ENERGY ONLY MARKETS. DO THEY WORK AND ARE THEY EFFICIENT WITH LARGE AMOUNTS OF WIND?

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“Economic Paradox”

- Low-carbon power system
- High cap cost low and very low variable costs eg. Wind, geothermal, solar………
- Expect low prices (often zero) and price spikes when investment covers fixed costs.

Cost of capital

- Low carbon power- Cost almost completely determined by up front cost.
- Very sensitive to discount rate
- May need more price spikes and even outages (VOLL).
- Market finance depends on interest rate and risk….rare price spikes =risk
- Politically feasible?

- Low Carbon power may put a lot of pressure on Energy Only market design

Major new investment in wind farms expected

- Wind energy resource very promising as average wind speed high with long coastline.
- But New Zealand is isolated so can’t rely on backup from offshore (cf Denmark)

Increase in wind poses significant challenges to grid

- By 2025 wind in NZ may generate between 5%-80% of power depending on wind speed and time of day.
- Market power issues?
- More volatile prices?
- More wind means lower prices when wind blowing reducing viability of extra wind generation.
- Also lots of other capacity is “must run” – geothermal, RR hydro bids in at zero

- How does this affect Energy Only Market?
- How does this affect dispatch?

Literature

- Many papers on impact of wind with competitive markets. Eg UK study 20% wind means more reserve requirements adds £5-8/MWh of wind. ge
- Less studies with market power
- Green and Vasilakos (2008) look at the UK market using SFE. Find that market power increases price volatility.
- Twomey and Neuhoff (2010) Cournot find thermals gain from more wind.
- Sensfuß *et al* (2008) agent based model finds in short run merit order effect pushes down prices in Germany.
- Some empirical evidence from South Australia that some periods with little wind see extreme market power. (We call this market power effect) (Mountain, 2013)

Long Run

- Short run evidence that more wind lowers average prices….Merit Order effect.
- Also looks like some periods at least see lots of market power.
- <u>Long run</u>
- Mix of generation changes. Eg. more peakers.
- But baseload plants should just cover costs. Suggests average prices won’t change
- Green and Vasilakos (2008) find no change in average prices with optimal technology mix.

Methodology

- Model long run technology mix using GEM. Lowest cost.
- Model NZ market prices using Agent Based Computer Model (simulates market power)
- Look at different scenarios with increased wind penetration.

Agent-Based Modelling

- Agent-based models are simulation models
  - Allows for very realistic network representations
- Each player in the model is represented by an *agent*
  - Usually some type of learning algorithm

- Agents try different actions. Actions which yield "high profit" are more likely next round

Agent Based Model

- If profit from an action is “good” then action more likely next round.
- Action here is to specify price for the generation capacity of plant to be offered into the wholesale market.
- Typically 1500 rounds for agents to learn.
- Computers not very smart!

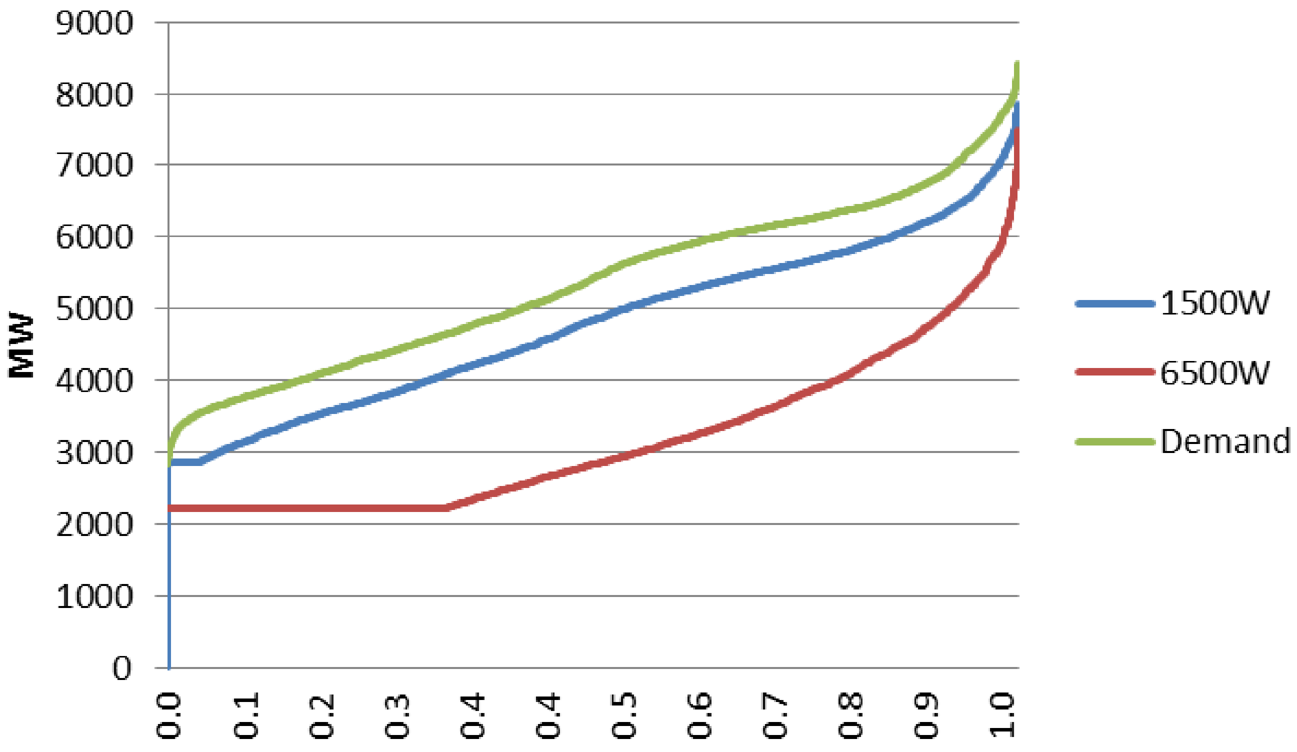
E-R model of NZ market

- Firms have portfolio of generators. Usually choose different price to offer capacity of each generators to the wholesale market. So firm step function supply curve.
- Simplified 19 node network. Market solver similar to one used by ISO.
- Reserves market accounted for.
- Line losses and line capacity.
- Must runs bid in at cost such as some hydro, wind and geothermal.

Scenarios for 2025……

- Use the Electricity Generation Expansion Model which builds least cost generation subject to constraints
- Will use a low gas price scenario
- And force 1500MW----65000MW of wind
- DSR bids in at $1000/MWh
- Limit bids to start with to $3000/MWh and below. EA declared UDTS earlier this year reset prices from $20,000 to $3000

Residual Demand suggests 1. less base-load&mid 2. more peakers



Develop three scenarios

1. let GEM build what it wants apart from imposing wind builds. {SEES VERY HIGH PRICES AND PROFITS WHICH FALL AS WIND INCREASES}

- Conclusion: Not feasible as profits too high (>> 10%ROR) which would encourage entry.
- Competitive market wouldn’t cover costs. Highlights the role that “market power” plays in making Energy Only Markets “work”.

SCENARIO 2

- New constraint (Effective Capacity)/(Peak Demand) same as existing market.
- Sees similar prices to existing market but wind and peakers don’t cover costs.
- Conclusion not feasible

SCENARIO 3 – Most realistic

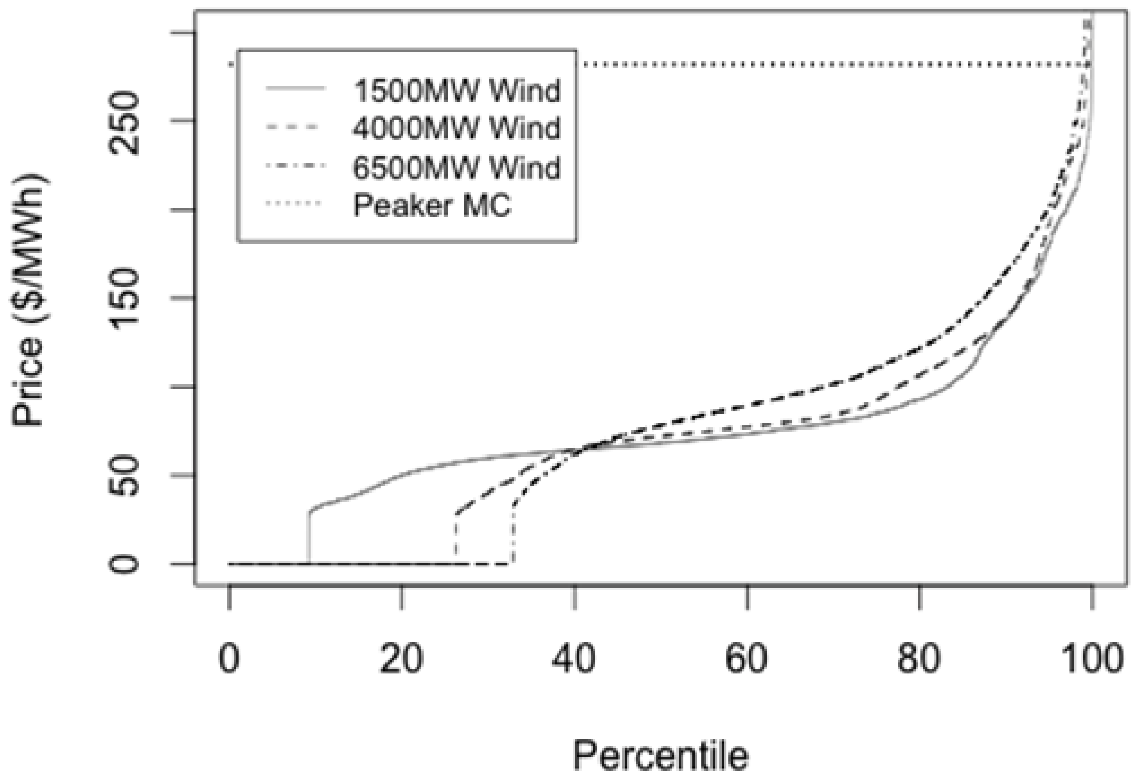
- Strategic Investment Scenario.
- Trial and error. Look for an {effective capacity}/{peak demand} constraint which allows wind to break and peakers to break even.
- Conclusion. Yes market works but market power plays a crucial role

- Peaker profits increase from 7% (low wind) to 40% (high wind)
- But wind profits decrease (form 15% to 9%)
- So market works.
- Again see role of market power.
- Average prices with strategic behaviour increase as wind increases! (Even though competitive prices decreases!)
- And even though number of zero price periods increases from 4% to 33%!
- Market Power (when wind is low) trumps merit order effect (more periods with zero price)! (cf empirical results from SA)

Prices

Wind Capacity Scenario	Current (600MW)	Low (1500MW)	Medium (400MW)	High (6500MW)
Average of Price	62	127	128	141
Average Marginal Cost	30	25	23	25
Std Dev of Price	61	149	237	353
Std Dev of Marginal Cost	28	37	65	84
% Periods Price greater than peaker cost	0.50%	0.04	0.04	0.05
% Periods zero price	2%	0.06	0.26	0.33
Infeasible Hours per year	0	0	2	18

Price duration curve swivels up



Price zero 33% but market power when wind not blowing more than makes up for this and average prices increase. Cf South Australia

Profits

	Low (1500MW)	Medium (400MW)	High (6500MW)
Hydro	25%	26%	28%
Geothermal	19%	19%	26%
CCGT	28%	41%	50%
Peakers	7%	17%	40%
Wind	15%	12%	9%

10% is about break even. So delicate balancing act wind viable but dips below for 6500MW
Peakers dip below for 1500MW but 6500MW good return.
NOTE. Peakers have 14% cf whilst comp its 3% (for 6500MW).
Very unlikely that peakers could break even at 3%.

Efficiency. I dispatch

Capacity Factors	Hydro		Gas CCGT		Peakers		Wind
	Comp	Stratgic	Comp	Stratgic	Comp	Stratgic	Comp /Strategic
Wind 1500MW	79%	69%	23%	48%	1%	11%	39%
Wind 4000MW	66%	58%	19%	46%	3%	13%	35%
Wind 6500MW	62%	55%	13%	42%	3%	14%	34%

Firms behaving strategically means
different dispatch for thermals than competitive market.
Looks like holding back hydro to force thermal dispatch at high price

Efficiency

Cost of Dispatch	Competitive	Strategic	Cost Distortion
Wind 1500MW	52.2	86.6	66%
Wind 4000MW	46.5	79.1	70%
Wind 6500MW	43.6	76.3	75%

So inefficiency of dispatch increases as wind penetration increases!

Thermals particularly peakers dispatched too much!

Implications for CO2 emissions as well as efficiency

Notes on Inefficiency of dispatch

- Too High?
- Driven by large amount of expensive peakers that GEM builds and SWEM dispatchs when wind not blowing. (don’t have much peakers in existing market so likely get hydro dispatch)
- Market power –prices twice as high as existing market.
- Water values are zero.
- Would expect much lower efficiency losses for current market simulations.

Tentative Conclusions

- Even though prices zero much the time intermittency leads to huge amount of market power.
- Low-carbon power system with socially optimum (SO not economics) plus implicit price cap can only work if there is market power.
- Investment Equilibrium also sustained by market power.

Discussion

- However, high electricity prices (due to market power) and high volatility are a sensitive combination for regulators in many countries.
- It is easy to see price caps or other regulatory mechanisms deployed to prevent these high peak prices in practice.
- Any scheme to reduce those prices may cause a lack of sufficient new capacity into the market – causing outages.

Conclusions

- Policymakers face an increasingly difficult choice if they wish to retain energy only electricity markets.
- On one hand, they could keep the status quo, and **accept large amounts of market power** and high price volatility.
- Or they could use price caps or other regulatory mechanisms to rein in prices, but accept occasional blackouts.
- Both options are politically unpalatable.

Conclusions

- The alternative is to price capacity in a separate market, an option which has gained some popularity in recent years, particularly in the United States, despite earlier fiascos such as Britain’s experiment with capacity payments

Market efficiency

- Looks like large amounts of intermittent wind increases the inefficiency of dispatch.

- Too much thermal is dispatched as wind penetration increases which may undermine attempts to mitigate CO2 emmissions.

- THE END