Submission to Draft 2024-25 GenCost

Thank you for the opportunity to provide a submission to the Draft Gencost 2024-25 report.

As a citizen I am concerned public debate on electricity infrastructure is well informed and leads to efficient investment, low emissions and generation adequacy supporting long term system security.

The Draft GenCost report assesses the economics, emissions, performance and maturity of various generation and storage technologies and compares technologies on these bases. The stated purpose of earlier GenCost reports was to inform AEMO's Integrated System Plan. However, the present GenCost annual report implies a greater purpose, stating:

"GenCost represents Australia's most comprehensive electricity generation cost projection report. It uses the best available information each cycle to provide an objective annual benchmark on cost projections and updates forecasts accordingly to guide decision making, given technology costs change each year."

The report has become the benchmark used by media and industry proponents to compare the relative cost of generation technologies which directly, or indirectly, is informing Government policy and community debate.

The Draft GenCost report doesn't appropriately consider generation adequacy

Whilst the independent presentation of costs, emissions and performance for various technologies (as prepared by Aurecon) may be correct within the confidence levels stated, the methods used to draw comparison of the capital cost and levelized cost of energy (LCOE) between technologies are, in my opinion, misleading.

For example, the method used to determine the required mix of variable renewables (VR) and storage when comparing to other non-variable generation technologies (e.g. large nuclear). The report states:

"We incorporate the uncertainty in variable renewable production by modelling nine different weather years, 2011 to 2019, and the results represent the highest cost outcome from these alternate weather years."

For a system with high penetration of VR and storage, a period of 9 years doesn't adequately account for a generation adequacy risk arising from variability in renewable resource (wind and solar), or if the risk is to be avoided, the increased cost of procuring adequate VR and firming capacity.

In other infrastructure planning contexts such a short study period would not be an acceptable basis for accounting for weather variability, particularly in an environment of climate uncertainty. For example, building codes typically consider 100-year flood levels.

Rather than modelling to account for this variability, this risk appears to be discounted in the report by assuming sufficient VR firming is available from non-renewable sources (gas), committed projects (e.g. Snowy Hydro II) or diversity of wind resource between renewable energy zones (REZ). Neither of these assumptions provides a sound basis for comparing options. Gas is not zero emissions, utilising capacity from committed projects distorts the comparison and wind capacity factors between REZs are not negatively correlated so provide no guarantee of spare capacity.

The justification for not considering alternative scenarios or sensitivity analysis is presented in the section *D.2.2 Why is no sensitivity analysis conducted and presented?*

"The staff delivering GenCost have many decades of experience in energy and electricity system modelling. They understand which parameters in the model have the greatest impact on model outcome. The scenarios have been designed to explore those parameters that are the most uncertain

and impactful (within a plausible range) so that they provide a set of results that represent the likely range of outcomes…"

Whilst the staff delivering the report are undoubtedly experienced and talented, the scenarios presented don't include sufficient sensitivity analysis to account for variability in the fuel available to power VR generation (wind and solar) when comparing technologies.

Consequently, the Government, the Clean Energy Council and/or AEMO relying on this comparison may incorrectly prioritise or incentivise solutions which have long term generation adequacy risks, with unaccounted community cost and national security implications. Other report submissions have previously raised concerns about the basis of technology comparison.

Recommendation

A methodology is required which avoids the pitfalls of quasi-technical comparison of the economics of different generation technologies leading to erroneous conclusions.

To provide a valid comparison of generation technology portfolios I recommend the report should utilise one of two alternative methodologies:

1. A whole of electricity system simulation for both the Wholesale Electricity Market (WEM) and National Electricity Market (NEM) for the projected operating year(s) or

2. Performance benchmarking.

Both methods would utilise the costs and technology inputs (emissions, efficiency, availability etc) stated within the report. To ensure generation adequacy each method should also utilise historic solar and wind data to simulate VR generation over a consecutive period of at least several days or weeks with *low renewable energy conditions (*LREC*).*

LREC should be based upon a credible event, such as data for the lowest one in 100-year wind capacity factors across REZs. If wind data is not available for certain regions these conditions can be determined using a statistical approach as has been demonstrated below. Both methods should also consider multiple scenarios by employing a Monte Carlo approach to cater for variations in input assumptions within credible limits.

Whole of System Simulation

The goal of this method is to use an energy balancing and optimisation model to identify the least cost portfolio(s) of new generation and storage assets capable of delivering zero (or near zero) emissions when coupled with remnant generation assets, whilst maintaining generation adequacy when operating through a period of LREC coincident with a period of relatively high system demand.

The portfolio composition is optimised at a system level by varying the mix of investment in new zero emission generation and storage technologies at various locations (REZs and bulk transmission connection points) to deliver the forecast system electricity demand, at the least cost, during the selected period of *LREC*.

This method will yield a mix of generation and storage technologies which meet the criteria of low cost, low emission and generation adequacy and are relevant to the WEM or NEM systems where the investment is proposed. Typically, this modelling would be conducted by the system operator (AEMO).

Performance Benchmarking

The goal of this method is to compare technologies on a like for like basis by specifying performance criteria against which portfolios of competing generation technologies can be independently benchmarked under *LREC*. If the benchmark is capital cost or LCOE then the criteria for emissions and generation adequacy should be the same for all generation portfolios.

Unlike the whole of system simulation method, this simpler method does not identify the optimal investments for a particular electricity system, but instead determines the technology composition of portfolios capable of meeting a baseload generation performance and low emissions criteria. It is then the role of the system operator to determine the appropriate investment mix comprised of high performing technology portfolios.

Appendix A provides an example of this methodology which compares three generation portfolios (onshore wind and battery, onshore wind and PHES and large nuclear) with performance criteria being the capability to supply with zero emissions 1GW of firm demand (baseload) continuously through a 4-day (96 hour) period of variable wind capacity factor.

In this example, in absence of the one in 100-year *LREC,* various generation portfolios are compared in four renewable energy scenarios where the wind capacity factor is randomly generated each hour assuming a normal distribution with 40% mean, 5% minimum and 15% standard deviation. Capital costs and other input assumptions where available have been used from the Draft GenCost report.

Figure 1 presents the findings of this simulation and shows that even over this relatively short period (4 days) and utilising random, rather than historically low, renewable energy conditions, all of the renewable and storage portfolios are a higher capital cost than the large nuclear generation portfolio where generation adequacy is a requirement.

Conclusion

As Australian electricity systems evolve to meet low emissions targets there will be a commensurate reduction in traditional baseload generation and, due to increased reliance upon VR generation, increasing fluctuations in generation supply (and market prices), as has been observed in recent years.

In this future, maintaining system security under wide ranging but credible renewable energy conditions (wind and solar) will be increasingly challenging to the system operator and require either a significant overbuild of VR generation and storage capacity or investment in non-weather dependent low emission baseload generation.

The performance benchmarking example above illustrates that the Draft GenCost report approach, of comparing technologies on an economic basis under limited scenarios, does not accurately assess the amount of variable renewable capacity overbuild required to deliver firm generation capacity under various environmental conditions.

Given the strategic importance of the electricity systems and the amount of investment which will be made, much of it informed by this report, this provides justification to employ a more robust modelling method capable of comparing the merit of competing new technology investments to provide reliable and zero emissions operation in the context of the Australian electricity systems (NEM and WEM) under *low renewable energy conditions*.

Without addressing this issue, readers of the Draft GenCost report will be mislead as to the relative merits of competing technologies, with potentially long-lasting community cost and national security consequences.

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Note: the author has no affiliation with any political party or industry group and is supportive of efficient investment in renewable and non-renewable generation for a low emissions energy future.

Appendix A: Example performance specification method simulation with varying wind capacity factor

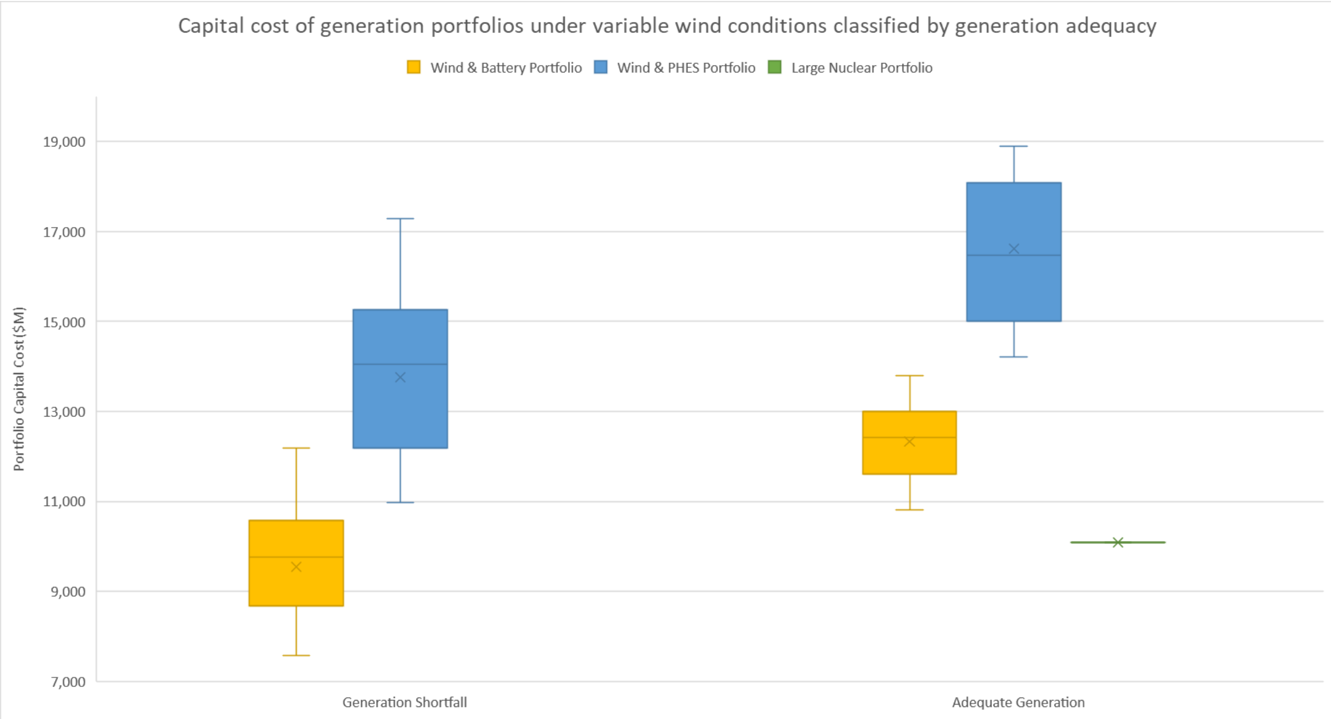


Figure 1 Graph of outcome of 56 simulations with varying wind generation and storage composition and wind capacity factor

Table 1 Assessment of generation adequacy of onshore wind and storage portfolios under randomised wind capacity factor

	VR Portfolio Capacity		**Renewable Energy Conditions**			**Capital Expense**			**Generation Adequacy**	
Scenario	Storage Energy (hours)	Wind generation capacity (GW)	WCF mean	WCF Standard Deviation	WCF Minimum	Wind & Battery Portfolio	Wind & PHES Portfolio	Large Nuclear Portfolio	Max Generation Shortfall (GW)	Generation Adequacy
1	8	1.50	43.5%	5.0%	14.0%	7,587	10,979	10,094	0.84	Generation Shortfall
1a	8	1.50	39.8%	7.8%	14.6%	7,587	10,979	10,094	0.88	Generation Shortfall
1b	8	1.50	40.3%	5.0%	15.5%	7,587	10,979	10,094	0.93	Generation Shortfall
1c	8	1.50	39.2%	5.0%	15.7%	7,587	10,979	10,094	0.93	Generation Shortfall
1d	12	1.50	41.5%	5.0%	14.7%	8,963	14,051	10,094	0.89	Generation Shortfall
1e	12	1.50	41.0%	7.4%	15.1%	8,963	14,051	10,094	0.89	Generation Shortfall
1f	12	1.50	39.8%	5.0%	15.5%	8,963	14,051	10,094	0.93	Generation Shortfall
1g	12	1.50	40.5%	5.8%	13.6%	8,963	14,051	10,094	0.91	Generation Shortfall
2	8	1.75	39.5%	10.2%	14.6%	8,392	11,784	10,094	0.82	Generation Shortfall
2a	8	1.75	42.8%	5.0%	15.0%	8,392	11,784	10,094	0.70	Generation Shortfall
2b	8	1.75	38.8%	12.6%	13.7%	8,392	11,784	10,094	0.76	Generation Shortfall
2c	8	1.75	40.4%	5.0%	14.1%	8,392	11,784	10,094	0.91	Generation Shortfall
2d	12	1.75	42.3%	5.0%	14.8%	9,768	14,856	10,094	0.84	Generation Shortfall
2e	12	1.75	36.7%	5.0%	13.9%	9,768	14,856	10,094	0.83	Generation Shortfall
2f	12	1.75	38.9%	5.0%	16.3%	9,768	14,856	10,094	0.91	Generation Shortfall
2g	12	1.75	38.0%	6.3%	12.8%	9,768	14,856	10,094	0.89	Generation Shortfall
3	8	2.00	38.0%	5.0%	15.4%	9,198	12,590	10,094	0.84	Generation Shortfall
3a	8	2.00	40.1%	5.0%	15.2%	9,198	12,590	10,094	0.82	Generation Shortfall
3b	8	2.00	39.7%	5.9%	13.8%	9,198	12,590	10,094	0.88	Generation Shortfall
3c	8	2.00	39.4%	7.8%	15.5%	9,198	12,590	10,094	0.72	Generation Shortfall
3d	12	2.00	39.0%	5.0%	14.5%	10,574	15,662	10,094	0.90	Generation Shortfall
3e	12	2.00	41.9%	5.0%	14.5%	10,574	15,662	10,094	0.82	Generation Shortfall
3f	12	2.00	38.4%	5.0%	15.8%	10,574	15,662	10,094	0.84	Generation Shortfall
3g	12	2.00	40.3%	9.5%	14.6%	10,574	15,662	10,094	0.73	Generation Shortfall
4	8	2.25	40.8%	5.0%	16.6%	10,004	13,396	10,094	0.52	Generation Shortfall
4a	8	2.25	39.4%	5.0%	14.2%	10,004	13,396	10,094	0.89	Generation Shortfall
4b	8	2.25	38.5%	11.6%	14.8%	10,004	13,396	10,094	0.55	Generation Shortfall
4c	8	2.25	41.8%	5.0%	16.6%	10,004	13,396	10,094	0.57	Generation Shortfall
4d	12	2.25	44.2%	5.0%	16.5%	11,380	16,468	10,094	-	Adequate Generation
4e	12	2.25	39.6%	5.0%	15.1%	11,380	16,468	10,094	0.36	Generation Shortfall
4f	12	2.25	40.2%	9.1%	15.4%	11,380	16,468	10,094	0.16	Generation Shortfall
4g	12	2.25	39.2%	5.0%	13.8%	11,380	16,468	10,094	0.56	Generation Shortfall
5	8	2.50	39.0%	5.0%	14.4%	10,810	14,202	10,094	-	Adequate Generation
5a	8	2.50	41.4%	7.9%	14.7%	10,810	14,202	10,094	-	Adequate Generation
5b	8	2.50	39.3%	5.0%	15.6%	10,810	14,202	10,094	-	Adequate Generation
5c	8	2.50	38.0%	5.0%	13.1%	10,810	14,202	10,094	0.88	Generation Shortfall
5d	12	2.50	40.5%	13.5%	14.0%	12,186	17,274	10,094	-	Adequate Generation
5e	12	2.50	41.4%	5.0%	15.4%	12,186	17,274	10,094	-	Adequate Generation
5f	12	2.50	36.5%	9.3%	14.1%	12,186	17,274	10,094	0.51	Generation Shortfall
5g	12	2.50	41.0%	7.9%	15.4%	12,186	17,274	10,094	-	Adequate Generation
6	8	2.75	40.4%	5.0%	15.5%	11,615	15,007	10,094	-	Adequate Generation
6a	8	2.75	42.0%	6.1%	13.2%	11,615	15,007	10,094	-	Adequate Generation
6b	8	2.75	38.8%	5.0%	13.6%	11,615	15,007	10,094	-	Adequate Generation
6c	8	2.75	44.1%	16.9%	13.5%	11,615	15,007	10,094	-	Adequate Generation
6d	12	2.75	42.2%	5.0%	15.4%	12,991	18,079	10,094	-	Adequate Generation
6e	12	2.75	42.2%	5.0%	14.4%	12,991	18,079	10,094	-	Adequate Generation
6f	12	2.75	38.4%	5.0%	14.7%	12,991	18,079	10,094	-	Adequate Generation
6g	12	2.75	39.5%	5.0%	14.7%	12,991	18,079	10,094	-	Adequate Generation
7	8	3.00	40.6%	5.0%	13.7%	12,421	15,813	10,094	-	Adequate Generation
7a	8	3.00	39.0%	5.0%	14.0%	12,421	15,813	10,094	-	Adequate Generation
7b	8	3.00	37.1%	5.0%	15.1%	12,421	15,813	10,094	-	Adequate Generation
7c	8	3.00	38.4%	5.0%	13.1%	12,421	15,813	10,094	-	Adequate Generation
7d	12	3.00	40.5%	5.7%	15.2%	13,797	18,885	10,094	-	Adequate Generation
7e	12	3.00	39.5%	5.0%	13.9%	13,797	18,885	10,094	-	Adequate Generation
7f	12	3.00	41.8%	5.0%	15.0%	13,797	18,885	10,094	-	Adequate Generation
7g	12	3.00	38.8%	5.0%	16.6%	13,797	18,885	10,094	-	Adequate Generation

Simulation of Onshore Wind and Storage and Large Nuclear against a Performance Benchmark

Purpose Test the technical capability of a portfolio of wind and storage or large nuclear to meet performance criteria requiring the generation portfolio to supply with zero emissions 1GW of firm demand through a continous four day (96 hour) period of varying randomised wind capacity factor. Compare the capital cost of the resulting onshore wind generation / storage portfolio to a large scale nuclear generator using the assumptions in the CSIRO Gencost report.

Assumptions (from Gencost report 2024 values)		
Cost of Onshore Wind Capacity	3,223	$/kW or $M/GW
Cost of Battery Storage (8 hrs)	344	$/kWh or $M/GWh
Cost of Battery Storage (24 hrs)	442	$/kWh or $M/GWh
Cost of Hydro (PHES)	768	$/kWh or $M/GWh
Cost of Large Nuclear Capacity	8,984	$/kW or $M/GW
Large Nuclear capacity factor	89%	[2]

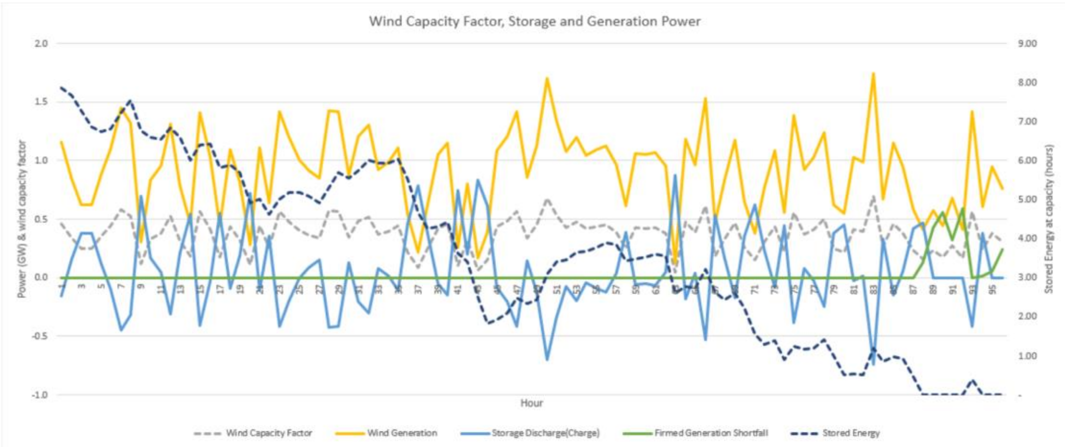
Onshore Wind & Battery Portfolio	$M	**Onshore Wind & PHES Portfoli**	$M	**Large Nuclear Portfolio**	$M
Cost of Wind Capacity	8,058	Cost of Wind Capacity	8,058	Cost of Large Nuclear Capacity	10,094
Cost of Battery Energy [1]	2,752	Cost of PHES	6,144		-
Cost of Wind with Batt Firming	**10,810**	Cost of Wind with PHES	**14,202**	Cost of Large Nuclear	**10,094**

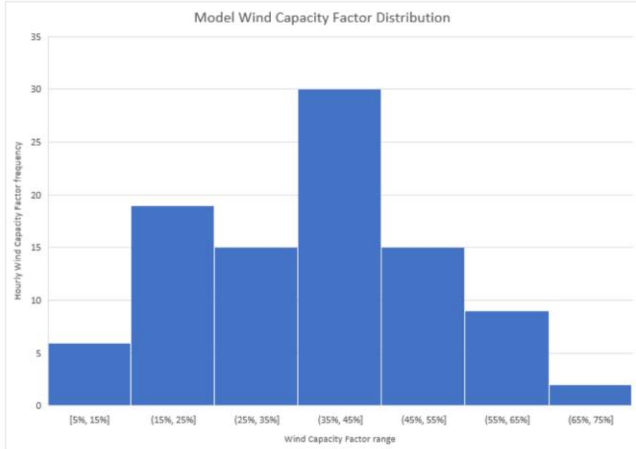
Model Inputs			
Baseload Demand	1.00	GW	
Storage Power	1.00	GW	
Storage Energy	8.00	hours	
Charge Efficiency	92%		
Dishcarge Efficiency	92%		
Storage Round Trip Efficiency	85%		
Wind generation capacity	2.50	GW	
Wind Capacity factor (WCF) mean	40%		Note [3]
WCF Standard Deviation	15%		Note [3]
WCF Minimum	5%		Note [3]

Model Wind Capacity Factor	
Mean	37%
Min	5%
Standard Deviation	14.1%

Performance Compliance			
Max Generation Shortfall	0.59	GW	Note [4]

Generation Portfolio Capex		
Onshore Wind & Battery Portfolio	**10,810**	$M
Onshore Wind & PHES Portfolio	**14,202**	$M
Large Nuclear Portfolio	**10,094**	$M





Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Model Results																								
Wind Capacity Factor	46%	34%	25%	25%	35%	44%	58%	53%	12%	33%	38%	52%	31%	18%	56%	41%	18%	44%	33%	11%	44%	26%	57%	48%
Wind Generation	1.15	0.84	0.62	0.62	0.88	1.10	1.45	1.32	0.31	0.83	0.96	1.31	0.79	0.46	1.41	1.03	0.45	1.09	0.81	0.28	1.11	0.64	1.41	1.19
Storage Discharge(Charge)	(0.15)	0.16	0.38	0.38	0.12	(0.10)	(0.45)	(0.32)	0.69	0.17	0.04	(0.31)	0.21	0.54	(0.41)	(0.03)	0.55	(0.09)	0.19	0.72	(0.11)	0.36	(0.41)	(0.19)
Stored Energy	7.85	7.67	7.26	6.86	6.73	6.82	7.24	7.53	6.77	6.59	6.54	6.83	6.60	6.01	6.39	6.42	5.81	5.90	5.70	4.91	5.01	4.62	5.00	5.18
Firmed Generation Shortfall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Hour	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Model Results																							
Wind Capacity Factor	40%	36%	34%	57%	57%	35%	48%	52%	37%	40%	44%	22%	9%	25%	42%	46%	10%	32%	7%	16%	43%	48%	57%
Wind Generation	1.00	0.91	0.85	1.43	1.42	0.87	1.21	1.30	0.92	0.99	1.11	0.54	0.21	0.62	1.05	1.15	0.25	0.80	0.17	0.39	1.09	1.20	1.42
Storage Discharge(Charge)	(0.00)	0.09	0.15	(0.43)	(0.42)	0.13	(0.21)	(0.30)	0.08	0.01	(0.11)	0.46	0.79	0.38	(0.05)	(0.15)	0.75	0.20	0.83	0.61	(0.09)	(0.20)	(0.42)
Stored Energy	5.18	5.09	4.92	5.31	5.69	5.55	5.74	6.02	5.94	5.93	6.02	5.52	4.67	4.26	4.30	4.44	3.63	3.41	2.50	1.84	1.91	2.10	2.48
Firmed Generation Shortfall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note:
[1] As there is no Aurecon price for 12 hour storage, assume if battery storage duration greater than 12 hours, use 24 hour storage cost else use 8 hour storage cost
[2] Reduced capacity factor increases required nuclear capacity (and cost). Uses capacity factor in report, however, typically this would be higher. As this model compares portfolios providing baseload capacity for system security, assumes dispatch is not limited by wholesale market price
[3] Input to randomised normally distributed hourly WCF value used in simulation
[4] Red shading indicates total generation shortfall, use solver to determine optimal battery or wind generation required to maintain this at (or above) zero for a given WCF scenario.

Figure 2 Simulation of generation and storage portfolios over 4 days (96 hours) against randomised wind capacity factors