BATTERY STORAGE
THE NEW, CLEAN PEAKER

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CLEAN ENERGY COUNCIL

Large-scale battery storage is now the superior choice for electricity peaking services, based on cost, flexibility, services to the network and emissions. It is the new clean peaker that Australia needs.

Batteries can store low-cost, zero-emission, excess renewable energy from the grid to support periods of peak demand with clean, cheap and reliable energy.

Between 6 and 19 GW of new dispatchable resources are needed across the National Electricity Market by 2040. Batteries are now a prudent choice to meet this level of dispatchable capacity.

Two- and four-hour batteries outcompete open-cycle gas turbine peakers on both a levelised cost of energy and levelised cost of capacity basis.

Batteries can provide a premium peaking service in periods of high demand traditionally met by peaking gas plants. Batteries can ramp up quickly, have near zero start-up time and provide a better frequency response.

The commercial case for batteries will continue to improve as advancements are made with battery technology and new markets are established to reward the services they provide.

Up-to-date information on battery projects in Australia can be found on the project tracker page on the Clean Energy Council website.

The National Electricity Market is undergoing an unprecedented transition.

26–50 GW

large-scale renewable energy generation needed in the NEM by 2040

30%

levelised cost of energy saving of battery storage compared to a gas peaker

The Australian Energy Market Operator's (AEMO's) 2020 Integrated System Plan (ISP) anticipates an additional 26 to 50 GW of new large-scale renewable energy generation (depending on the scenario) will be needed in the National Electricity Market (NEM) by 2040, supported by between 6 and 19 GW of new dispatchable resources.

These dispatchable resources will be made up of pumped hydro, large-scale battery energy storage systems, distributed batteries, virtual power plants and other demand-side participation.

THE ROLE OF PEAKERS AND THE SERVICES THEY PROVIDE

While the ISP has a limited role for new gas generation, there are some that hold a preference for new gas peakers as the firming support for variable renewable energy generation. Peaking generation plants are generators that can respond in a short timeframe to periods of both expected and unexpected high electricity demand. These generators traditionally have high short-run marginal costs and as such, are only used for short periods in times of sharp increases in demand or peak periods. In the NEM, peaking plants are generally needed for generation after 6.00pm for an average of three to four hours as solar systems ramp down and demand peaks.

Traditionally, peaking plants have been gas-fired generators due to their ability to begin generating within 15 minutes. The market is now seeing a rapid transition to battery storage systems as a replacement for gas peakers as battery technology has advanced to the point where it can provide faster response for a much lower cost. Battery solutions can serve the same role traditionally performed by gas peakers by discharging when demand (and correspondingly prices) approach peak levels and sustaining output to cover the typical daily peak duration.

Battery storage, known for its fast and accurate response across numerous energy applications, has improved its capability and cost-effectiveness to become the pre-eminent peaking plant solution for energy grids across the world. The key barrier for batteries has been capital cost, but rapid and continuing cost efficiencies driven by product innovations and manufacturing at scale are reducing this barrier, to the extent that it is no longer economically rational (or necessary) for proponents, investors or governments to build gas peaking plants in Australia.

THE CASE FOR BATTERY PEAKERS

Battery storage is the true bridge to a clean energy future, providing a modern, more flexible alternative to gas turbines for meeting peaking and firming needs.

PREMIUM PEAKING SERVICES

Battery storage offers a 'premium' peaking service (faster ramp rate, higher accuracy and better-quality frequency response) and a wider range of network services (including digital inertia, voltage support, system strength and fast frequency response) at lower cost (both upfront capital cost and ongoing operational expenditure) – making it far more suitable to complement increasing levels of variable renewables.

OPTIMAL FIRMING DURATION

Batteries have quickly expanded energy capacity to four hours and more, outcompeting gas to play the optimum intraday 'firming' role. Given Australia's existing energy mix and diversity in renewable output, there are very few periods forecast to require more than four hours of storage in the next decade. For interday 'seasonal' firming, a combination of different storage technologies will be required in the longer term.

EMISSIONS REDUCTION

By shifting renewable energy through the day, batteries allow for greater uptake of renewable energy technologies while providing system stability and network security services in parallel. On the other hand, there are clear direct emissions from gas peakers.

DEPLOYMENT FLEXIBILITY

Batteries offer fast, modular and scalable deployment profiles, and can be deployed in any location on the network. Relative to equivalent gas or pumped hydro developments, batteries have a minimal land footprint and a reduced carbon footprint.

DIVERSE VALUE

Batteries offer diverse value streams from negative price events (being paid to charge), network services (demand response, system integrity protection, loss factor improvements, voltage stability, investment deferral), proposed market reforms (five-minute settlement) and essential system services (inertia, fast frequency response, premium frequency stability and system strength).

GUARANTEED TECHNICAL LIFE

As variable renewable generation increases, the cost of operating gas plants goes up due to increased ramping causing more wear-and-tear that will shorten their technical lives. In addition, gas plants require more regular downtime to perform maintenance. In contrast, batteries have higher availability (given less maintenance work is required) and can offer guaranteed fixed power and energy for over 20 years to effectively maintain capacity over the entire useful life.

GETS BETTER OVER TIME

Battery technology continues to receive new features and functionality updates, making it highly adaptable to new markets and system settings.

FUEL INDEPENDENCE

Independence from fossil fuels reduces exposure to commodity price risk and enables the provision of more responsive, lower-cost and carbon-free capacity.

While the case for battery peakers is compelling, the risks for gas peakers are increasing. For example, the NEM's move to five-minute settlement from October 2021 is one of the initial market reforms that will undercut gas peaking revenue opportunities – with five-minute timeframes challenging the ability for peaking plants to defend cap contracts and respond to price spikes.

Historically, gas peakers have relied more heavily on cap contracts (with their longer runtime duration), but cap prices have softened and are not expected to see the same extreme volatility as evidenced in the one or two isolated years since the commencement of Australia's national market. The lower price outlook for caps is therefore removing much of the future earnings potential for both existing and new build plants. Coupled with increased uncertainty and volatility in input gas fuel prices, unclear supply volumes, carbon risk premiums and broader policy and political sentiments, the case for new gas investments is becoming increasingly challenging.

FIGURE ONE

INDICATIVE OPPORTUNITY AND RISK STACK FOR BATTERY STORAGE VS GAS PEAKERS

BATTERY STORAGE

OPPORTUNITY

- NETWORK SERVICES (DEMAND RESPONSE, SYSTEM INTEGRITY PROTECTION SCHEME, VOLTAGE)
- FIVE-MINUTE SETTLEMENT
- ESSENTIAL SYSTEM SERVICES (INERTIA, FAST FREQUENCY RESPONSE, PRIMARY FREQUENCY RESPONSE, SYSTEM STRENGTH)
- NEGATIVE PRICE EVENTS
- PEAK PRICE EVENTS

RISK

- FREQUENCY CONTROL ANCILLARY SERVICES MARKET DEPTH
- GOVERNMENT POLICY INTERVENTION

GAS PEAKERS

OPPORTUNITY

- ESSENTIAL SYSTEM SERVICES (INERTIA, PRIMARY FREQUENCY RESPONSE, SYSTEM STRENGTH)
- PEAK PRICE EVENTS

RISK

- GAS FUEL PRICE EXPOSURE
- REDUCED CAP REVENUES
- FIVE-MINUTE SETTLEMENT
- CARBON RISK

BATTERIES VS GAS PEAKERS: WHICH IS CHEAPER?

Comparing the levelised cost of energy (LCOE) and levelised cost of capacity (LCOC) for a new-build 250 MW gas peaker with new-build 250 MW two-hour and four-hour battery storage systems, all located in New South Wales, grid-scale battery storage systems provide a peaking solution with a lower LCOC than an equivalent new-build open cycle gas turbine plant (OCGT or 'gas peaker'). Battery storage also provides more than 30 per cent in LCOE savings, with both capital and operational cost advantages (before considering fuel and carbon risks).

While this analysis does not include NEM dispatch or revenue modelling, from first principles the lower variable operating costs and higher operational agility of battery storage will result in better utilisation and therefore larger market revenues. Battery storage can also generate strong revenues from arbitrage opportunities, even if the average price of electricity declines (or is negative) due to strong growth in renewables. For the assumptions used in this study, please see the Appendix.

LEVELISED COST OF CAPACITY (AUD$/KW/YR)	TWO-HOUR BATTERY	FOUR-HOUR BATTERY	OPEN CYCLE GAS TURBINE PEAKER
Capital cost	89	139	128
Fixed operations and maintenance	13	23	16
Variable operations and maintenance	18	35	59
TOTAL	**119**	**197**	**203**

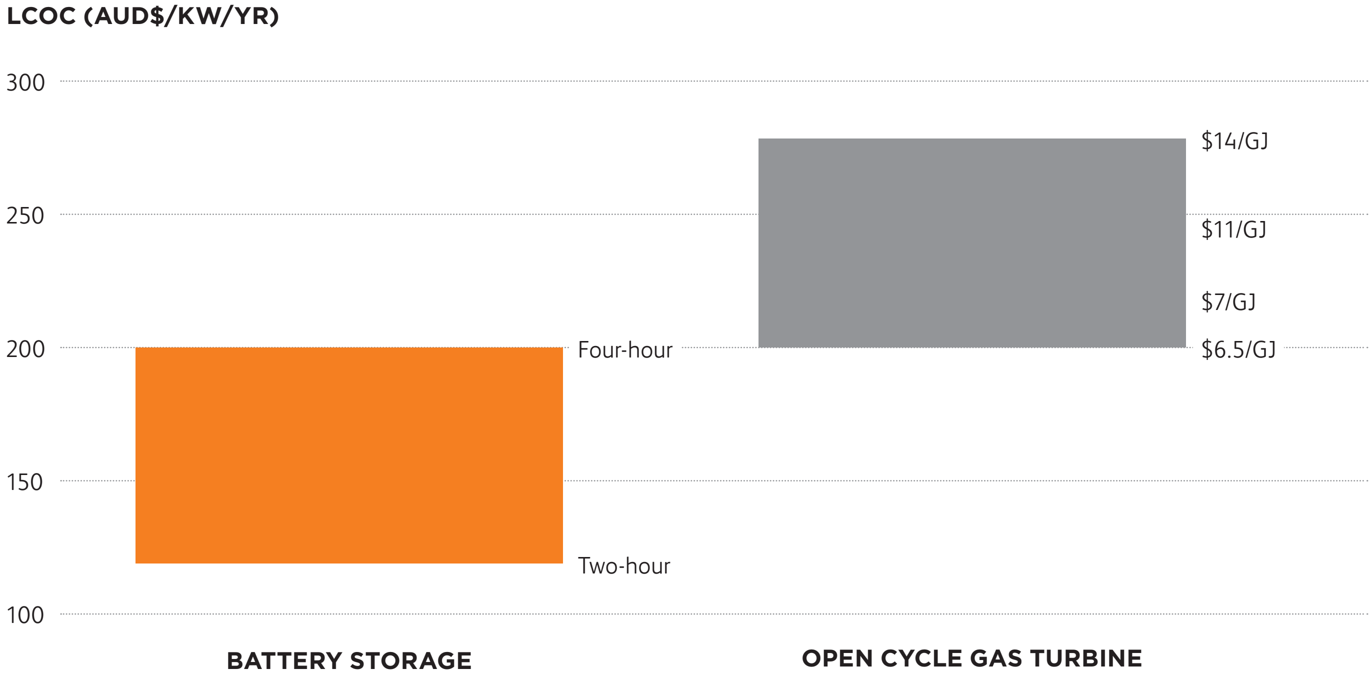
LEVELISED COST OF ENERGY (AUD$/MWH)	TWO-HOUR BATTERY	FOUR-HOUR BATTERY	OPEN CYCLE GAS TURBINE PEAKER
Capital cost	143	117	156
Fixed operations and maintenance	26	13	13
Variable operations and maintenance	26	26	65
TOTAL	**195**	**156**	**234**

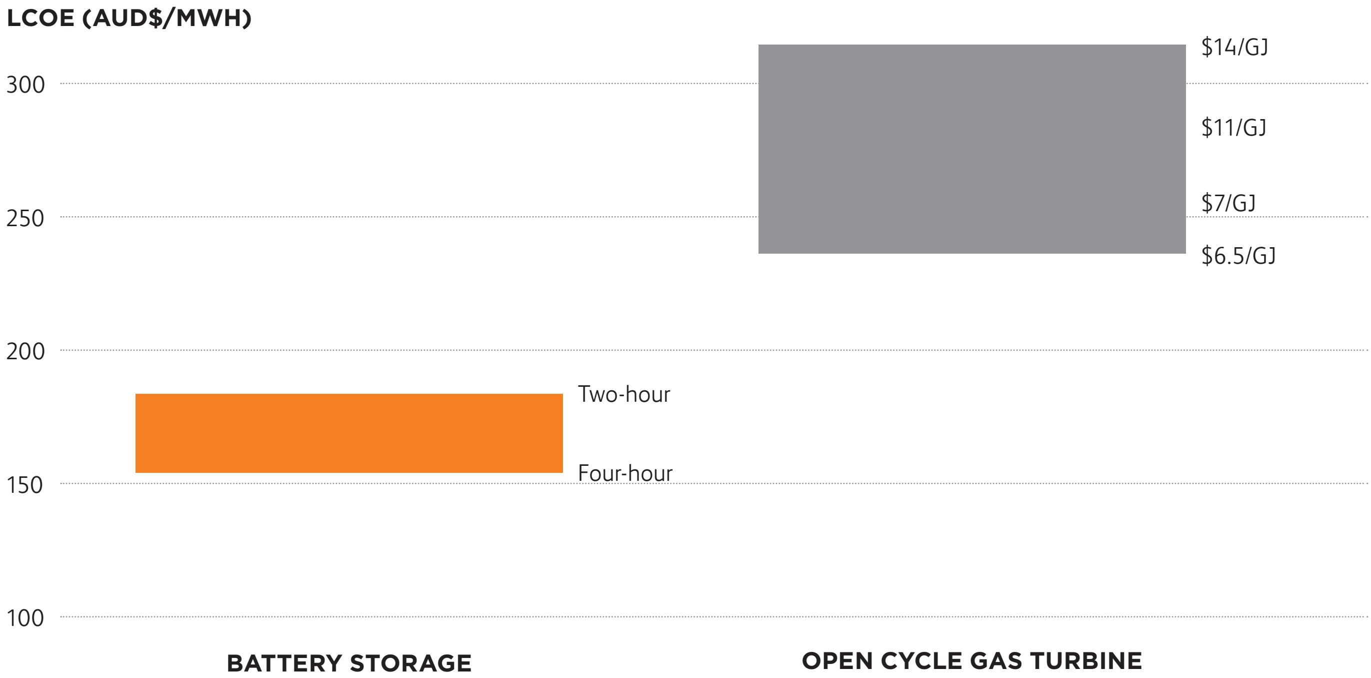
Note:

- **Capital cost** – Batteries' advantage will improve as capital costs decline, while commodity price and carbon risks for gas plants will escalate.
- **Fixed operations and maintenance (O&M)** – Due to lower labour intensity and the lack of moving parts, fluids and turbomachinery, the O&M charges for batteries are nominally lower than gas peakers. However, the battery values above have included a fixed cost uplift for the optional capacity maintenance agreement that maintains power and energy capacity over the life of the asset.
- **Variable operations and maintenance** – Commodity price exposure of gas fuel is significant. In contrast, the main variable cost of batteries is charging, which benefits from low/negative prices that will become more frequent as cheap solar/wind proliferate. In addition, with its many mechanical systems, gas costs rise in proportion to its use and start-up/shut-down frequency.

FIGURE TWO

BATTERY STORAGE OUTCOMPETES GAS PEAKERS ON A LEVELISED COST OF CAPACITY (LCOC) AND LEVELISED COST OF ENERGY (LCOE) BASIS





A key sensitivity for gas peakers is the exposure to natural gas price fluctuations. Figure 2 includes a base case of AUD$6.5/GJ (aligning with AEMO's latest gas supply hub data and verified by independent experts) as well as three sensitivities to account for forecast cost pressures: AUD$7/GJ, AUD$11/GJ and AUD$14/GJ. These sensitivities are based on independent advice suggesting long-run levels below AUD$8/GJ are hard to achieve given cost estimates of new supply.

Capacity factors also have some influence, however OCGTs would need to triple their typical utilisation to over 30 per cent and benefit from low gas prices to even start to compete.

Carbon price risk is another known unknown with potentially substantial cost impacts on gas peakers. While not modelled in this analysis, it remains front of mind for policy makers and investors. In reality, by choosing a battery energy storage system, developers can shield themselves from these downside risks and uncertainties.

Battery storage offers a compelling new technology to serve traditional peaking and firming roles.

Battery storage outcompetes gas peakers because of its faster reaction time, higher accuracy and flexibility to respond to price variability by both charging and discharging. With the rapid reduction in capital costs complementing its already lower operating costs, battery storage offers this superior performance at much greater commercial value than its gas peaker alternative, and at much lower exposure against future gas, carbon and market reform risk.

Both two-hour and four-hour battery storage solutions are more cost-competitive than a conventional OCGT peaker – outperforming it on an LCOC and LCOE basis. The competitiveness of battery storage will only increase over time as costs continue to fall, average electricity prices decline as renewable penetration accelerates and natural gas prices remain volatile and at the behest of global market economics. Given these risks and opportunities, developing a new gas peaker in Australia is both irrational and imprudent, exposing shareholders to potential losses, taxpayers to unnecessary debt and electricity customers to high costs.

Battery storage is the true bridge to a clean energy future and can become the new flexible peaker to accelerate Australia’s transition to sustainable energy. The case for batteries as the new clean peaker is impossible to ignore.

APPENDIX

METHODOLOGY

This analysis compares the operational and capital costs of a 250 MW gas peaker and two- and four-hour batteries over a 20-year period, starting from 2021. Costs are combined into a levelised cost of capacity (net present value of costs relative to each plant in Australian dollars per kilowatt-year – $AUD/kw/yr) and a levelised cost of energy (net present value of costs relative to each plant's use – $AUD/MWh), which are two common representations and comparisons of energy plant costs. The discount rate is 7 per cent and annual gas price inflation is conservatively assumed to be zero. In addition to standard capital costs, the battery systems are burdened with capacity maintenance opex (costs to maintain full capacity given battery cell degradation over time). Charging energy is assumed to cost $0.03/kWh, which conservatively assumes no charging price deflation despite a forecast decline due to higher renewables penetration (and increasing potential for frequent negative price events).

This analysis focuses on both capital and operational costs but excludes revenue comparisons as these are highly dependent on individual plant dispatch profiles, market bidding strategies and long-term price forecasts in the NEM, which will be impacted by new market services and ongoing reforms.

Including the additional revenues capable of being generated by a battery would make the analysis even more favourable for battery storage given that they have the following advantages over gas peaker plants:

- provide fast frequency response within milliseconds and at a higher accuracy than gas peakers, leading to higher compensation in markets that reward performance
- receive frequency control ancillary services 'enablement' revenue (for readiness to address frequency contingencies) with very low operational costs, compared to a gas peaker that operates at an inefficient heat rate to prepare for a fast ramp
- get paid to charge during brief periods with negative prices, while gas peakers (because of their relatively slow ramp rate) may be forced to pay to generate if they want to stay online during brief price drops.

MODELLING ASSUMPTIONS

INPUT ASSUMPTION	SOURCE/NOTES
Gas plant capital cost	• AUD$1250/kW (Aurecon, 2019 Cost and Technical Parameter Review)
Gas plant O&M costs	• Fixed: AUD$12.6/MWh (net) (Aurecon, 2019 Cost and Technical Parameter Review) • Variable: AUD$4.1/MWh (net) (Aurecon, 2019 Cost and Technical Parameter Review)
Gas plant heat rate	• 10,397GJ/MWh LHV net (Aurecon, 2019 Cost and Technical Parameter Review)
Gas fuel input costs	• AUD$6.5/GJ (AEMO Gas Supply Hub, February 2021) with no inflation (base case); with sensitivities run for AUD$7/GJ, AUD$11/GJ and AUD$14/GJ. • Sensitivities based on independent advice suggesting that long-run levels below AUD$8/GJ will be hard to achieve given cost estimates of new supply. • Note: unlike energy markets, gas supply is traded via bilateral gas supply contracts, providing much less transparency on pricing. While AEMO's gas supply hub data has been used and peer reviewed by independent experts, there are additional risk premiums not included, such as carbon price risk, international and domestic production, storage and transport influences, and increasing supply-side constraints. Collectively, these factors are underpinning analysts' forecast of future gas costs considerably higher than legacy contracts.
Carbon price	• n/a – not included in analysis
Gas capacity factor	• 10% • Australian gas assets have operated at a relatively wide (and declining) range of load factors over the past five-six years, with OCGTs typically operating at 5-15% load factors (independent advice).
Battery capital cost	• AUD$470 for two-hour • AUD$370 for four-hour • Note: prices based on AEMO 2022 ISP Draft Input Assumptions – taking average of Sustainable Growth scenario pricing across 2021/22 and 2022/23
Battery round-trip efficiency	• 89.5% (two-hour) • 92.5% (four-hour)
Average wholesale energy price – battery charging cost	• AUD$0.03/kWh – used as input charging cost for battery. • Note: this is conservative as it assumes no charging price deflation despite a forecast decline from higher renewables penetration (and increasing potential for frequent negative price events).
Discount Rate	• 7%

GAS SENSITIVITIES

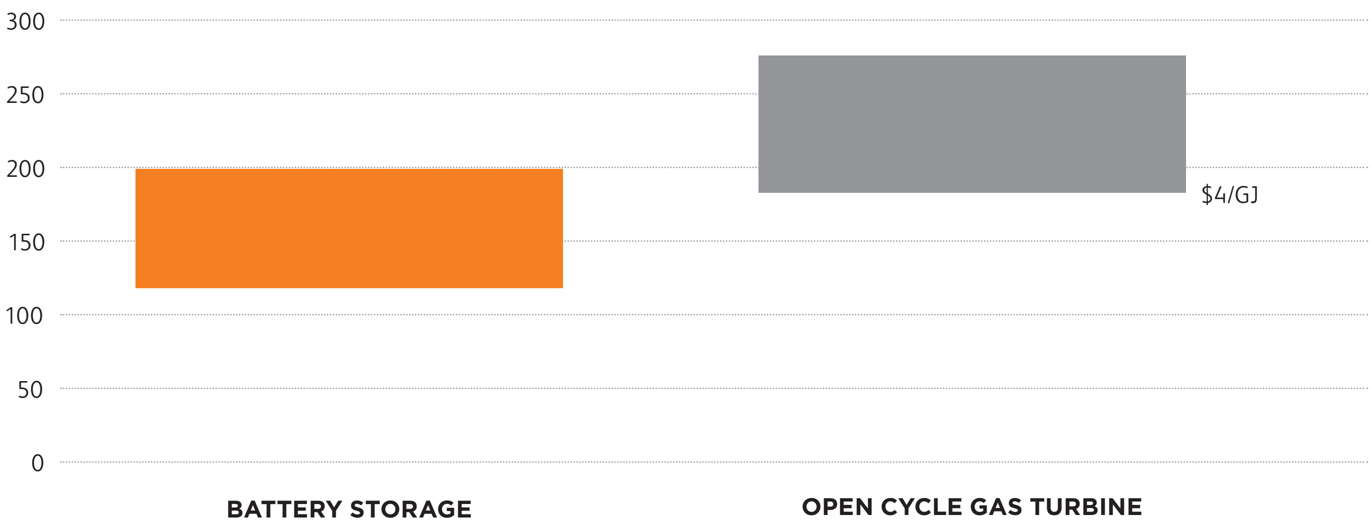
The case study in this paper uses the following gas price inputs:

- AUD$6.5/GJ (AEMO Gas Supply Hub, February 2021) with no inflation (base case)
- sensitivities run for AUD$7/GJ, AUD$11/GJ and AUD$14/GJ

These values and sensitivities were based on independent advice suggesting long-run levels below AUD$8/GJ will be hard to achieve given cost estimates of new supply. Unlike energy markets, gas supply is traded via bilateral gas supply contracts, providing much less transparency on pricing. While AEMO's gas supply hub data has been used and peer reviewed by independent experts, note there are additional risk premiums not included, such as carbon price risk, international and domestic production, storage and transport influences, and increasing supply-side constraints. Collectively, these factors are underpinning analysts' forecast of future gas costs considerably higher than legacy contracts.

To include an exhaustive analysis across both lower and higher gas price assumptions, an additional sensitivity was run with gas price inputs of AUD$4/GJ. This price is artificially constructed to be below the credible forecasts of gas prices and is highly unrealistic. However, it still shows that under such an unrealistic assumption, OCGTs are only barely able to compete with battery storage today from an LCOC basis and would still not stack up from an LCOE basis. In addition, capturing the risks from elements such as carbon emissions, downstream production and transport would further dampen the prospects of new-build gas plants in the NEM, even if they could secure artificially lowered gas prices.

LCOC (AUD$/KW/YR)



LCOE (AUD$/MWH)