in spot prices

Flatter, then steeper supply stack acts to increase volatility in spot prices



Short-run marginal cost 'SRMC' ($/MWh)

- Increased periods with low / zero SRMC
- System SRMC more volatile, driven by intermittent renewables

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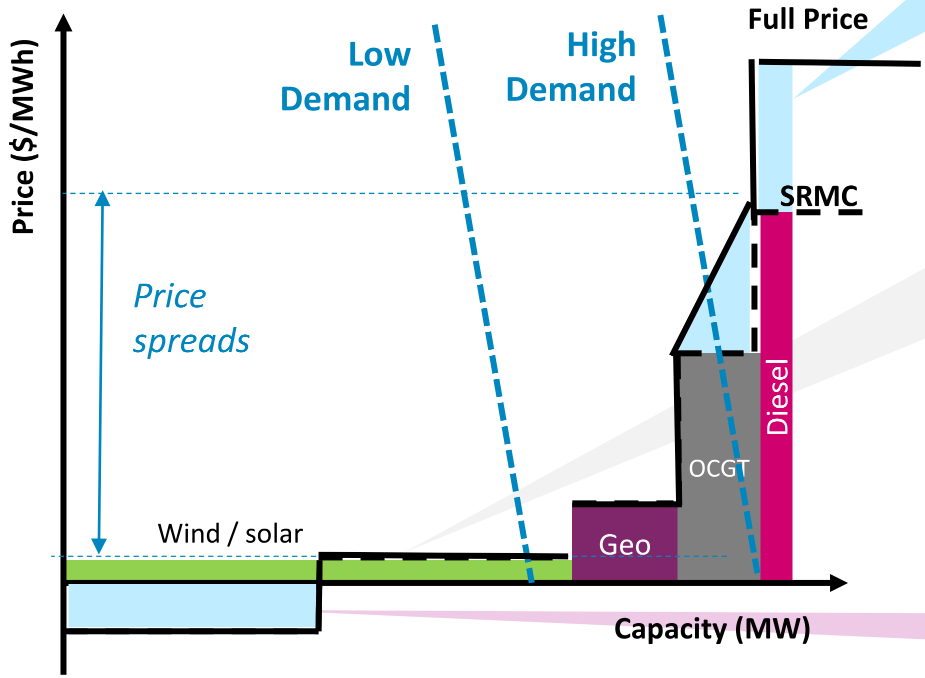

Scarcity ($/MWh)

- Increase in periods in which scarcity sets price

Short-run marginal cost ‘SRMC’ ($/MWh)

- Increased periods with low / zero SRMC
- System SRMC more volatile, driven by intermittent renewables

Market features

- Potential increased prevalence of zero / negative price periods
- Scarcity may make up larger proportion of plant revenue
- Potential increased volatility, increased risk in hedging

‘Negative uplift’ ($/MWh)

- Risk of negative prices if zero-marginal-cost plant bid to negative subsidy level

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Context and international examples → Define NZ Problem Statement → Define Longlist of Options → Options Assesment → Selection of preferred option

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   - Signals for dry year capacity
   - Signals for new-build renewables
   - Locational signals
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Problem statement framework: Price signals in 100% RE spot

Questions on the efficacy of spot markets alone to deliver the right signals to manage deeply decarbonised markets are being asked across the globe

	Short term (HH / within week)	Medium term (e.g. monthly, interseasonal)	'Dry Year'
Operational efficiency	• Potential prevalence of zero/negative prices, and implications • Efficient dispatch / clearing the market with very flat/steep supply curve • Effective participation of demand side	• Does the market produce sufficient signals for inter-seasonal shifting? • Ability for customers to hedge load & electrify (including location)	• Avoiding exercise of market power • How to ensure capacity is available when required? (e.g. pumped hydro does not discharge in other periods)
New Investment	• Impact on WACC for new assets of increased price volatility • Change in correlation between output and scarcity periods changing capture price • Price impact of new-build storage	• Ability of energy market alone to incentivise new long-duration storage (e.g. long pumped-hydro, H2) • Ability of energy market to send effective locational signals	• Ability of energy market alone to incentivise dry year capacity (i.e. over-build renewables, zero-emissions back-up (H2, biogas)) • Cost efficiency of reaching 100% RE (vs. 99%)

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1 Potential for high frequency of zero price periods

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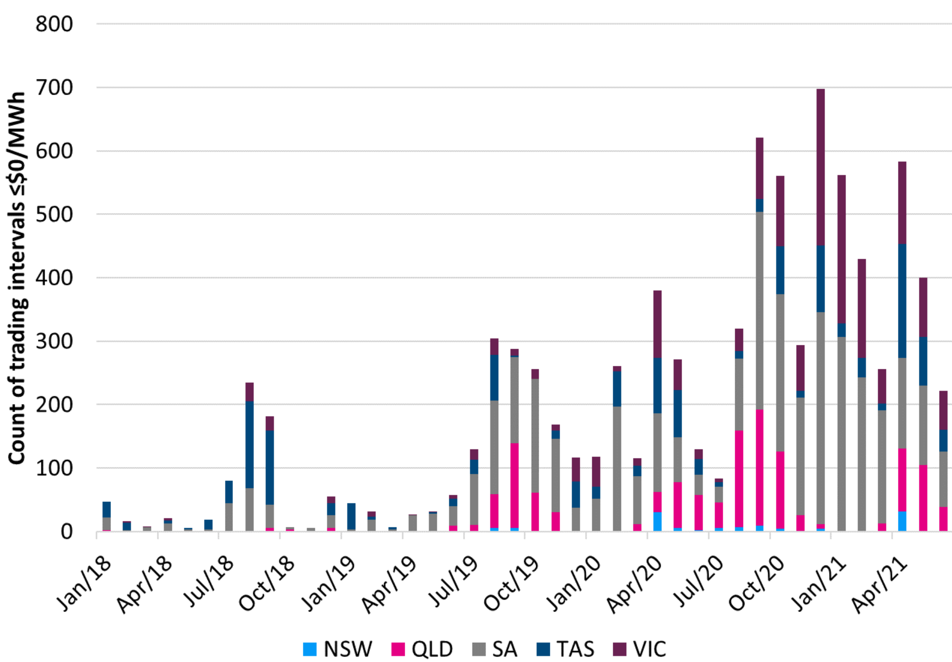
Example: Frequency of negative pricing events in the Australian NEM, and the role of flexible capacity

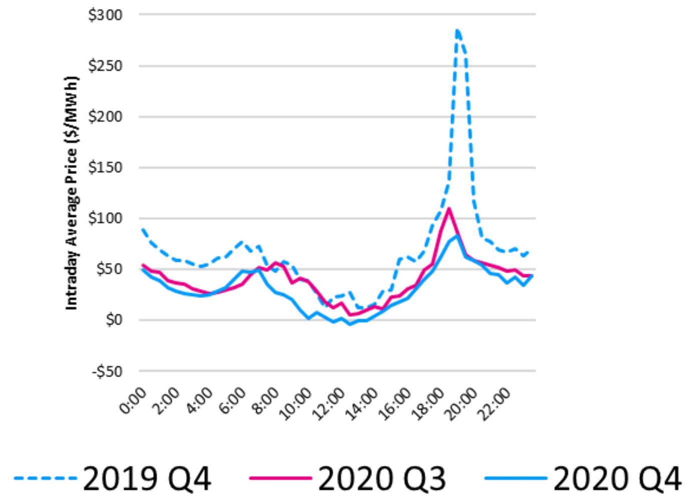
Historical negative pricing in the NEM

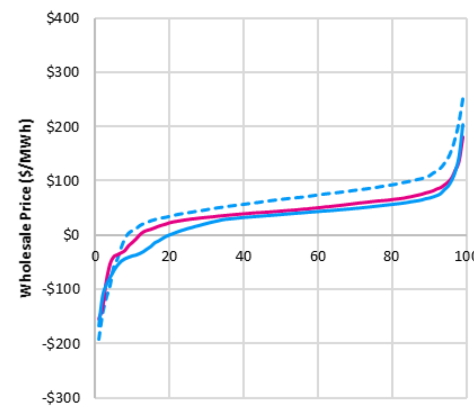


Issues observed

- Investor sentiment
- Inability to hedge risk to revenues (off takers unwilling to pay for zero or negative price periods)
- Unexpected adjustment of plant output at zero (semi-scheduled self-curtailment) increasing balancing complexity

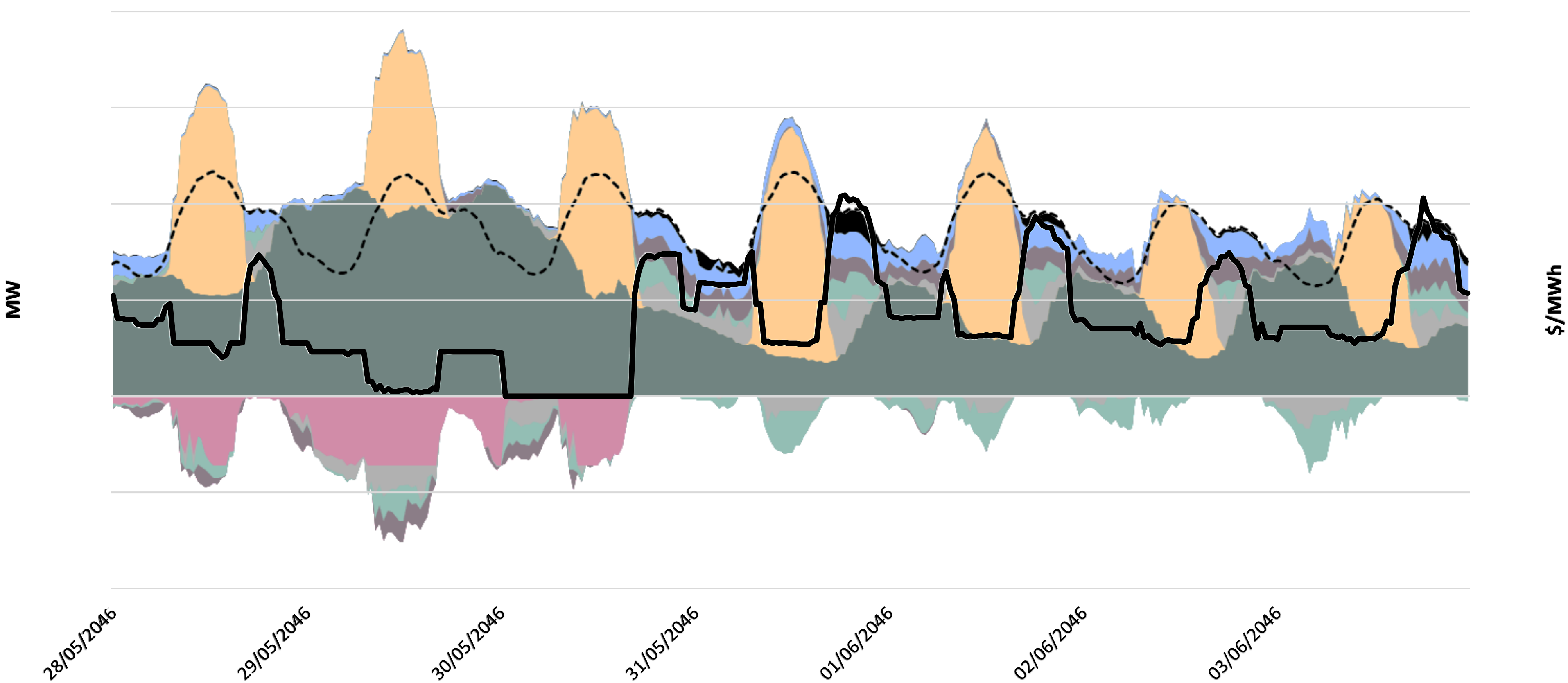
South Australian prices Q4





1 Potential for high frequency of zero price periods

Example: Looking forward to deeply decarbonised markets we see load playing important role in setting prices, reducing frequency of zero price periods



2 Facilitating demand-side participation (short-term)

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Example: Market design and retailer products designed to manage demand response contribution to short-term system balancing

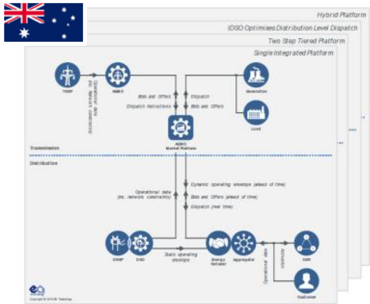
Market design

Markets globally have been considering how to best integrate demand-side response into the market

E.g. ESB Two-sided market

E.g. EU / US example

E.g. AEMO DSO Framework



E.g. UK example

Avoiding "Cliff Edge" / short-term system clearing

Demand-side participation is more likely to be "set-and-forget" or algorithmically traded on customer behalf. Design required to avoid 'cliff edge' impact of automated response.

octopus energy

Octopus Go – EV discount for charging overnight

Octopus Go Faster – Differentiated overnight charge bands to flatten peak demand

Potential problem statements

- How to improve visibility of DER actions to balancing entity?
- What is the most efficient role of aggregators, distribution companies, retailers and system operator in DER dispatch?
- How to baseline and monitor DER response?
- Role for prices vs. direct control? *[and lots more]*

Potential problem statements

- Potential for sudden demand changes at 'trigger point' expected prices increasing complexity of balancing

Signals for long duration storage and demand response

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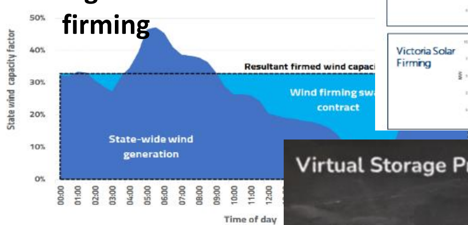
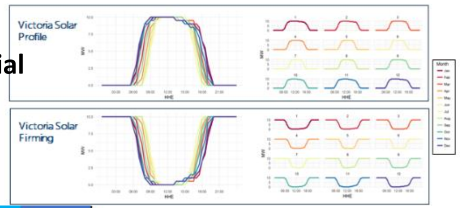
Example 1 : Financial contracts for shorter-term storage are being developed by the market in Australia, however government support is still expected to be required for longer duration storage

Short-term flexibility / firming

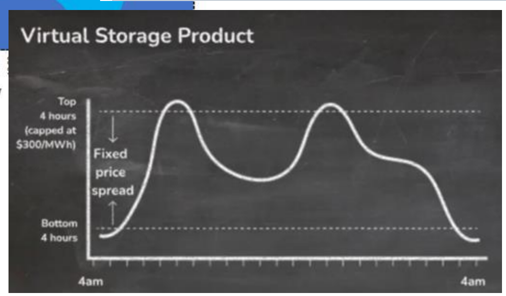
There has been significant development recently of short-term financial products to hedge volume risk

E.g. wind and solar financial firming





E.g. super-peak or "virtual storage" hedges



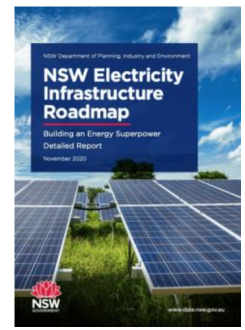
Longer-term storage

The need for long-term storage has been identified, but spot market signals, alone, are not expected to be sufficient for new long-term storage. State and Federal governments have leaned in to provide policy support

E.g. government development funding for new pumped-hydro

snowy 2.0

Hydro Tasmania



Potential problem statements

- How to develop products to de-risk arbitrage revenues for storage assets?
- Policymaker co-ordination of market-led initiatives to redesign contracts – to ensure timely development of new contracts, and liquidity
- How best to manage market power issues (while storage assets relatively few)

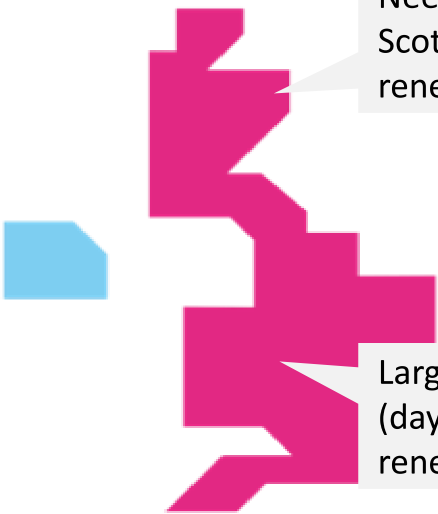
Potential problem statements

- How to de-risk long development leadtimes?
- Design on technology-agnostic subsidy, vs. funding of specific projects

3 Signals for long duration storage and demand response

Example 1 : Government support for inter-seasonal storage in Great Britain

Need for long-duration storage



Potential problem statements

- Unique identified barriers to investment
  - High capital cost and long lead times, (and lack of track record in some cases)
  - A lack of forecastable revenue streams (particularly with respect to location)

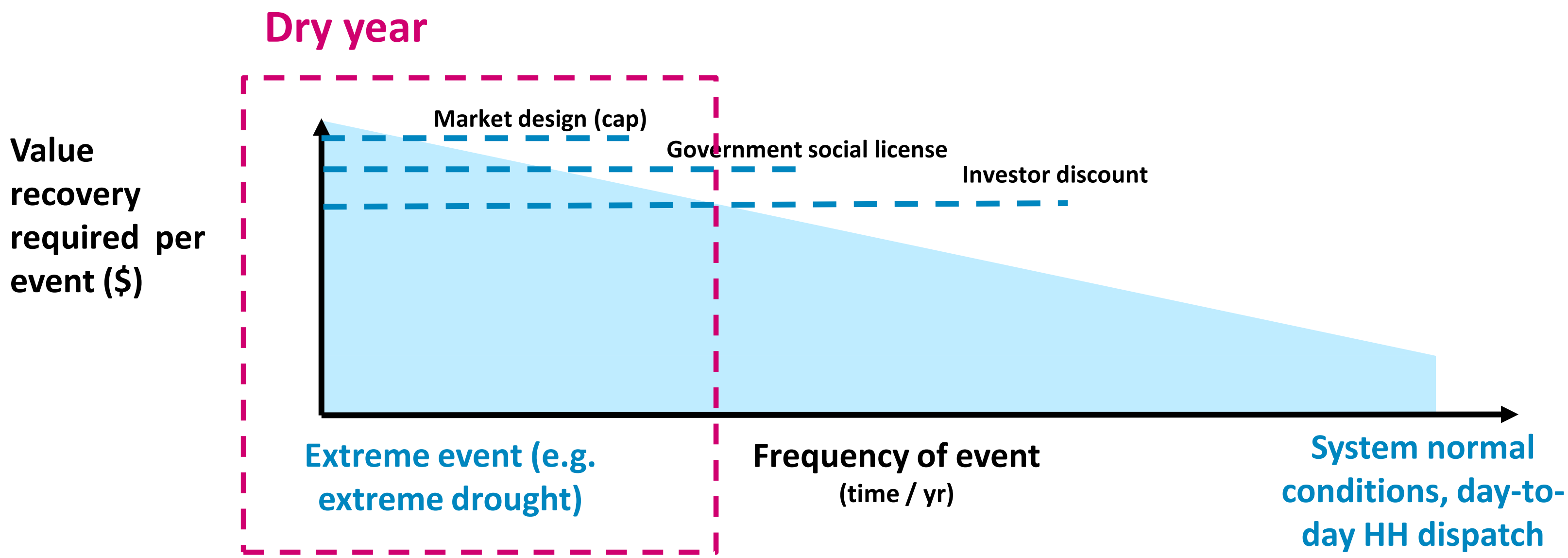
Options under consideration

UK government is considering a number of policy interventions, and drawing on parallels with interconnection

- Regulated Asset Base
- Cap and Floor
- CFD for Storage (similar to that for CCUS)
- Reformed Capacity Market (addressing issues for long lead time capacity)

4 Use of energy market only for dry year capacity

The low frequency of dispatch, and therefore concentration of value into extreme scarcity periods presents difficulties in using the energy only market to incentivize generation needed in a dry year



- Plant which is required to meet demand in extreme events will need to recover a large amount of value from infrequent events
- However, the price signal may be insufficient to trigger new investment due to:
  - **Market design**
  - **Government social license**
  - **Investor discount**

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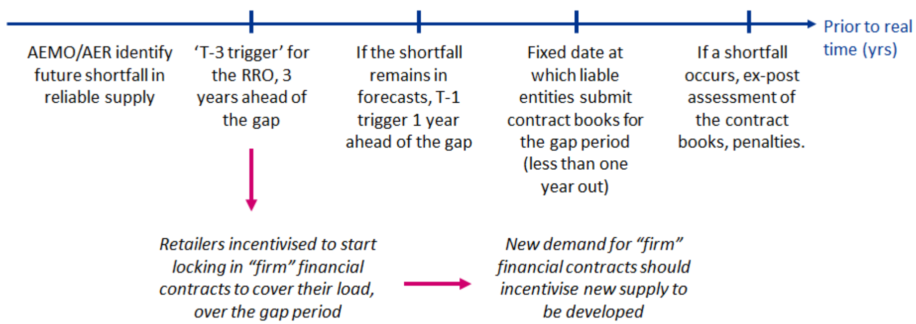
Use of energy market only for dry year capacity

Example: Australian introduction and development of the Retailer Reliability Obligation

Introduction of a Retailer Reliability Obligation



Rationale for introduction

- Concern over lack of investment in firming capacity, due to insufficient 'dispatchability premium'
- RRO provides stronger signals for firming capacity, than status quo, via prescribed contract demand
- Maintains some market participation through retailer procurement

Mechanism

- Forces a higher level of contracted demand than BAU
- Restrict range of valid contracts to those most likely supplied by dispatchable capacity

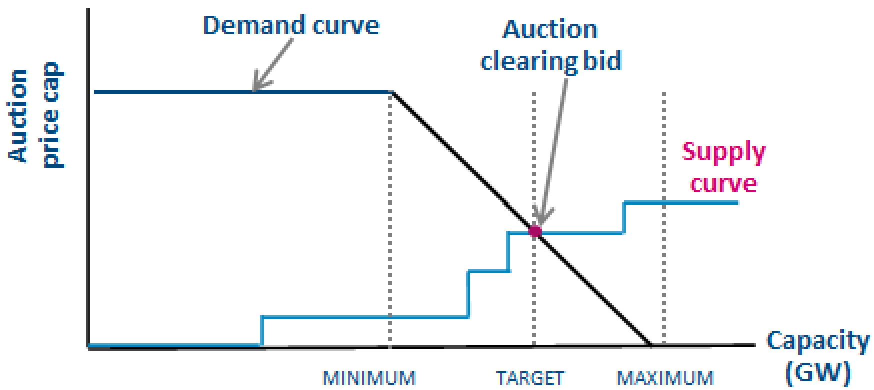
Potential future considerations

- Efficiency of spot market price mechanisms vs. alternatives
- Does mechanism provide sufficient certainty for new investment?
- How to avoid excess capacity from prescribing contracting levels above best-practice?
- Putting role of large scale investment on poorly capitalized businesses

4 Use of energy market only for dry year capacity

Example: UK Capacity Market introduction, as part of the Energy Market Reforms

Introduction of a Capacity Market



- The ESO determines the required capacity, with a demand curve set around this target level
- Auctions are held at four and one year ahead of the delivery year
- Auction design: Descending clock, and "pay as clear" (not "pay as bid")
- Price makers: new plants, DSR capacity, existing plants (by choice)
- Price takers: existing plants (by default) cannot bid higher than 25 £/kW
- New plants are eligible for a 15-year contract at a fixed price; existing plants will be subject to rolling one-year contracts if they are successful in the auction

Rationale for introduction

- Reducing load factors for thermal generation (CCGT)
- Potential that scarcity in energy only market would be insufficient for new investment
- Or, investors may place limited values on these uncertain revenues or required a higher return
- Strategic Reserve options also considered as alternative

Observations

- Low clearing price
- Technology neutrality supported gas and diesel engines; emissions rules progressively tightened
- Almost all plant in UK now receive non-energy revenues

Potential future considerations

- How to get the right locational issues
- "Last yard" expense
- Focus on low-CAPEX, high-OPEX options
- De-rating factors

5

Impact on investment in renewables and cost of capital

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Potential change to drivers of price shape and revenues for renewables require changes to risk management options. A question is whether government intervention is needed to promote this

Government

Examples:

- De-risking market price downside for long term renewables
- Coordination of transmission and generation / de-risking locational downside

Financial Institutions

Examples:

- Weather insurance products
- Flexible debt (e.g. repayment profile flexibility with income)

Retailers / Traders

Examples:

- Weather-triggered options / swaps
- Storage hedges
- Firming contracts
- Supply agreements accounting for demand flex

Potential problem statements

- How to stimulate a market / create liquidity? Particularly if few asset owners at beginning
- What risks should government hold / role should government play vs. market development? (e.g. what are the risks which are difficult for private players to value)
- Role of government in commercial demonstrations / Pilot

6 Ability of market to send effective locational signals

In a 100% renewable system, locational signals will be critical to maintaining whole system efficiency, regardless of market design

	Nodal	Zonal	Single price
Description	• Full locational (congestion) signal in spot prices • Transmission investment signals need to recognise beneficiaries from investment	• Pricing at zonal level in spot price, with zones based on key transmission constraints	• No spot price locational signal • Transmission constraints managed by System Operator – consumers bear the cost • Locational signals mainly via long run transmission pricing only
Challenges in a 100% renewable	• Investment is dependent on highly uncertain locational price differentials	• A static zonal definition may not be suitable	• Hard to balance cost-reflectivity and stability • Higher potential for over-investment in transmission

Potential problem statements

- In a 100% renewable system, locational price divergences may become more extreme (zero <-> scarcity) with greater potential for local market power
- Will sufficient products (FTRs) be available, and efficiently priced, in order to allow parties to hedge locational price risk?
- How are choices made between generation/storage investment, demand-side solutions, and network investment? Are price signals sufficient or is coordination required?
- In the pathway towards 100% renewables, is the increasing carbon signal in power prices equally valued in generation and network investment?

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Overview of approach

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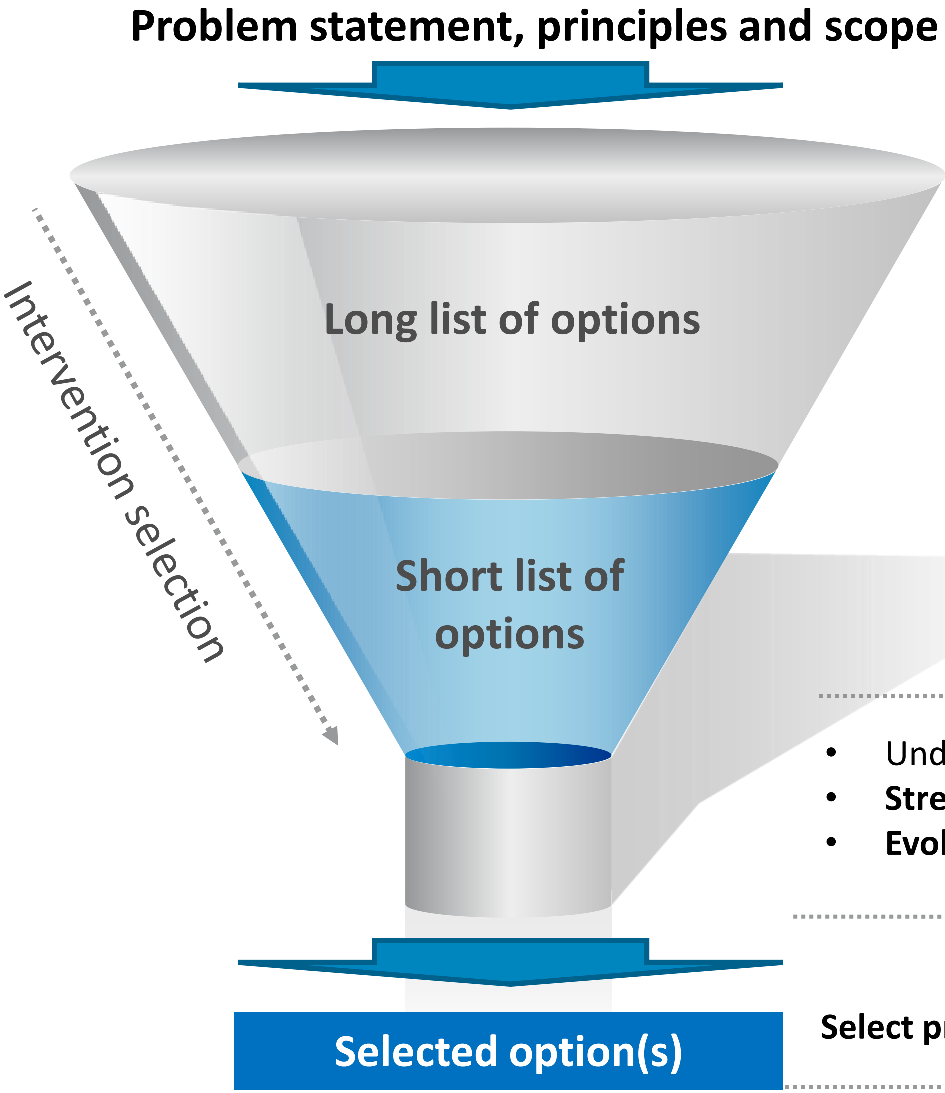

- Define the **problem statement**
- Define the **key principles**, and **assessment criteria**
- Define **quantitative assessment approach** starting with **conceptual CBA** and clear **counterfactual**
- Define **scope of potential options**

- Develop **long list** of potential options/ interventions
- Map **interpendencies** between policy options (and other potential reforms), and identify potential **unintended consequences**
- Undertake initial **qualitative screening** using assessment criteria
- Determine **shortlist**

- Undertake **quantative assessment**
- **Stress test**
- **Evolve** options

Select preferred option(s) on the basis of the evaluation

Examples of typical assessment criteria

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Cost efficiency	Fair allocation of costs	Appropriate allocation of risk	Financeable
Promotes competition	Maximises customer choice	Promotes transparency	Equitability
Clear accountabilities	Promotes whole systems approach	Minimises risk of distortions	Maintains investor confidence
Implementable	Avoids unnecessary complexity	Proven	Minimises risk of unintended consequences

Brighter together