Does the electricity market fail as renewables approach 100%?

Abstract

The percentage of renewables in the national generation mix has recently exceeded 80% on an annual basis and appears to be on a rapid rise toward the government's target of 90% by 2025. New Zealand's deregulated energy-only electricity market was developed during an era when the fossil-fuelled thermal sector was more prominent than it is today. Retention of the energy-only market model for the long term, as the renewables penetration approaches 100%, assumes that it can meet demand in an economically efficient manner. But there are early warning signs that this assumption may not be well founded. This presentation briefly outlines the issues and challenges, and gives some early results from modelling of the energy-only market as renewables approach 100%.

Greg Sise, Energy Link Ltd

A Growing Area of Research Interest

- **Operating with very high % of renewables presents technical challenges**
  - managing frequency
  - providing instantaneous reserve capacity
  - covering dry periods that can be many months long
- **There are also market challenges**
  - electricity markets evolved when fossil-fuelled generation that backs up renewables also ran baseload
  - longer periods of prices well below the cost of owning and operating generation
- **For example, Riesz et. al. (2016) suggest the Aussie NEM would need:**
  - the price cap to increase from $13.50/kWh to $60 - $80/kWh; or
  - customers would select reliability based on what they are prepared to pay (and could set the price very high)

What is Market Failure?

- A price mechanism fails to account for all of the costs and benefits involved when providing or consuming a specific good

- Hence the allocation of goods and services is not efficient
  - efficiency as defined in economics

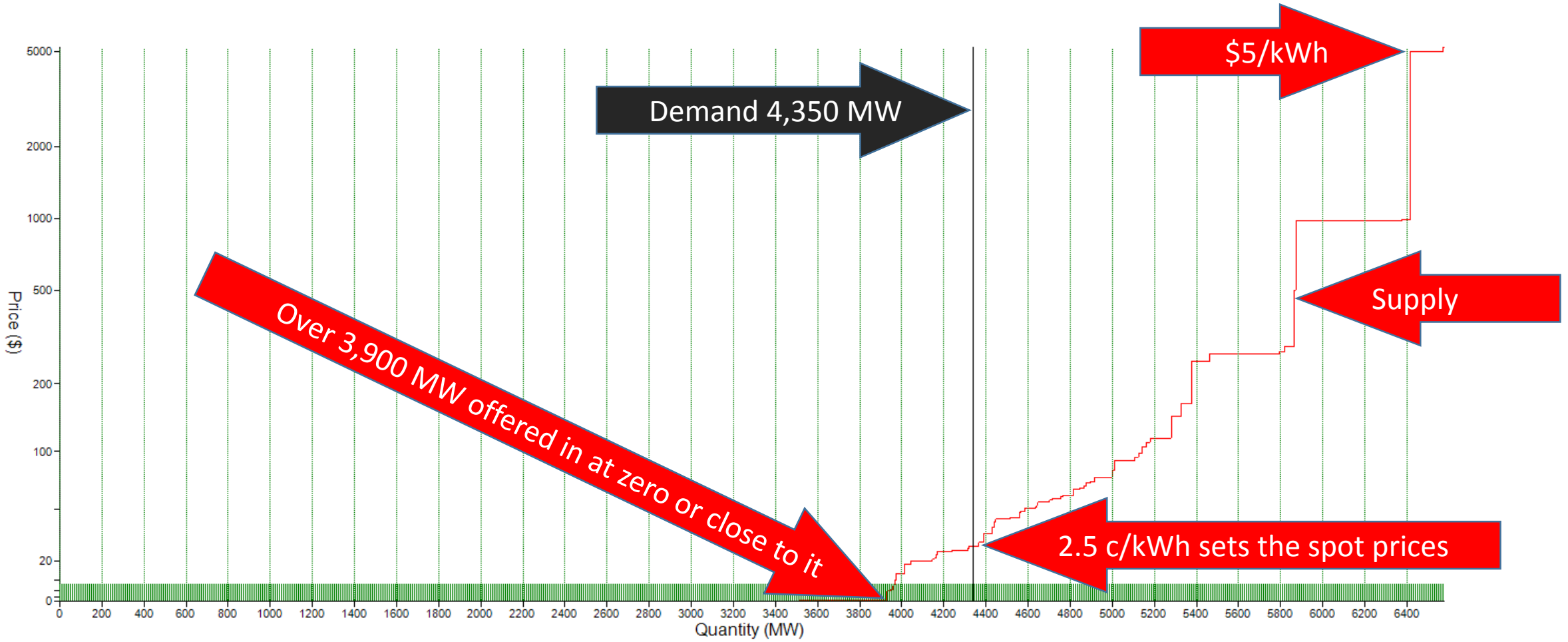
- In other words, there is another outcome where an individual may be better-off without making someone else worse-off (in economic terms)

- Example: cost of climate change not factored into spot prices => ETS

Our Market is Energy-only

- Generators offer quantity and price into the spot market
- The highest offer accepted is “marginal” and sets the price
  - generators with higher offer prices don’t run
- Generators are paid only for MWh (energy) produced
- Generators are not paid for being available (MW capacity)
  - except to a very limited extent for instantaneous reserves

Supply and Demand (Recent Peak Half Hour)

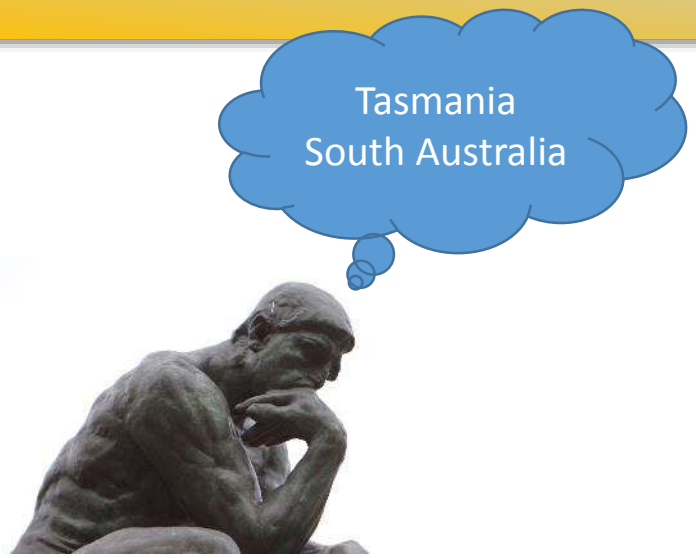


Early Warning Signs

- Meridian Energy pays Genesis Energy to keep the gas-coal unit available at Huntly to cover dry periods

- Electricity Authority introduced “scarcity pricing” in 2012
  - spot price could be set lower (not higher) in the event of shortage
  - so scarcity pricing sets spot prices between $10 and $20/kWh

A Question of Flexible Storage



Hydro lakes

Assume:

- demand response is not viable for dry period cover
- batteries not viable for dry period cover

Security of Supply

Gas fields

Coal stockpile

Towards 100% Renewables Using *EMarket*

Water Values

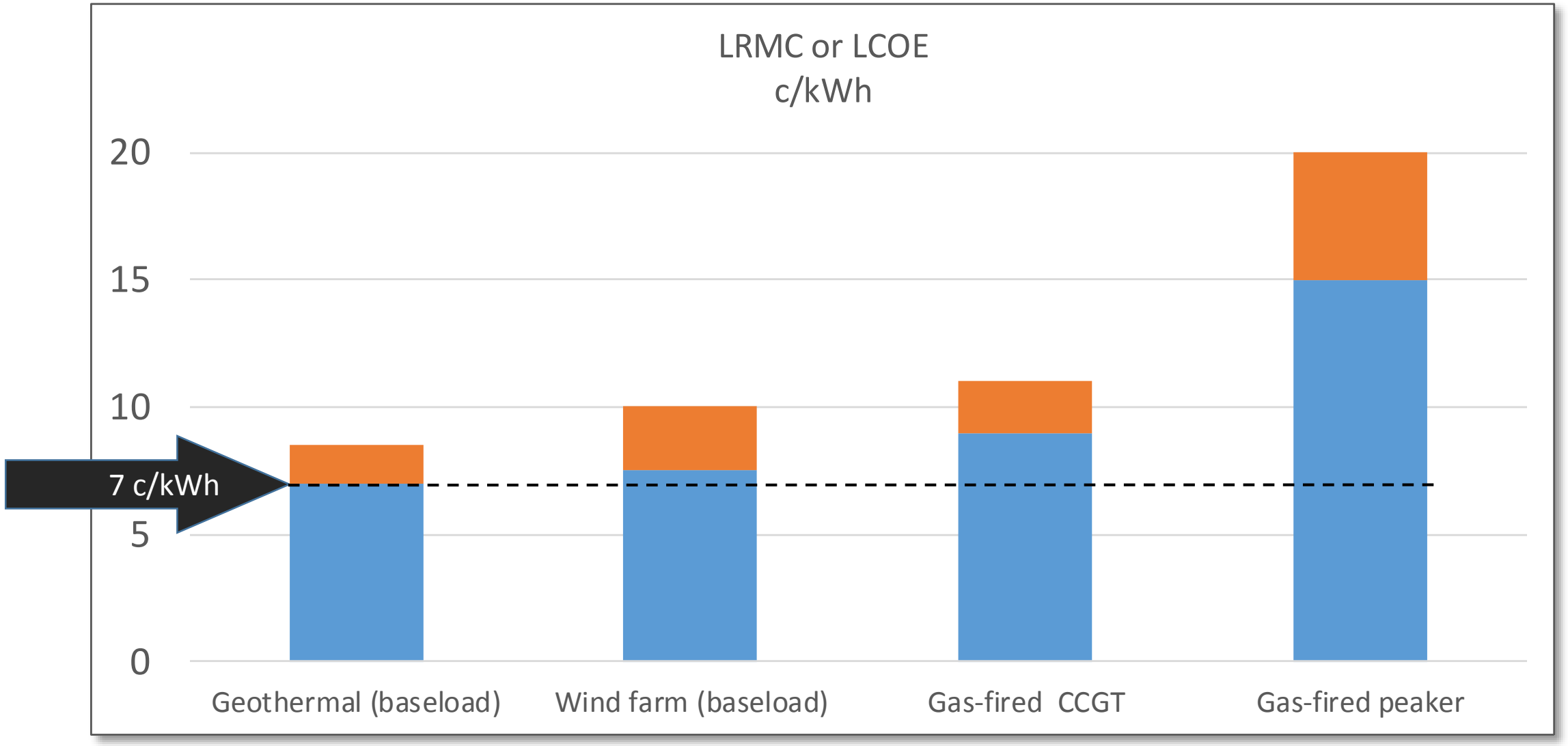
Grid

Spot Prices

Hydro Storage

- Developed with the original Mercury Energy (now Vector) 1997/98
- All major hydro systems, 200+ nodes and lines in the grid
- Large hydro systems adjust water values to ration water optimally
- Thermal, geothermal, wind and small generators
- 85 years of inflows are modelled, then averaged
- 3 hour resolution (can go to half hourly)

Total Cost of Best New Plant



Preliminary Results

Scenario	Renewables	Demand (GWh)	Demand response (GWh)	Losses	Spill	Average Capacity Margin	Minimum Capacity Margin	Average Price (c/kWh)	Large Thermals (GWh)
Base Case (Existing Plant)	82%	40,288	-178	2.9%	2.1%	893	209	6.9	6,858

2016/17

Voluntary curtailment of demand in dry years

In wet years

Capacity margin is the MW **not** running

Over all 85 inflow years

Note: 209 MW of spare capacity is very tight when the largest plant running is over 380 MW

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Remove Huntly	85%	40,269	-198	3.0%	2.7%	559	96	8.2	5,614

+198 MW geothermal

Spill increases

-500 MW at Huntly

More expensive thermal runs esp. in dry years

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Remove Huntly, e3p	93%	40,306	-161	3.5%	2.9%	549	81	7.4	2,504

+302 MW geothermal

-385 MW at e3p

More geothermal starts to depress prices

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Remove Huntly, e3p, TCC	98%	40,467	0	3.8%	4.3%	431	101	4.6	531

+206 MW geothermal

Almost no demand response due to lower prices & lakes run higher

Spill double the Base Case

-365 MW

Price now dominated by renewables

Significantly less than the cost of a power station
But the capacity margin is already too slim

Preliminary Conclusions

- As the percentage of renewables approaches 100%, spot prices will fall
- Building less plant would lead to lower capacity margin, lower prices still
- This could be a market failure
  - total cost of non-supply may not be factored into spot prices
  - generators may not be able to stay in business
- Corollary: if it is a market failure, then a capacity market may be required

Capacity Market

- Generators receive payments for MW capacity that is always available
- Payments may differentiate between types of plant, e.g.
  - fast-start gas-fired peaking stations; or
  - slow-start plant that can run at low cost during prolonged dry periods
- Capacity markets are already in operation in some countries
  - they have their own issues
  - but we might have to consider such a market one day…

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