Merchant renewables & the valuation of peaking plant in energy-only markets

Prof. Paul Simshauser AM

Griffith University
Queensland, Australia

Overview of Australia's National Electricity Market

- Formed in 1998, covers eastern seaboard of Australia (QLD, NSW, VIC, SA, TAS, ACT)
- Max Demand 35,000 MW (Sum of Regions = 39,000 MW)
- Energy Demand 204,000 GWh (incl. 9,170 GWh rooftop PV)
- Gross pool, energy-only, zonal market design with OTC derivative & futures markets ~350% physical
- Average Spot Price, ~$70/MWh. Market Price Cap $14,700. Turnover $15 - $20 billion per annum
- 9 million residential connections + 1 million business connections
    - ~2 million NEM households have a rooftop solar PV system (10,000+ MW)
- Installed (utility-scale) Capacity 47,500 MW
    - Energy Market Shares: Coal 71%, Gas 8%, Renewables 21% (~14% VRE)
    - South Australian region: 51% renewables (wind & solar)

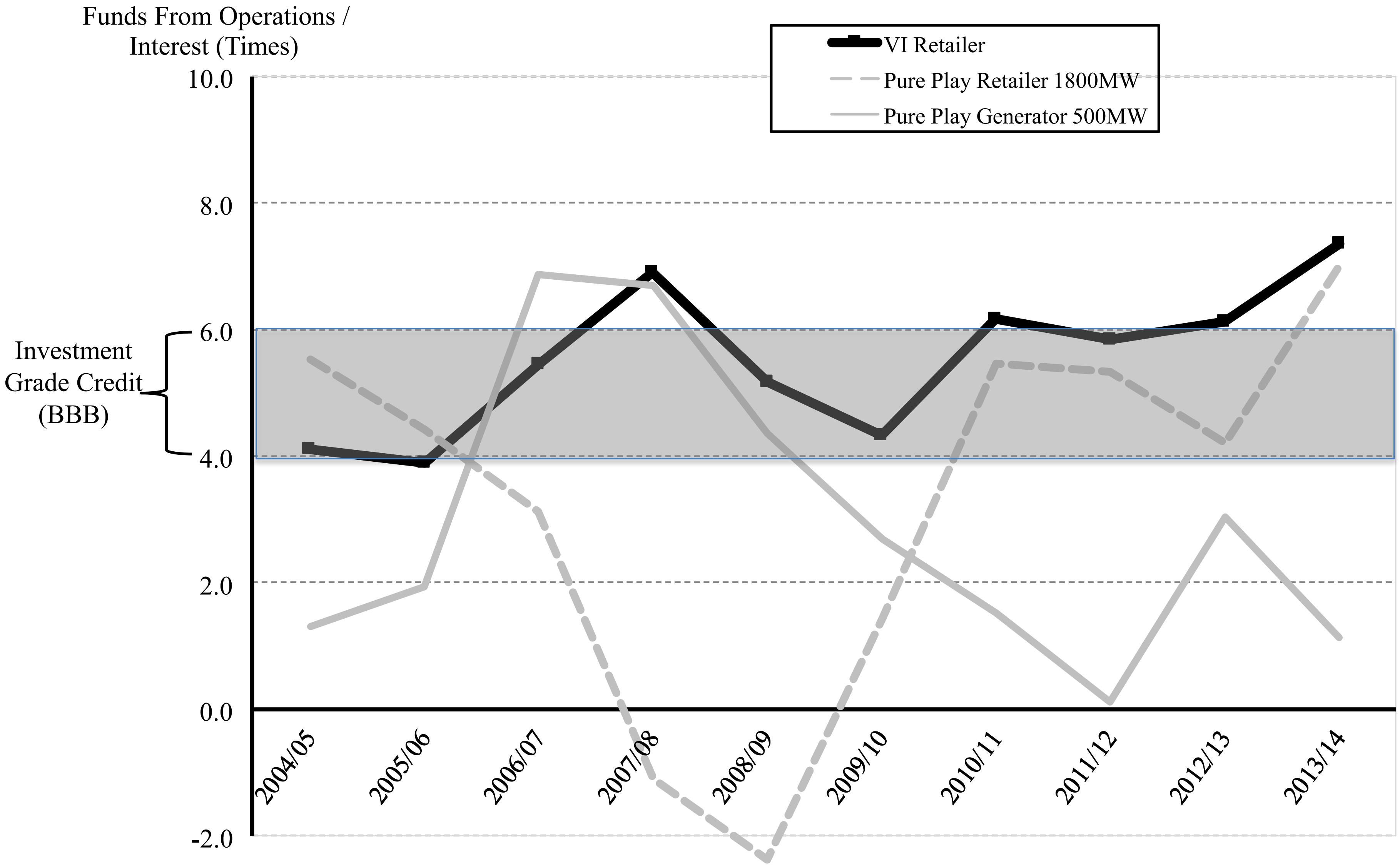
Griffith UNIVERSITY Queensland, Australia

Energy-Only Markets & Resource Adequacy

- In theory, competitive electricity markets have long been shown to deliver an adequate plant stock relative to peak demand in spite of heavy fixed & sunk costs, and a requirement for reserve plant margins (Schweppe et al 1988)
- But in practice, risks to Resource Adequacy // timely investment in 'energy-only' electricity markets dates at least as far back as von der Fehr & Harbord (1996)
- The theory is based on equilibrium conditions and an array of explicit (& implicit) assumptions: unlimited price caps, no political or IMO interference, harsh realities of applied corporate finance ignored (Joskow, 2006; Simshauser, 2010)
- If a close nexus exists between Reliability Criteria & VoLL, there should be no doubt plant will eventually be delivered
  - The issue is whether new plant is timely, or in response to an unfolding crisis
- Central to this is the concept of "missing money" (i.e. prices too low, too often - Cramton & Stoft, 2006; Finon, 2008)
  - Peaking plant thought to be particularly vulnerable (Doorman, 2002; Peluchon, 2003… Keppler 2017 etc)
- Practical evidence: subject to Reliability & VoLL nexus, transient episodes of missing money (and economic losses from general oversupply) can be navigated or softened via altering Vertical business boundaries. UK, NZ, AUS, SING etc (see Hogan & Meade 2007, Simshauser et al 2015 etc).

Griffith UNIVERSITY
Queensland, Australia

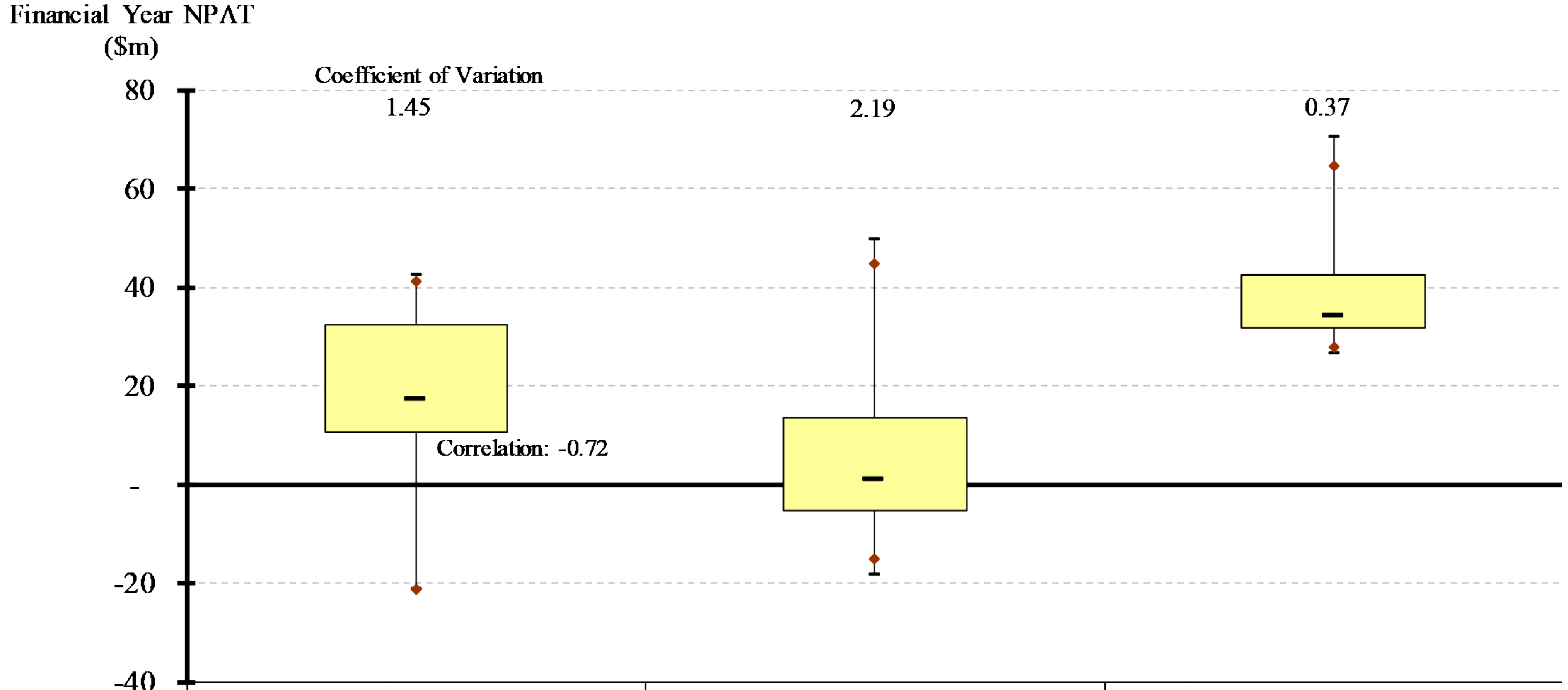
10 Yrs of Annual CFs of Vertical vs Pure Play: Retail Supply, Gas Turbine



Source: Simshauser, Tian, Whish-Wilson, 2015.

Griffith UNIVERSITY Queensland, Australia

10 Yrs of Annual CFs of Vertical vs Pure Play: Retail Supply, Gas Turbine



	Pure Play Retailer	Generator	Vertical Retailer
75th Percentile	$32.52	$13.42	$42.41
Maximum	$42.50	$49.48	$70.54
Minimum	-$21.26	-$18.17	$26.49
25th Percentile	$10.48	-$5.27	$31.78
Median	$17.38	$1.32	$34.24
5th Percentile	-$21.19	-$15.04	$27.81
95th Percentile	$41.18	$44.89	$64.49

Source: Simshauser, Tian, Whish-Wilson, 2015.

Griffith UNIVERSITY Queensland, Australia

Entry of Variable Renewable Energy in Australia's NEM

- Australia's Renewable Portfolio Standard: 33TWh by 2020. Policy discontinuity over the period 2012-2015 led to a fast ramp and *'cyclical investment boom'* conditions in the final years of the policy, ie 2016-2019. Specifically:
  - 96 utility-scale Variable Renewable Energy (VRE) projects committed (34 wind, 62 solar PV)
  - 11,400 MW installed capacity (5500 MW wind, 5900 MW solar PV, excluding rooftop PV)
  - $20.4 billion aggregate investment commitment ($10.7b wind, $9.7b solar)
  - Investments were primarily structured in the conventional manner, viz. Institutional Money (Infra Funds *cf.* Utilities), single asset Special Purpose Vehicle, long-dated run-of-plant PPA, Project Finance.
- But… when the dust settled, a surprising number of VRE projects were committed on a "merchant" basis (!!)
  - ~2400MW is purely 'merchant' (i.e. no PPA whatsoever)
  - + ~650MW of 'residual' merchant capacity (i.e. VRE plant oversized compared to PPA commitments)
  - + ~600MW of aged Wind plant (i.e. entry in 2000s) expiring legacy PPAs.

Griffith UNIVERSITY
Queensland, Australia

Merchant VRE

- On Resource Adequacy in energy-only markets, the entry of renewables is thought to complicate matters further vis-à-vis missing money due to so-called (*transient*) merit order effects
- Given high historic costs, consequently, Merchant VRE is a very new asset class, with no real history
- In an energy-only market with high Market Price Cap ($14700/MWh), probably not an investment for the feint hearted
- However, in reality a merchant wind plant is no more complex than merchant stochastic load
  - For Retail Supply, altering firm boundaries became the dominant business model in the UK, NZ, AUS, SING etc.
- With merchant renewables, prima facie, the same business combination should also be (risk-adjusted) profit maximising
  - PPAs are easier, but not necessarily profit maximising (liquidity)
- **Research Objective:** if Vertical Integration of Retail Supply and Gas Turbines de-risks Retail (vis-à-vis transaction costs, bounded rationality) and overcomes *the missing money* (vis-à-vis Gas Turbine), shouldn't the same portfolio gains exist when Integrating Merchant Wind and Gas Turbines?

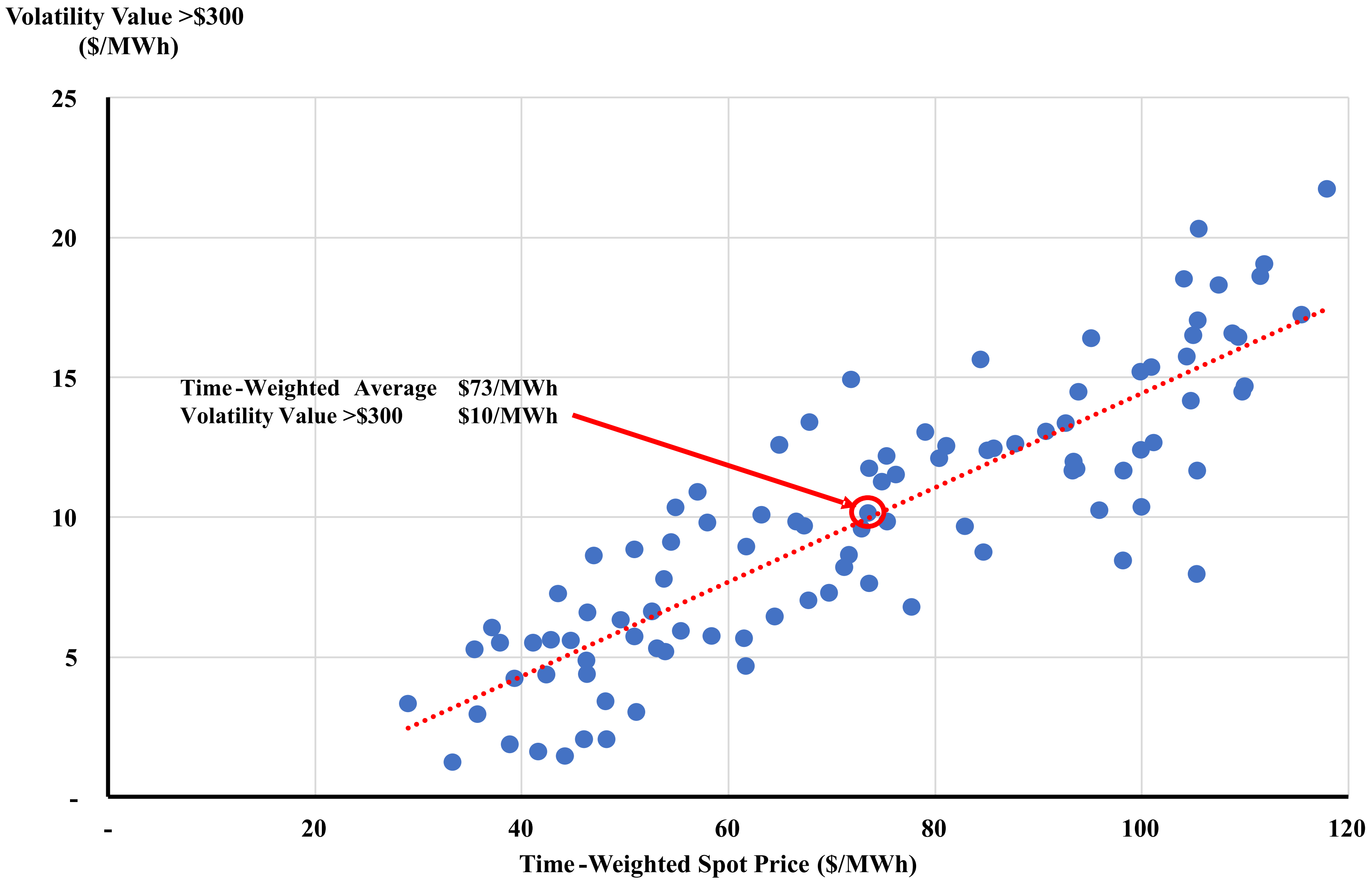
Griffith UNIVERSITY
Queensland, Australia

Scenario set-up: merchant wind, merchant OCGT

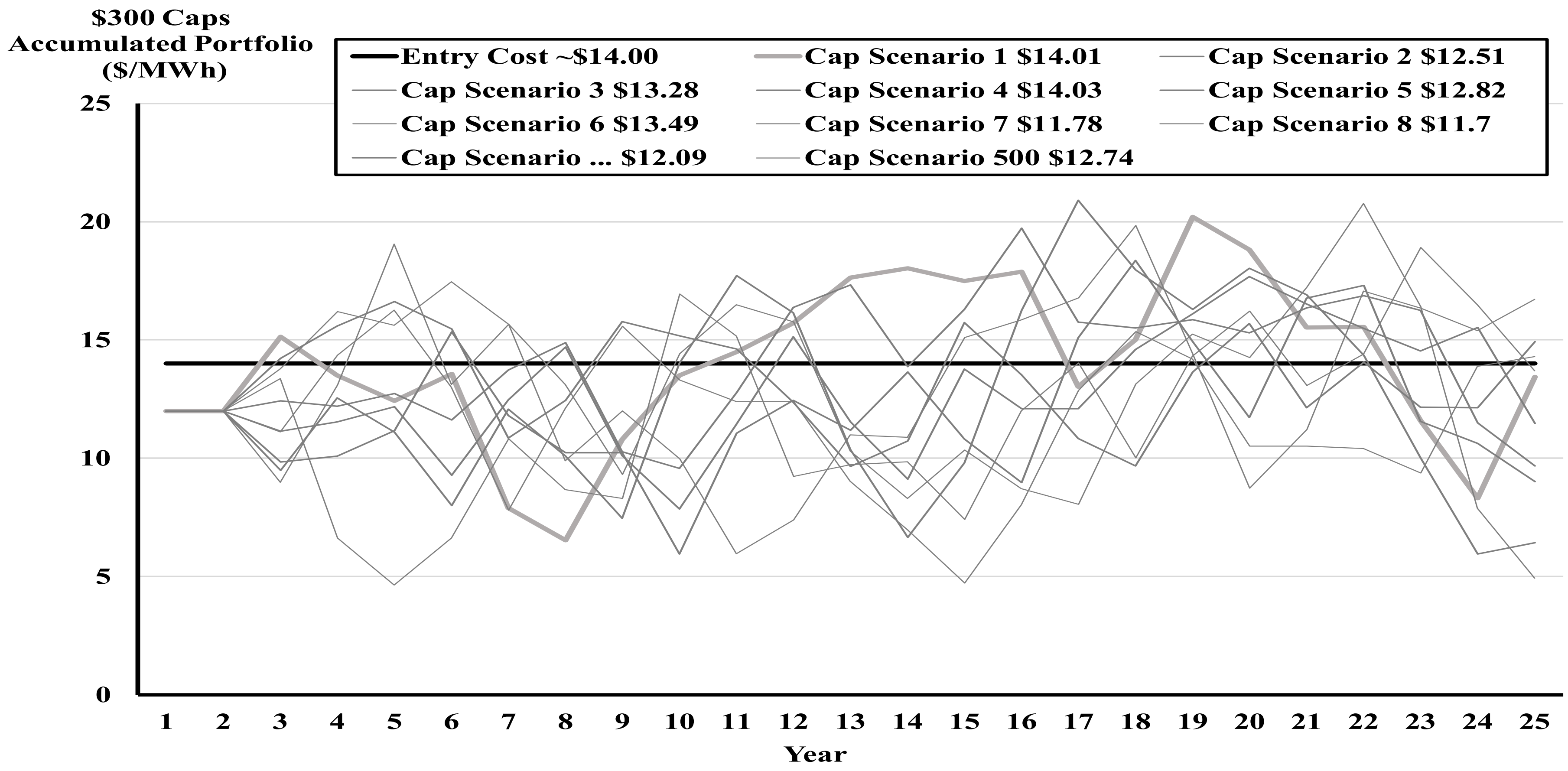
- Sunk 250MW merchant wind portfolio (ACF 31%), NEM South Aust region where VRE exceeds 50% market share
- New 90MW merchant OCGT plant ($102m, HR 10.3GJ/MWh, $9.50/GJ) with an implied carrying value of ~$14/MWh (i.e. equivalent break-even price of $300 Caps which meets expected returns to equity)
- Analytical process:
  - Generate 100 years of South Aust. stochastic spot price data, 30min resolution
  - Model Forward Derivatives: Baseload Swaps (wind), $300 Caps (GT)
  - Unit Commitment Model (30min resolution, 100 years) for both plant
  - Stochastic DCF Valuation Model (25-year DCFs, annual resolution, Revenues Sub-Sampled from Unit Commitment Model for each of the 25 years, then, 500 iterations)
  - Value Wind. Value OCGT. Value as Combined Portfolio. Portfolio vs Sum-of-the-Parts = VI Value

Griffith UNIVERSITY
Queensland, Australia

Stochastic Spot Prices (n = 100 years, t = 17520 intervals)



$300 Cap Prices: Historic vs Modelled (i=500)

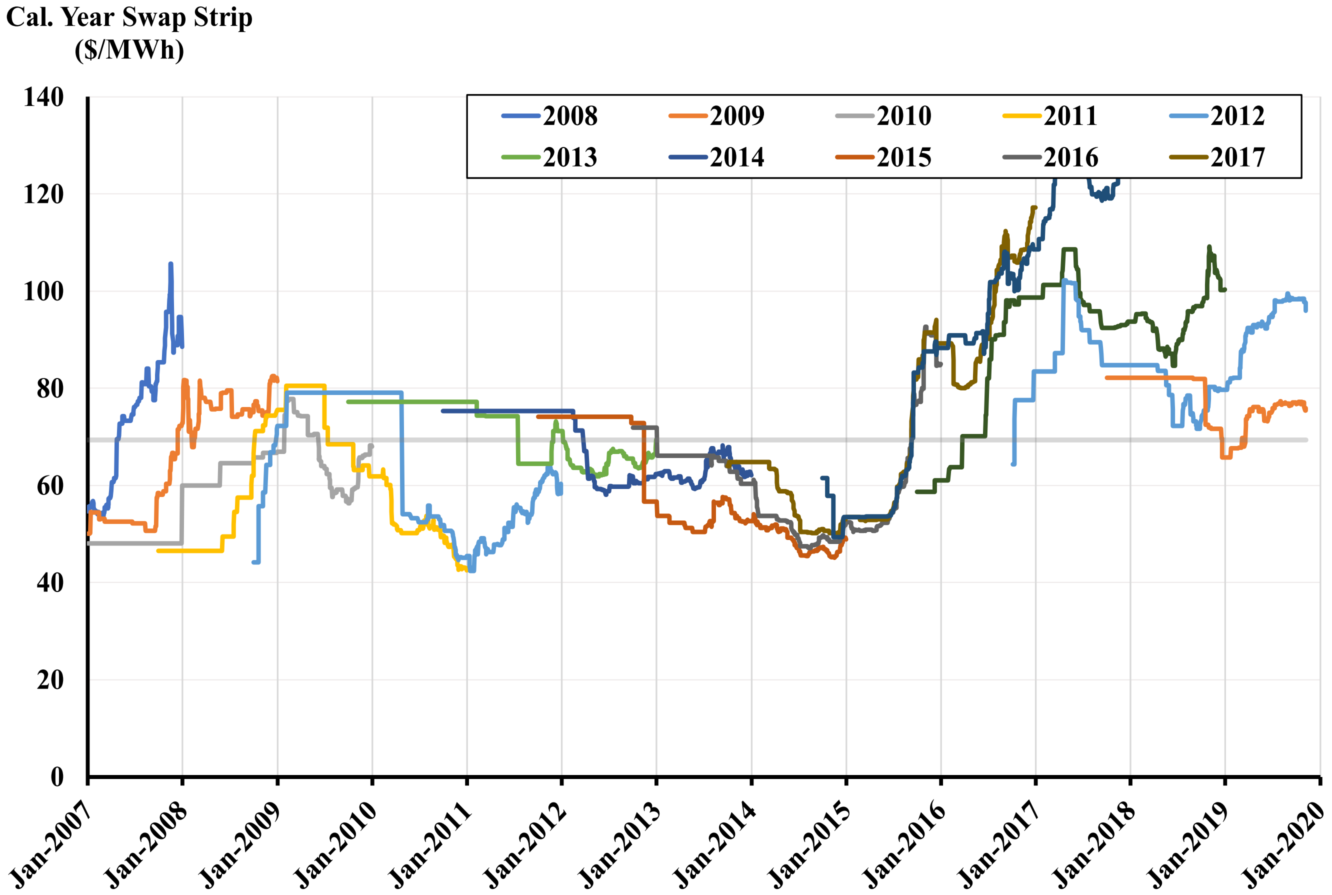


	Avg of Traded $300 Caps	Fair Value $300 Cap Ex Post	2010-19 $300 Cap Accum. Portfolio	Modelled $300 Cap Accum. Portfolio
Observations	6,933	10	10	500
Average	12.84	10.00	12.98	12.91
Std Deviation	4.49	5.09	2.96	3.05
Coeff. Variation	0.35	0.51	0.23	0.24
Min	6.32	1.65	8.90	`7.46
Max	29.40	17.67	17.51	`17.69

`Sample results from a single 25 Year Simulation.

Griffith UNIVERSITY Queensland, Australia

Swap Prices: Historic vs Modelled (i=500)



	Avg of Traded Swaps	Fair Value Swap Ex Post	Stochastic Spot Prices	2010-19 Swaps Accum.	Modelled Accum. Swap
Observations	8,186	10	100	10	10
Average	69.46	72.36	73.15	69.36	73.83
Std Deviation	18.53	25.58	24.47	12.13	13.01
Coeff. Variation	0.27	0.35	0.33	0.17	0.18
PoE5	106.69	105.92	109.78	90.55	97.00
PoE95	47.14	46.03	37.85	59.12	53.77

Griffith UNIVERSITY
Queensland, Australia

Merchant Wind can obviously participate fully in the spot electricity market.

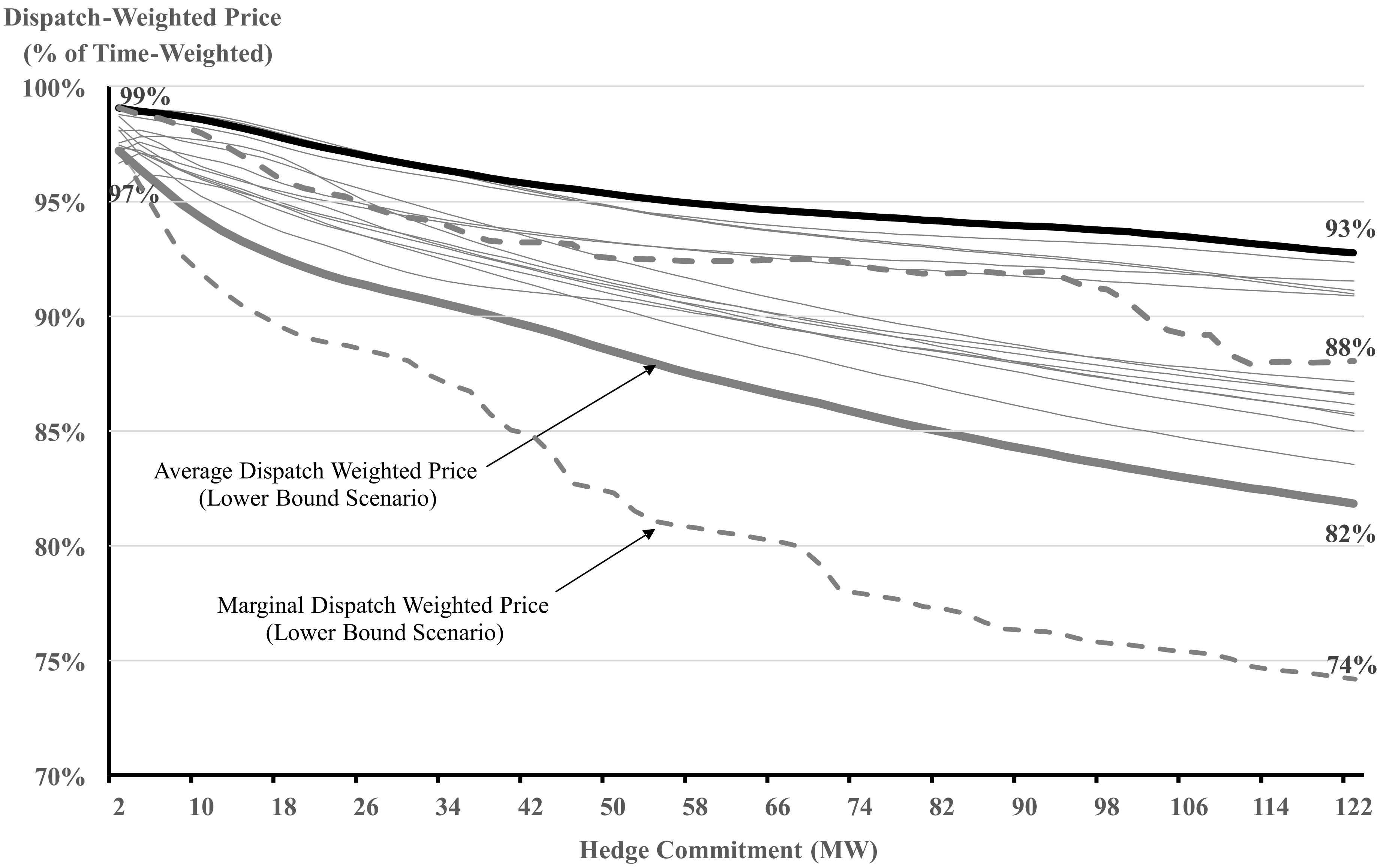
Question: Can a 250MW Merchant Wind Farm fully participate in the market for forward derivatives (viz. fixed price, fixed volume Swaps, firm to VoLL), and, is it prudent?

Answer: Yes and yes.

Merchant Wind: Annual Dispatch Weighted Price (n=100 years)

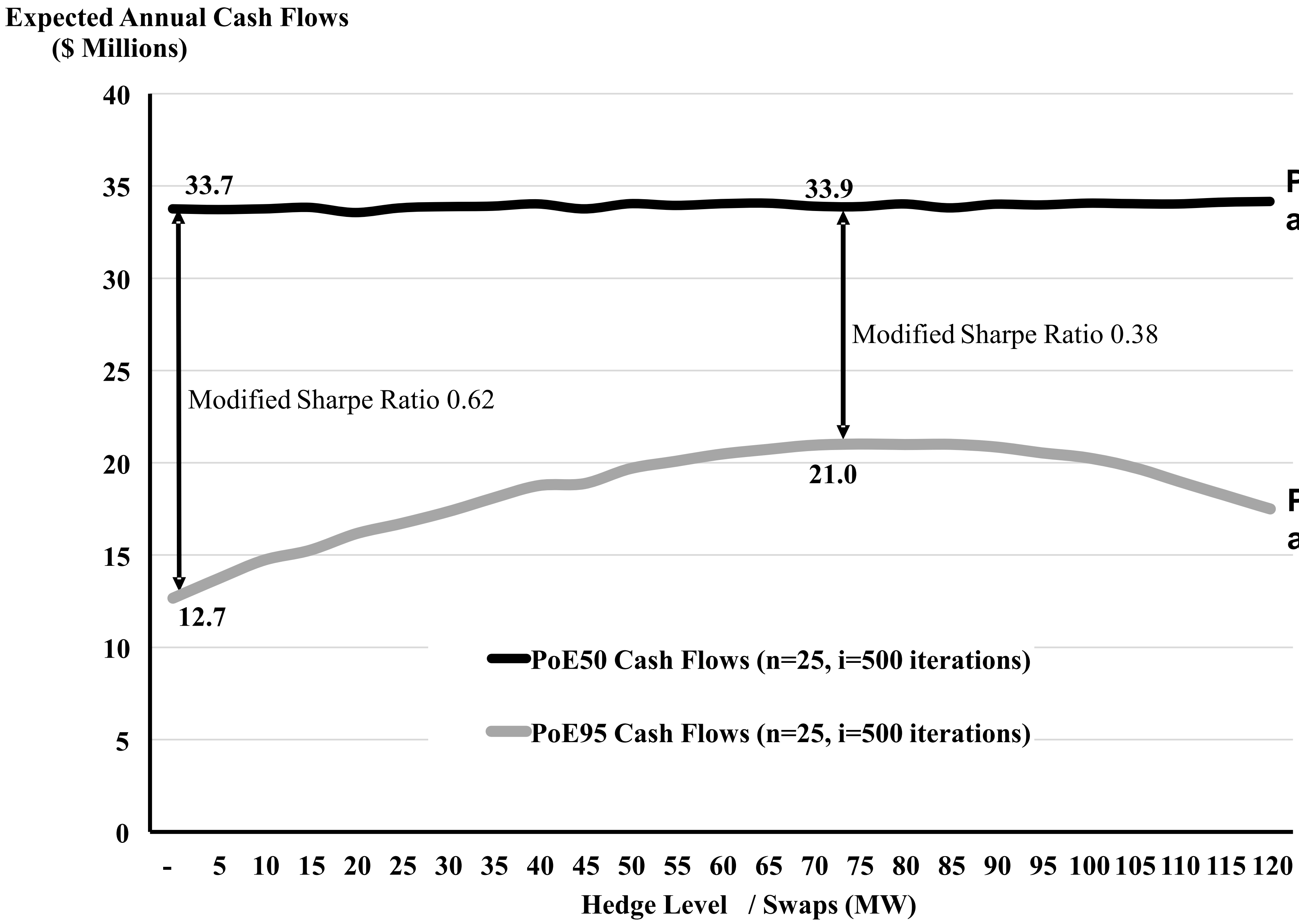
Griffith UNIVERSITY
Queensland, Australia

Average & Marginal DWP vs Priority Capacity



Griffith UNIVERSITY
Queensland, Australia

250MW Wind Annual Cash Flows: Baseload Swap Contracts 0-120MW



PoE50 CFs, Swaps written at Fair Value at n-1

NB. Annual CF modelling masks intra-period liquidity events

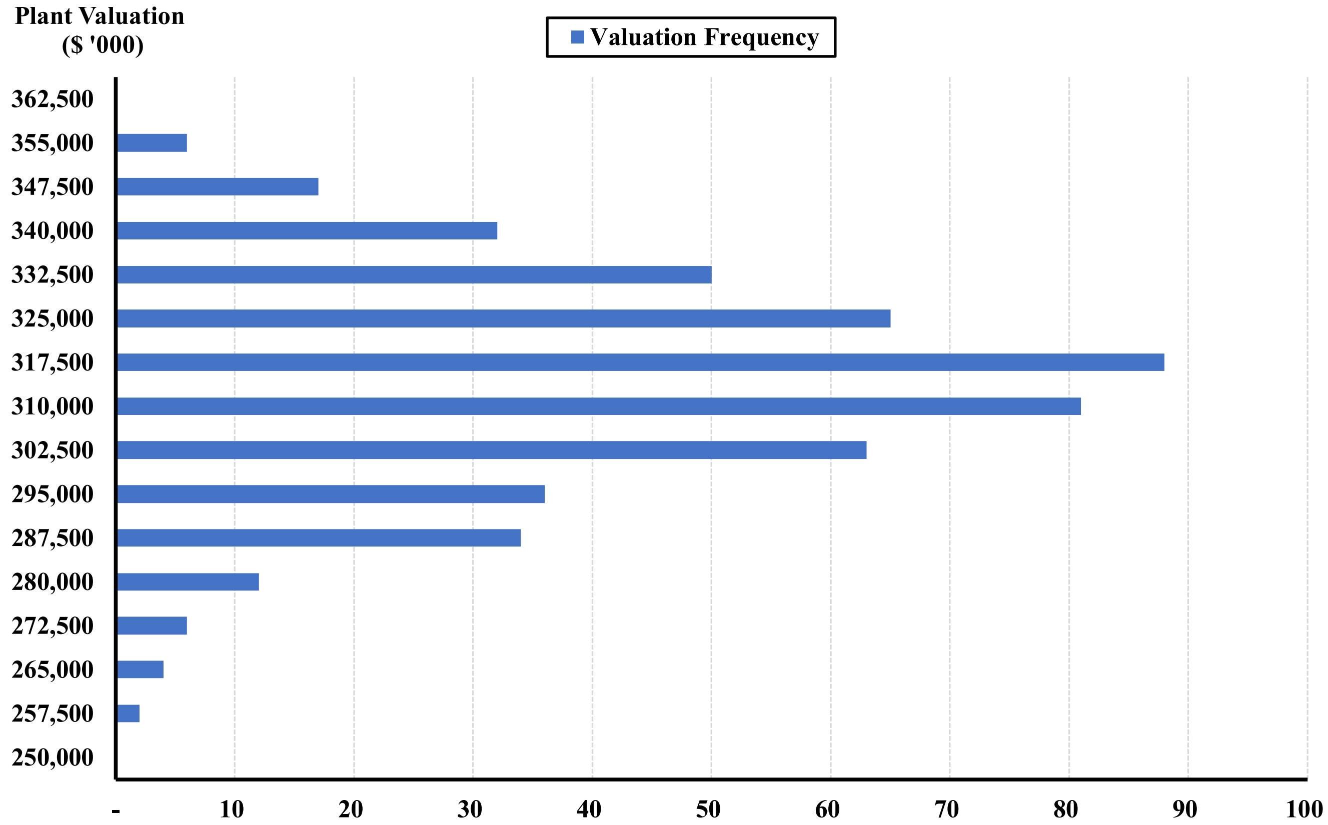
PoE95 CFs, Swaps written at Fair Value at n-1

Griffith UNIVERSITY Queensland, Australia

Wind Valuation (ex-RET certificates or $C0_2$) with 75MW Swaps

250MW Wind Portfolio	Valuation ($ Million)	ACF (%)
Plant Valuation (Avg of 500 iterations)	319.0	31.1
PoE5 Valuation	348.1	33.9
PoE95 Valuation	288.5	28.2
Minimum Valuation`	268.9	28.2
Maximum Valuation`	366.5	33.9
Avg Annual Cash Flow (500 iterations)	34.0	31.1
PoE95 Cash Flow (500 iterations)	21.0	28.2

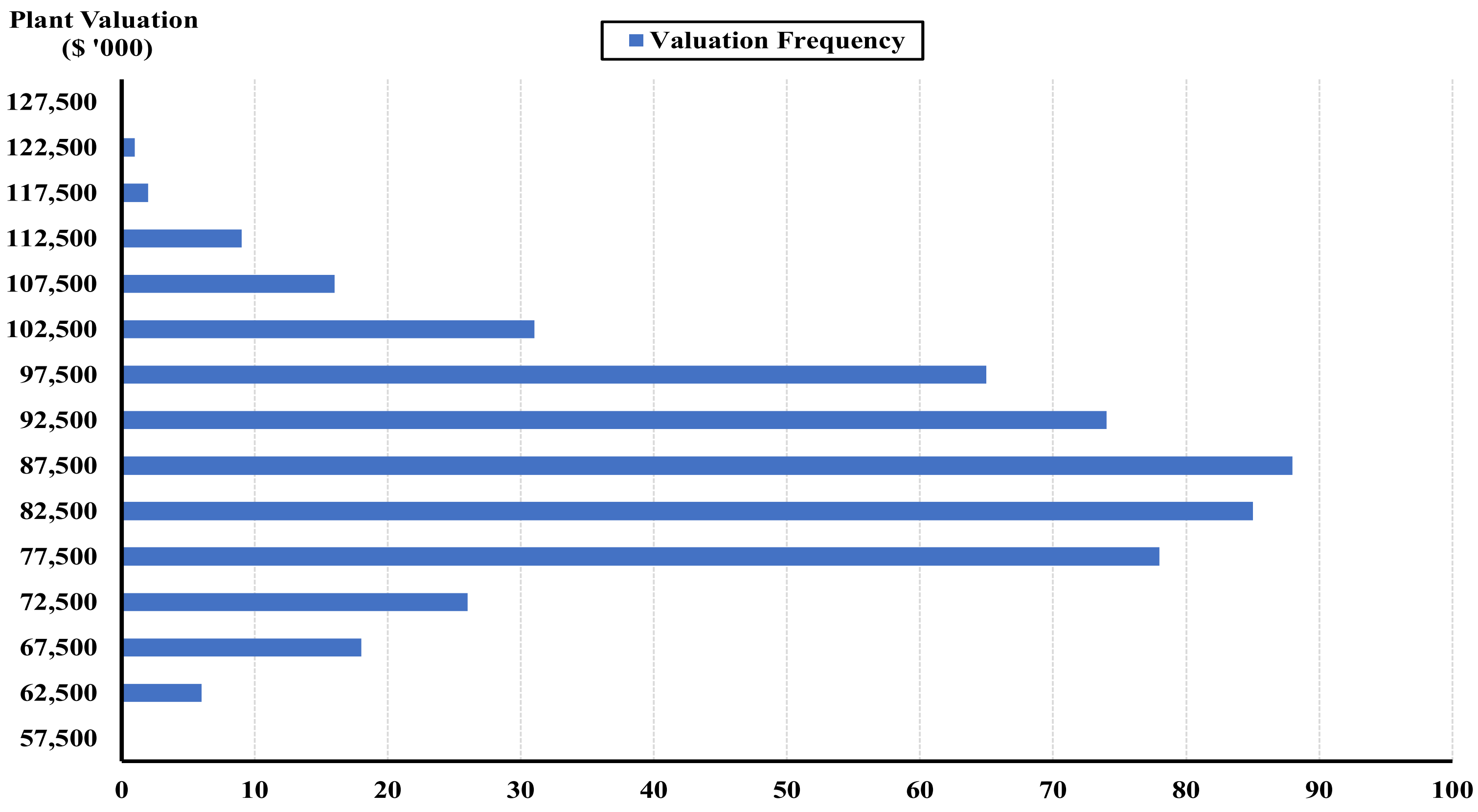
` Min and Max Annual Capacity Factor results are for a single year. Valuations relate to 25 years.



Griffith UNIVERSITY Queensland, Australia

OCGT Valuation (Investment = $102m): a case of Missing Money

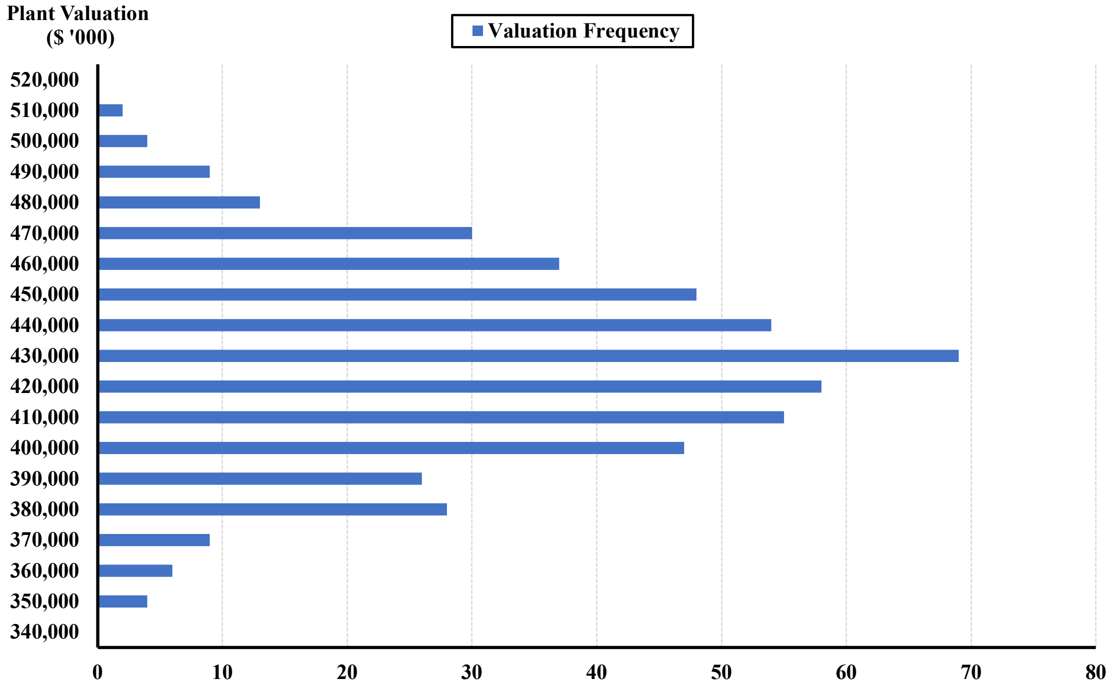
3 x 30MW OCGT Plant	Valuation ($ Million)	ACF (%)
Plant Valuation (Avg of 500 iterations)	89.2	7.8
PoE5 Valuation	107.0	9.9
PoE95 Valuation	72.6	5.6
Minimum Valuation`	55.2	0.9
Maximum Valuation`	119.3	24.5
Avg Annual Cash Flow (500 iterations)	9.9	7.8
PoE95 Cash Flow (500 iterations)	4.5	5.6



Griffith UNIVERSITY Queensland, Australia

Portfolio Valuation: outperforms Sum-of-the-Parts ~$24m

Valuation	OCGT	Wind	Simple Sum of the Parts	Wind+OCGT Portfolio	Portfolio Effects
	A	B	C	D	E
			C = (A + B)		E = (D - C)
	($ Million)	($ Million)	($ Million)	($ Million)	($ Million)
Plant Valuation (Avg of 500 iterations)	88.6	319.0	407.6	432.0	24.4
PoE5 Valuation	105.4	348.1	453.5	482.7	29.1
PoE95 Valuation	71.6	288.5	360.1	382.0	21.9
Minimum Valuation`	57.7	268.9	326.7	330.4	3.7
Maximum Valuation`	117.3	366.5	483.8	518.4	34.6
Avg Annual Cash Flow (500 iterations)	9.8	34.0	43.9	45.8	1.9
PoE95 Cash Flow (500 iterations)	4.3	21.0	25.3	29.0	3.7
Modified Sharpe Ratio	0.56	0.38	0.42	0.37	



Griffith UNIVERSITY
Queensland, Australia

Policy Implications

- Following the cyclical boom (2016-2019), the NEMs renewable plant stock is c.15,000MW. A small but meaningful (c.20%) component is Merchant.
- Merchant renewables is a new asset class. To be sustainable, an optimal mix of debt and equity capital will be required
- For debt to be structured and allocated on a commercial basis, some minimum level of forward hedging is necessary
- On annual Cash Flows, hedging Wind to 'average output' is financially prudent on a risk-adjusted basis (i.e. PoE50 v PoE95)
    - nb. Annual DCF model results mask intra-year liquidity events. Not critical when combined with peaking plant.
- On a stand-alone basis, OCGT plant was found sub-economic: evidence of missing money.
- Combined, portfolio effects were material and 'found the missing money', just as integration with Retail Supply has done
- It would seem Merchant Renewables is, on balance, a helpful development. Investment risks are allocated to shareholders, and owners have strong incentives to accumulate optimal portfolio capacities – which can only assist power system Resource Adequacy.
- In spite of alternate views, the energy-only market design may yet be entirely compatible with high VRE & Resource Adequacy. Recall the South Australian region (on which this modelling is based) has >51% VRE market share…

Simshauser, P. 2020, "Merchant renewables and the valuation of peaking plant in energy-only markets", *EPRG Working Paper No.2002,* Energy Policy Research Group, University of Cambridge.

Available at **https://www.eprg.group.cam.ac.uk/eprg-working-paper-2002/**

Griffith UNIVERSITY
Queensland, Australia