OXFORD ECONOMICS AUSTRALIA

DISCOUNT RATES FOR ENERGY INFRASTRUCTURE

PREPARED FOR AEMO FOR THE 2026 INTEGRATED SYSTEM PLAN

DECEMBER 2024

OXFORD ECONOMICS AUSTRALIA

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DECEMBER 2024

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KEY TERMS

Key Terms	Definition
Asset lifecycle	The asset lifecycle is the various stages involved in the management of the asset. This goes from planning to construction / acquisition to commercialisation (i.e. when it generates revenue).
Basis points (bps)	This refers to one hundredth of one percentage point. i.e. 100 basis points = 1 percentage point.
Contracted revenue	Refers to future revenue secured through a contract agreement between a buyer and seller.
Construction risk	Risk associated with the construction of an asset, including delays, budget overruns, or environmental factors.
Hurdle rate	The hurdle rate is the minimum rate of return on a project or investment required by a manager or investor.
Idiosyncratic risk	This refers to asset-specific risks. This risk can be diversifiable.
Merchant risk	Refers to the financial risk faced by energy producers whose revenues depend on fluctuating market prices, without the protection of subsidies or fixed contracts.
National Electricity Market (NEM / The Grid)	The NEM is a wholesale market through which generators and retailers trade electricity in Australia. It interconnects the six eastern and southern states and territories and delivers around 80% of all electricity consumption in Australia. Western Australia and the Northern Territory are not connected to the NEM.
Non-regulated assets	Assets where revenue or prices charged for providing services are determined through third-party arbitration.
Offtake agreement	An offtake agreement is an agreement to buy or sell, in advance, production from an energy asset.
Policy risk	The risk that changes in government policies, regulations, or incentives could affect the return of an investment.
Power Purchase Agreement (PPA)	A power purchase agreement (PPA) is an offtake agreement to buy or sell, in advance, production from an energy asset.
Regulated assets	Assets for which revenue or prices charged for providing electricity network services are determined by a regulatory distribution determination, that of the Australian Energy Regulator (AER).
Systematic risk	This refers to risks that affect an entire system, and can be attributed to economic, socio-political, or other market-related events.
Technology risk	The uncertainty surrounding whether a technology will perform as intended, remain competitive, or avoid being rendered obsolete by market shifts
Technology-neutral discount rate	The technology-neutral discount rate determines the present value of future costs and benefits related to energy provision in the Integrated System Plan (ISP).
Weighted average cost of capital	The estimated overall cost of capital required by an investment, calculated by weighting the cost of equity and the cost of debt according to their proportions in the investment's capital structure.

EXECUTIVE SUMMARY

This report presents a technology-neutral discount rate and technology-specific weighted average cost of capital (WACC) estimates for energy assets. These estimates will inform AEMO's 2025 Inputs, Assumptions, and Scenarios Report (IASR) and 2026 Integrated System Plan (ISP). The ISP is a whole-of-system plan that provides an integrated roadmap for the efficient development of the National Electricity Market (NEM) over the next 20 years and beyond.

The WACC estimates are commensurate with commercially-orientated investments considered for projects included in the ISP, specifically those that have not yet achieved a positive final investment decision. Given the methodology used in the ISP modelling, the discount rate and cost of capital estimates are presented in real pre-tax terms.

This research extends on prior research completed over the past few years in two primary ways:

- By separately estimating the technology-neutral discount rate and technology-specific WACCs AEMO is better able to inform differences in the ongoing finance costs of projects based on different technologies,
- By forecasting these rates across different scenarios AEMO is better able to foresee expected changes in the cost of capital over time and across the three primary scenarios for the ISP.

Technology-neutral discount rate

The technology-neutral discount rate is used in the ISP modelling to estimate the current value of future costs and benefits of energy provision.

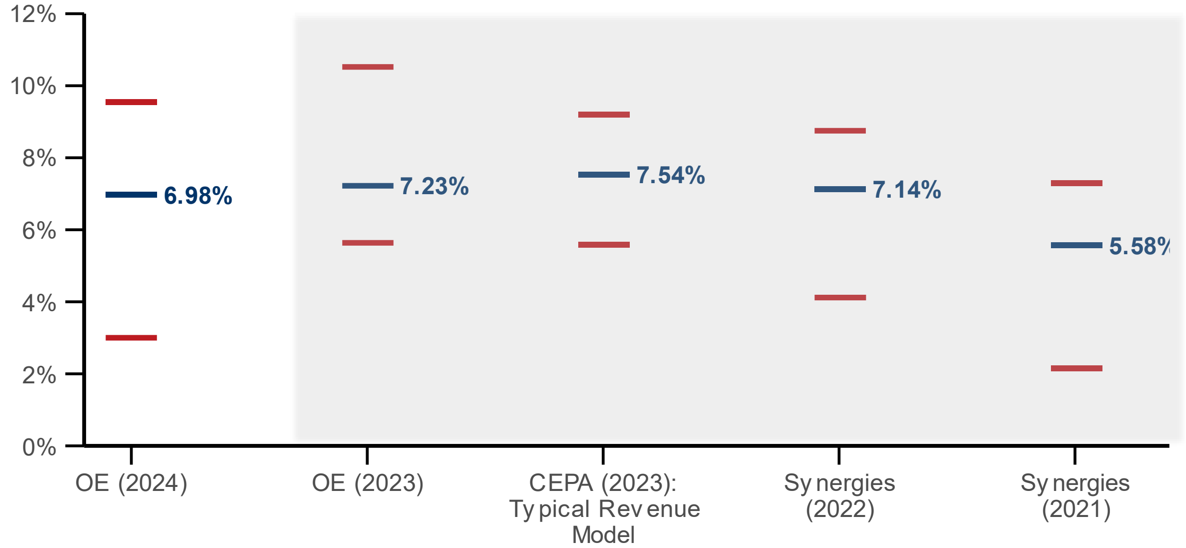
As per Fig. 1, we estimate the current rate to be 6.98%, slightly lower than comparable estimates produced over the last few years. This is in part due to lower expected inflation as well as a decline in credit spreads causing debt risk premiums to narrow. The RBA has attributed this compression to strong investor demand for Australian corporate bonds despite continued robust issuances by Australian corporations.[1]

The lower estimate is also driven by a methodological choice to restrict the sample period for calculating the market risk premium (MRP) to post-1988. We agree with the Australian Energy Regulator's (AER's) view that 1988 onwards is representative of modern macroeconomic conditions and current investor expectations. This approach is validated by the market view of the MRP collected by the survey results. A more detailed explanation can be found in section 3.4 and the Technical Appendix

The recommended discount rate is conventionally rounded to the closest 50 basis points to reflect the inherent uncertainty and limitations of the data informing the calculations. In support of this approach **we recommend that the current discount rate used in the 2026 ISP is 7.0%.**

[1] RBA (2024) *Statement on Monetary Policy – November 2024: 1. Financial Conditions.* Accessed November 2024. Available here.

Fig. 1. Technology neutral real pre-tax discount rate estimates



Note: The blue line represents the central estimate, red lines indicate the upper and lower bounds, and the shaded grey area are benchmark comparisons.
Source: Oxford Economics (2024); Synergies (2021 & 2022)[2], Cambridge Economic Policy Associates (CEPA) (2023)[3] and Oxford Economics (2023)[4]

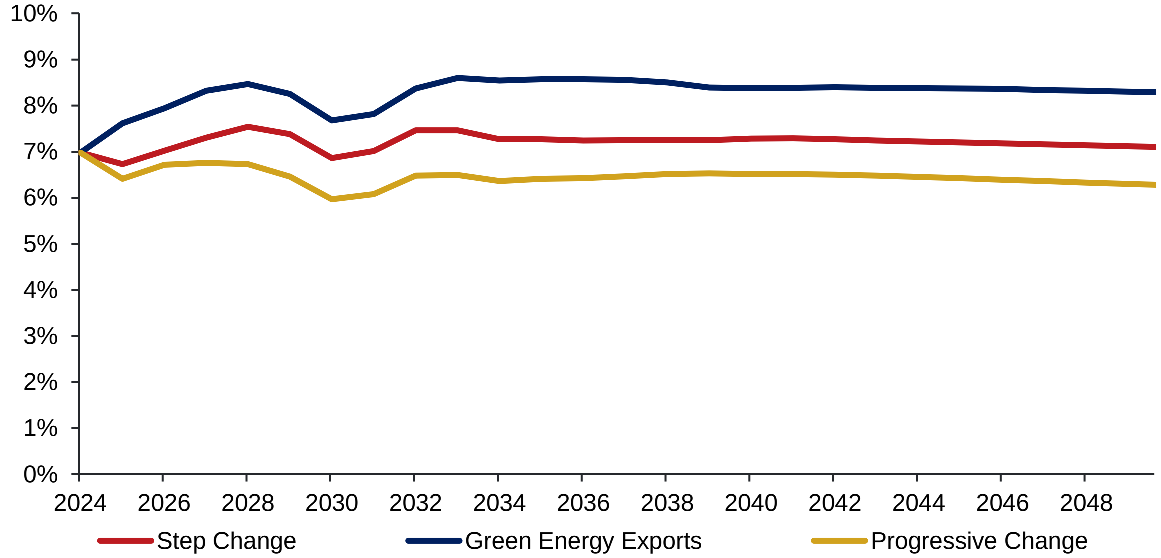
The lower bound estimate of the technology-neutral discount rate is 3.0%. Per AER guidance, the lower bound is an inflation-adjusted simple average of the AER's most recent determinations published in September and November 2024.[5]

The upper bound is 9.5% and is a simple average of the upper bounds reported by survey respondents applied to the recommended discount rate. The technology-neutral upper bound (+2.6%) is smaller in magnitude than what was used for the 2024 ISP (+3.3%). The difference is primarily because we recommend using an average of both regulated and unregulated assets while only unregulated asset responses underpinned the estimate applied in the 2024 ISP. This estimate broadly aligns with Infrastructure Australia's upper sensitivity of 10%.[6]

Beyond the current estimate of the technology-neutral discount rate we have also developed indicative projections to reflect changes to the risk-free rate under each of the three scenarios to be used in the 2026 ISP: *Progressive Change, Step Change, Green Energy Exports,* listed in order of decarbonisation pace from slowest to fastest.

[2] Synergies (2022) *Updating the 2022 ISP Discount Rate.* Accessed November 2024. Available here.
[3] CEPA (2023) *WACC Assumptions.* Accessed November 2024. Available here.
[4] Oxford Economics (2023) *Cost of Capital Survey 2023.* Accessed November 2024. Available here.
[5] The nominal vanilla rate of return from the three most recent determinations was converted to real rates using the 2.85% expected inflation cited in each of the three: AER (2024) *Draft Decision: Jemena Gas Networks.* Accessed November 2024. Available here; AER (2024) *Draft Decision: SA Power Networks Electricity Distribution.* Accessed November 2024. Available here; AER (2024) *Draft Decision: Ergon Energy Electricity Distribution.* Accessed November 2024. Available here.
[6] Infrastructure Australia (2021) *Guide to economic appraisal.* Accessed November 2024. Available here.

Fig. 2. Technology-neutral discount rate by scenario



Source: Oxford Economics (2024)

There is limited movement in the technology-neutral discount rate in the Step Change scenario – it remains within a 0.5% range suggesting that the trade-off between current and future costs and benefits will remain similar to the present environment.

Under the Green Energy Exports scenario there is a greater discount placed on future cash flows as the market competes for capital in a buoyant economic environment. The impact is moderated by higher expected inflation but not by enough to dampen a structurally higher discount rate which averages 8.3% over the forecast period. Conversely under the progressive change scenario lower economic activity reduces the risk-free rate leading future cash flows to be discounted less severely. The technology neutral discount rate averages 6.4% under the Progressive Change scenario.

Technology-specific weighted average cost of capital

Technology-specific WACC estimates inform the financing costs of projects based on different technologies considered in the ISP. These estimates are based on a combination of information sourced from a survey of energy sector stakeholders, macroeconomic modelling and global data gathering.

As per Fig. 2, regulated transmission and distribution assets for gas and electricity attract the lowest cost of capital at 3.0% - equivalent to the AER's latest determinations for such assets. Unregulated electricity transmission and distribution assets have a recommended WACC of 6.5%, slightly lower than 7.0% for unregulated gas transmission and distribution which faces greater policy risk.

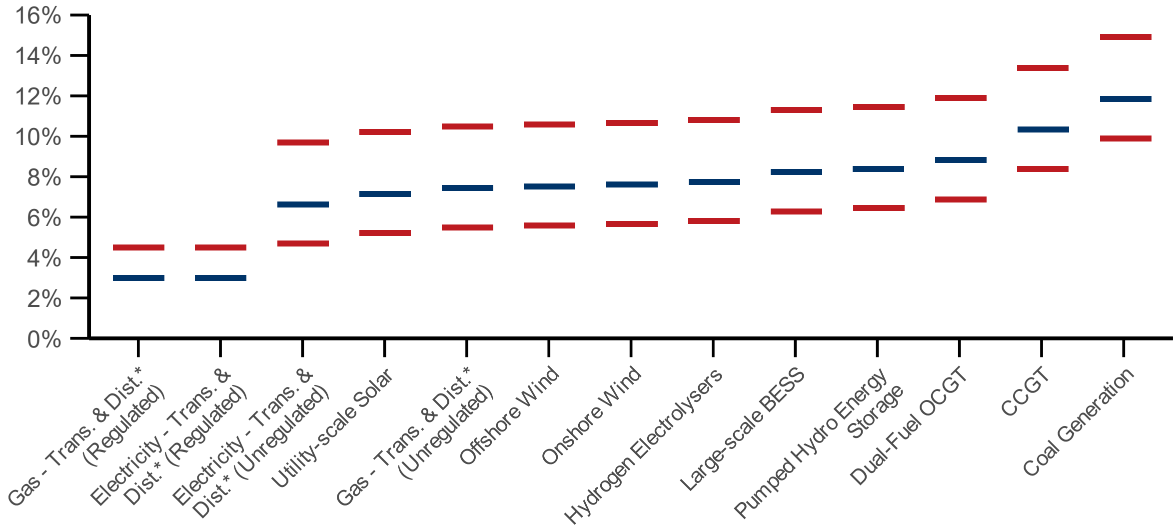
Utility-scale solar and onshore wind follows with a WACC estimate of 7.0% and 7.5% respectively. The maturity of these technologies from a construction and revenue model perspective supports their low cost of capital.

Our estimate of offshore wind is notably low at 7.5%. Our research suggests this is a reflection of the certainty of future revenues based on long term government secured offtake agreements in place to ensure the first tranche of projects are commercially viable.

Battery energy storage systems (BESS) and pumped hydro systems are estimated to attract a WACC of 8.0% and 8.5% respectively. The higher WACC largely reflects the greater revenue uncertainty associated with BESS and greater construction risks associated with pumped hydro.

While we have included estimated WACCs for hydrogen electrolysers, dual-fuel OCGT, CCGT and coal generation these estimates should be viewed with a low degree of confidence as fewer (if any) commercial projects using these technologies for large scale energy generation are at final investment decision.

Fig. 3. Technology-specific real, pre-tax WACC estimates

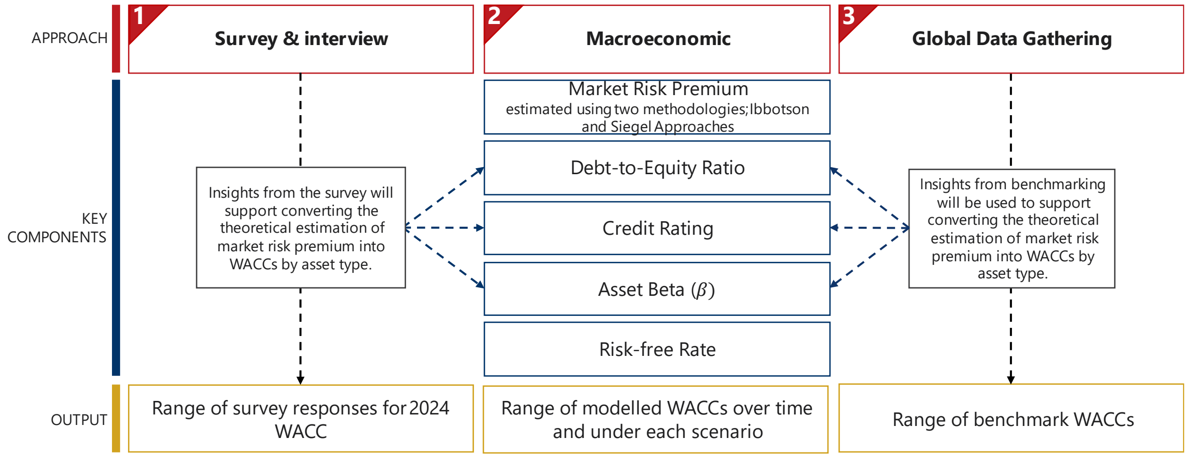


Note: The blue line represents the central estimate and the red lines indicate the upper and lower bounds. 'Trans. & Dist.' stands for transmission and distribution.
Source: Oxford Economics (2024)

Research approach

These results are based on information gathered from three distinct research approaches: conventional macroeconomic modelling for WACC estimates, a survey of energy sector stakeholders, and benchmarking.

Fig. 4. Research framework



Source: Oxford Economics

The macroeconomic modelling forms the core system of calculations used to estimate the discount rate and WACCs. Within the broader WACC model, three different methodologies were adopted to estimate the Market Risk Premium (MRP):

- **Ibbotson approach**: deriving a historical long-run MRP based on observed market returns.
- **Siegel approach**: adjusting the Ibbotson approach for unexpected inflation.
- **Survey average**: the average MRP reported by survey respondents.

The survey of energy market stakeholders was used to gather technology-specific input data within the context of the Australian market. These inputs were fed into the WACC model to inform the technology-specific cost of capital results.

Finally, a data gathering process was undertaken to further inform technology-specific WACC inputs and provide benchmarks to compare our results against.

Consultation and further research

This report is prepared for AEMO's *Draft 2025 Inputs, Assumptions and Scenarios Report*, scheduled for December 2024, and the final version *2025 Inputs, Assumptions and Scenarios Report*, planned for July 2025. We look forward to presenting the analysis and receive feedback from groups such as the *Forecasting Reference Group*, the *ISP Consumer Panel* and the *Consumer and Community Reference Group* in the next few months. This feedback will be consolidated and addressed before publication of our final report with the *2025 Inputs, Assumptions and Scenarios Report*.

In preparing this report we've identified the following areas for to be considered for further research:

- Extended survey analysis and stakeholder interviews specific to the following technologies which we've received limited data for to date: coal generation, dual-fuel OCGT and CCGT with CCS technologies and hydrogen electrolysers, gas plant & pipeline.
- Greater analysis of the implication on WACC of government support provided to various technologies under the three ISP scenarios.
- An update of inputs in 6-12 months to consider the market's response to the inauguration of President-elect Trump, the Federal election in Australia and changes to interest rates.

1. INTRODUCTION

This report presents a technology-neutral discount rate and technology-specific cost of capital estimates for energy infrastructure. These estimates will be used in AEMO's Inputs, Assumptions, and Scenarios Report (IASR) and Integrated System Plan (ISP). The ISP is a whole-of-system plan that provides an integrated roadmap for the efficient development of the National Electricity Market (NEM) over the next 20 years and beyond.

In the ISP, the technology-neutral discount rate is used to discount future costs and benefits of energy provision to appropriately reflect the time value of money. The technology-specific weighted average cost of capital (WACC) estimates inform the financing costs of different projects considered as part of the optimal future energy mix.

The estimates are commensurate with commercially-orientated investments considered for projects included in the ISP. Given the methodology used in the ISP modelling, the cost of capital and the discount rate are presented in real pre-tax terms. The technologies included in this research are listed below:

- Energy Transmission and Distribution
- Gas Transmission and Distribution
- Utility-Scale Solar
- Onshore Wind
- Offshore Wind
- Large-scale Battery Energy Storage System (BESS)
- Pumped Hydro Energy Storage (PHES)
- Dual-Fuel Open Cycle Gas Turbines (OCGT)
- Combined Cycle Gas Turbines (CCGT)
- Coal Powered Generation
- Hydrogen Electrolysers
- Gas Plants and Pipelines

Lower and upper bound estimates are also included for both the technology-neutral discount rate and the technology-specific cost of capital inputs. Forward looking sensitivities of the estimates are also included for each of AEMO's three scenarios: Green Energy Exports, Step Change and Progressive Change.

The results are based on a combination of information gathered from three distinct research approaches: a survey of energy sector stakeholders, macroeconomic modelling and benchmarking. Each approach serves a specific purpose while also providing a comparison to corroborate parameters and findings. A detailed explanation of each approach is included in chapter 2 and the Technical Appendix. Results are presented in chapters 3 and 4 with the forward-looking view presented in chapter 5.

2. RESEARCH APPROACH

This chapter presents an overview of the approach and key limitations. The purpose of the chapter is to support understanding of the results presented in chapters 3 and 4.

The WACC estimates are required to be commensurate with commercially-orientated investments considered for projects included in the ISP. The WACC of any given project changes as the investment moves from concept stage through to construction and operation. The WACCs estimated for this work are broadly based on the cost of debt and equity at the point of final investment decision. Given the methodology used in the ISP modelling, the discount rate and cost of capital estimates are presented in real pre-tax terms.

Further methodological information is presented in the Technical Appendix.

2.1 ESTIMATION METHODOLOGY

This research applies a conventional WACC calculation to estimate the discount rate. The pre-tax real WACC can be expressed as:

$$Pre-tax\ real\ WACC=\left\{\frac{1+Pre-tax\ nominal\ WACC}{1+CPI}\right\}-1$$

And pre-tax nominal WACC can be expressed as:

$$\text{Pre}-\text{tax nominal WACC}=Ke*\frac{1}{\{1-t*(1-\gamma)\}}*\frac{E}{V}+Kd*\frac{D}{V}$$

Where:

$Ke=$ post − tax return on equity

$Kd=$ post − tax return on debt

$E/V=$ proportion of equity within the capital structure

$D/V=$ proportion of debt (gearing)within the capital structure

$t=$ corporate tax rate

$\gamma=$ value of imputation credits

The post-tax return on equity is estimated using the Sharpe-Lintner Capital Asset Pricing Model (SLCAPM) – underpinned by three methodologies to estimate the Market Risk Premium (MRP):

- **Ibbotson**: deriving a historical long-run MRP based on observed market returns.
- **Siegel**: adjusting the Ibbotson approach for unexpected inflation.
- **Survey**: the average MRP reported by survey respondents.

An on-the-day estimate of debt is used to determine the post-tax return on debt and can be expressed as:

$$K_d=R_f+DRP$$

$$K_d = \text{Cost of debt}$$

$$R_f = \text{Risk} - \text{free rate}$$

$$DRP = \text{The debt risk premium } (\textit{proxied by the credit rating})$$

Technology-specific WACCs replace the asset beta, gearing and the debt risk premium with technology-specific parameters based on data collected from the survey for each technology. For technology-neutral components the technology-specific WACCs adopt the same estimate as the technology-neutral discount rate.[7] These variables are then benchmarked against a comparator sample of financial market data and international benchmarks where available.

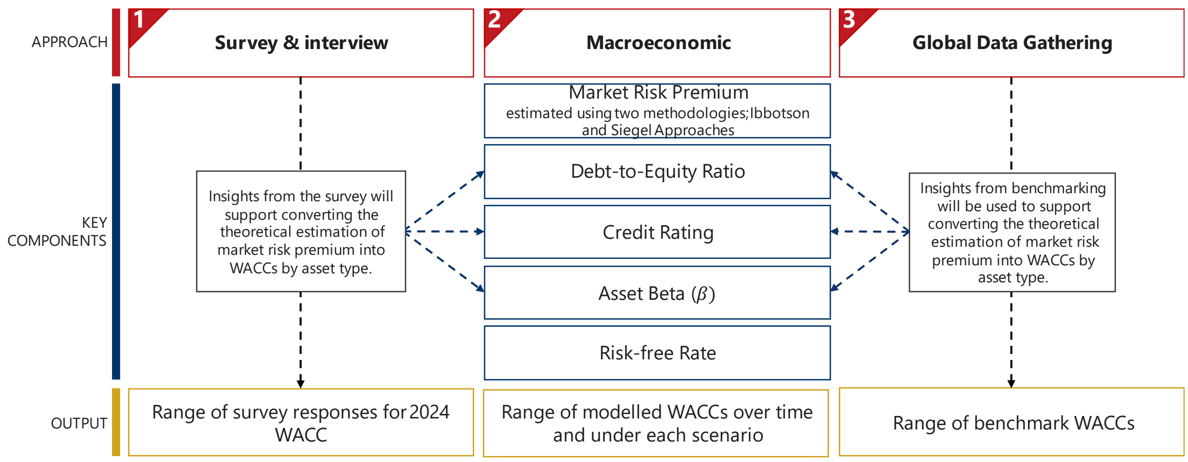
Forward-looking projections of the WACC for AEMO's three scenarios have been estimated by adjusting the risk-free rate and expected inflation. This estimate gives information about how the WACC may change over time in reaction to faster or slower economic growth.

2.2 INFORMATION GATHERING

Our research utilised three distinct approaches to gather relevant and timely information:

1. a survey (and interviews) of energy sector stakeholders,
2. financial and macroeconomic data, and
3. relevant domestic and international benchmarks.

Fig. 5. Research framework



Source: Oxford Economics

The survey of energy market stakeholders was used to gather timely information within the context of the Australian market. 108 organisations were invited to respond to the survey, of which 21 did. These responses provided 93 technology-specific observations (i.e. one company may have provided a response for both utility-scale solar and onshore wind).

Survey results were used as an input to the technology-neutral discount rate to inform the MRP alongside macroeconomic estimates based on the Ibbotson and Siegel approach.

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[7] See Fig. 16 for a breakdown of the source of each component of the technology-specific WACCs.

The survey results were more extensively used for the technology-specific WACC estimates to capture the systematic risks of technology-specific assets (represented by beta), and the typical gearing ratio and credit rating for specific technologies.

A secondary purpose of the survey was to gather headline WACC estimates to benchmark the calculated results against the pure market perception of survey respondents.

Macroeconomic and financial time series data was collected to inform core inputs to the WACC calculation including the risk-free rate and inflation expectations. The risk-free rate is based on a 20-day average of the 10-year Commonwealth Government bond yield. As of 24 October 2024, the estimated yield was 4.20%.

Expected inflation has been estimated using the 'break-even' methodology. This method estimates inflation as the difference between forward-looking yields on nominal long-term government bonds and on indexed bonds utilising the Fisher Equation.[8] The RBA publishes daily yields for both series. To ensure consistency with the risk-free rate and debt risk premium we adopt a 20-day averaging approach to 24 October 2024.

Finally, global financial data was gathered to inform the gamma and gearing levels for the technology-neutral discount rate calculation. This approach identified 44 relevant companies from across the world to estimate the systematic risk based on the historical relationship between these companies' equity returns compared to the market as a whole.

[8] AER (2017) *Regulatory treatment of inflation: discussion paper.* Accessed November 2024. Available here.

3. TECHNOLOGY-NEUTRAL DISCOUNT RATE

This chapter presents the economic rationale for the recommended technology-neutral discount rate.

Per the AER's guidelines, the purpose of the discount rate is, "to compare costs and benefits received at different points in time. It reflects the opportunity cost of cash flows associated with investments in terms of delays to consumption or alternative investment opportunities forgone. The discount rate in the ISP is required to be appropriate for the analysis of private enterprise investment in the electricity sector across the National Electricity Market (NEM)."[9]

Our recommended estimate builds on the work by Synergies (2022)[10], CEPA (2023)[11] and Oxford Economics (2023)[12] and aligns to these methodologies to generate a consistent and comparable body of work over time.

Our recommended central, lower and upper bound technology-neutral discount rates (rounded to 0.5%) are as follows:

- Lower bound - 3.0%[13]
- Central - 7.0%
- Upper bound – 9.5%

[9] AER (2024) *Cost benefit analysis guidelines.* Accessed November 2024. Available here.

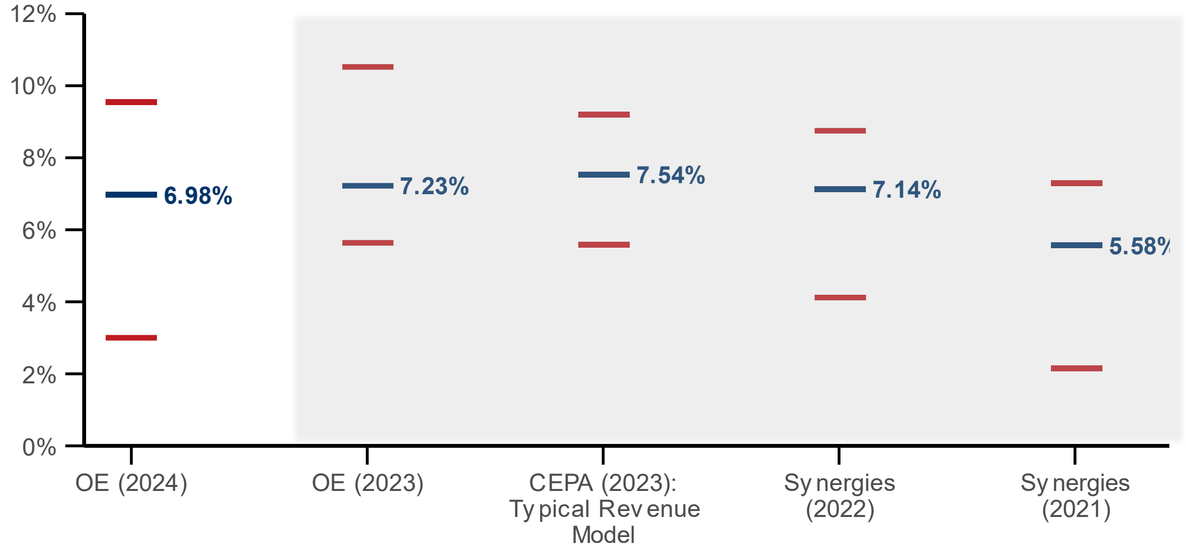
[10] Synergies (2022) *Updating the 2022 ISP Discount Rate.* Accessed November 2024. Available here.

[11] CEPA (2023) *WACC Assumptions.* Accessed November 2024. Available here.

[12] Oxford Economics (2023) *Cost of Capital Survey 2023.* Accessed November 2024. Available here.

[13] Per AER's most recent determinations. Ergon Energy (20 September 2024), SA Power Networks (20 September 2024), Jamina Gas Network (20 November 2024). Available here, here and here.

Fig. 6. Technology neutral discount rate estimates & benchmarks



Note: The blue line represents the central estimate, red lines indicate the upper and lower bounds, and the shaded grey area are the benchmark comparisons.
Source: Oxford Economics (2024); Synergies (2021 & 2022)[14], CEPA (2023)[15] and Oxford Economics (2023)[16]

The central technology-neutral discount rate is estimated using a conventional WACC calculation as described in chapter 2. The key parameters underpinning our central estimate are presented below and discussed in the body of the chapter.

Fig. 7. Technology-neutral WACC components

Parameter	Central Estimate
Risk-free rate	4.20%
Gearing ratio	50%
Gamma	0.25
Corporate tax rate	30%
CAPM Parameters	
Market risk premium (MRP)	5.87%
Asset beta	0.5
Equity beta	1
SL CAPM return on equity	10.07%
Debt Parameters	
Debt beta	0
Debt risk premium*	1.55%
Debt raising costs	0.10%
Return on debt (pre-tax)	5.85%

[14] Synergies (2022) *Updating the 2022 ISP Discount Rate.* Accessed November 2024. Available here.
[15] CEPA (2023) *WACC Assumptions.* Accessed November 2024. Available here.
[16] Oxford Economics (2023) *Cost of Capital Survey 2023.* Accessed November 2024. Available here.

Expected inflation	2.28%
Nominal pre-tax WACC	**9.42%**
Real pre-tax WACC	**6.98%**

*A BBB rating is used for the central estimate.
Source: Oxford Economics (2024)

The lower bound estimate is 3.0%. This is an inflation-adjusted simple average of the AER's most recent determinations published in September and November 2024.[17] Per the AER's guidelines, "The lower boundary should be the regulated cost of capital, based on the AER's most recent regulatory determination at the time of the final ISP."[18]

The upper bound is 9.5% and is a simple average of the upper bounds reported by survey respondents applied to the recommended discount rate. The technology-neutral upper bound (+2.6%) is smaller in magnitude than what was used for the 2024 ISP (+3.3%). The difference is primarily because we recommend using an average of both regulated and unregulated assets while only unregulated asset responses underpinned the estimate applied in the 2024 ISP. This estimate broadly aligns with Infrastructure Australia's upper sensitivity of 10%.[19]

3.1 RISK-FREE RATE

The risk-free rate is the theoretical rate of return on an investment that carries zero risk of financial loss and is typically represented by the 10-year Commonwealth bond yield. 10-year Commonwealth bond yields reflect current market expectations for growth and inflation.

Fig. 8. Risk-free rate over time

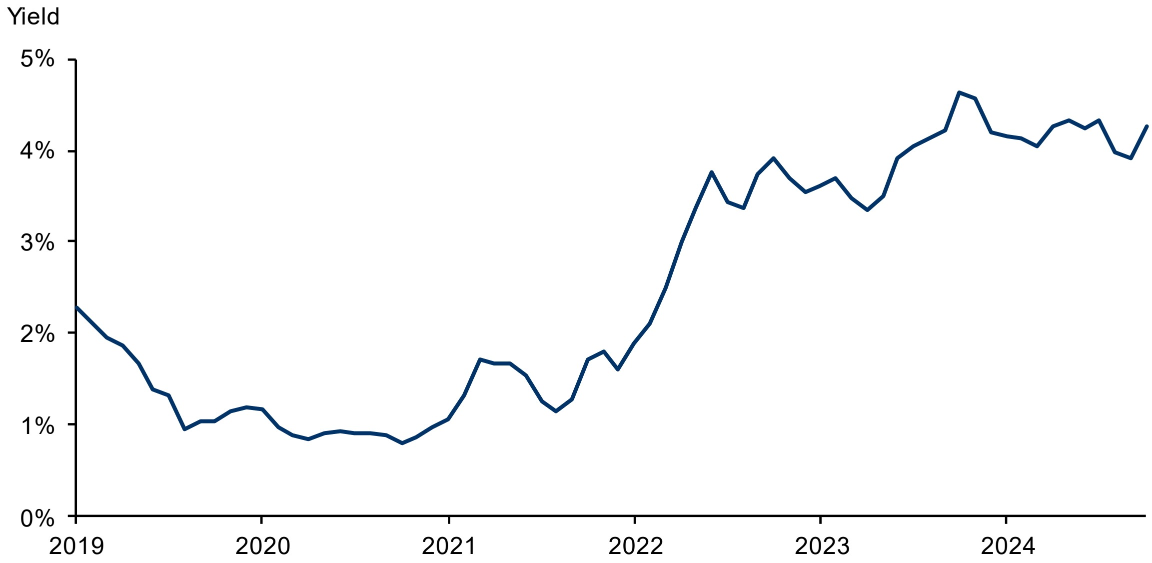
	OE (2024)	OE Survey Average (2024)	AER (2023)	OE (2023)	CEPA (2023)	Synergies (2022)	Synergies (2021)
Risk-free rate	4.20%	4.00%	4.27%	3.92%	3.75%	3.82%	1.63%

Source: Oxford Economics (2024), CEPA (2023), Synergies (2021 & 2022), AER (2023)

Changes in the risk-free rate reflect changes to the market outlook. Australia's 10-year bond yields fell to 1% at the onset of the 2020 pandemic, reflecting the Reserve Bank of Australia's (RBA) historic cash rate cut to 0.10% and low growth and inflation expectations. However, as inflation surged following the easing of pandemic restrictions and rising geopolitical tensions, the 10-year bond yield climbed sharply, reaching 4.35% by the end of 2023.

[17] The nominal vanilla rate of return from the three most recent determinations was converted to real rates using the 2.85% expected inflation cited in each of the three: AER (2024) *Draft Decision: Jemena Gas Networks.* Accessed November 2024. Available here; AER (2024) *Draft Decision: SA Power Networks Electricity Distribution.* Accessed November 2024. Available here; AER (2024) *Draft Decision: Ergon Energy Electricity Distribution.* Accessed November 2024. Available here.
[18] AER (2024) *Cost benefit analysis guidelines.* Accessed November 2024. Available here.
[19] Infrastructure Australia (2021) *Guide to economic appraisal.* Accessed November 2024. Available here.

Fig. 9. 10-Year treasury bond yield: 20-day moving average



Source: Haver Analytics, RBA

The average reported risk-free rate across our survey respondents was 4.0% - slightly below the current macroeconomic estimate of 4.2%. Despite the relatively well-anchored estimation of the risk-free rate some interview participants noted that there is a divergence in the risk-free rate between valuers.

We are comfortable with our final estimate of the risk-free rate being higher than previous benchmarks and the survey average as it reflects the current market conditions.

3.2 GEARING RATIO

The gearing ratio measures a company's financial leverage and reflects the proportion of its capital structure financed by debt compared to equity.

To estimate the gearing ratio for the technology-neutral discount rate we utilise financial market data. Due to the scarcity of applicable domestic public companies, a sample of domestic and global listed utility companies in developed economies is adopted.

Fig. 10. Gearing ratios

	OE (2024)	CEPA (2023)	Synergies (2022)
Gearing ratio	50%	50%	50%

Source: Oxford Economics (2024), CEPA (2023), Synergies (2022)

Under our central scenario, this generates a gearing ratio of 50%, which is roughly in line with our survey estimate of 53%. Our market estimates align with the conclusions of the previous two reports, indicating gearing ratios are not subject to a high degree of volatility over time.

3.3 MARKET RISK PREMIUM

The market risk premium is the realised return the market portfolio makes above the prevailing risk-free rate. To estimate the market risk premium we adopt the simple average of the Ibbotson method, Siegel method and an average of our survey responses. We estimate the Siegel approach in place of the Wright approach. The Siegel and Wright approaches are both motivated by attempts to capture the difference between historic expectations of inflation and actual historic inflation.[20] We prefer the Siegel approach as it is internally consistent with the Ibbotson estimate of the MRP and builds upon it.

Fig. 11. Market risk premium estimates

	OE (2024)	OE survey average (2024)	AER (2023)	CEPA (2023)	Synergies (2022)
Market Risk Premium	5.87%	5.97%	6.20%	6.80%	7.13%

Source: Oxford Economics (2024), CEPA (2023), AER (2023), Synergies (2022)

In estimating the MRP using the Ibbotson method we have shortened the sampling period for returns to 1988 onwards. We agree with the AER view adopted in 2018 and reaffirmed in 2022 that post-1988 data is more representative of modern macroeconomic conditions and current investor expectations. AER highlight that during this time a series of major macroeconomic and market reforms took place including the dollar being floated (1984), the system of imputation tax beginning (1987), and the RBA's inflation-targeting regime of 2-3% beginning in the early 1990s and being formalised in 1996.[21]

Synergies utilise data from Brailsford, Handley & Maheshwaran (BHM) to determine historical returns from 1883 onwards in their original estimate of the MRP.[22] Both AER and the Queensland Competition Authority (QCA) have noted concerns about the data quality in the earlier years. Concerns include; the number of listed equities, potential survivorship bias, changes to the market portfolio's characteristics over time and the BHM dataset being constructed from a series of distinct indexes to allow for estimates back to 1883.[23] Despite these concerns about the quality of the early data, regulators differ on when data should be relied upon to estimate the MRP. QCA in their 2021 rate of return review adopted 1958 when the Sydney All Ordinaries Index began being calculated daily as their starting point.

We acknowledge that these methodological differences lead to slight differences in the MRP adopted in previous reports. However our estimates aligns with the current market view as captured in the survey and confirmed when tested in subsequent interviews.

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[20] Capital Financial Consultants (2015) *Review of Submissions on the MRP and the Risk-Free Rate.* Accessed November 2024. Available here; Martin Lally (2014) *Review of Submissions to the QCA on the MRP, Risk-Free Rate and Gamma.* Accessed November 2024. Available here.

[21] AER (2023) *Rate of Return Instrument: Explanatory Statement, p. 141.* Accessed November 2024. Available here; RBA (2024) *Australia's Inflation Target.* Accessed November 2024. Available here.

[22] Tim Brailsford (2012) *The Historical Equity Risk Premium in Australia: Post-GFC and 128 years of Data.* Accessed November 2024. Available here.

[23] AER (2012) *Review of Regime Switching Framework and Critique of Survey Evidence, p. 19.* Accessed November 2024. Available here; QCA (2021) *Rate of Return Review.* Accessed November 2024. Available here.

3.4 ASSET BETA

The asset beta measures companies' systemic risk independent of the effects of debt.

Fig. 12. Asset betas

	OE (2024)	CEPA (2023)	Synergies (2022)
Central estimate	0.5	0.5	0.5

Note: In line with CEPA and Synergies, asset beta estimates are rounded to one decimal place.
Source: Oxford Economics (2024), CEPA (2023), Synergies (2022)

We use financial market data to estimate the asset beta for the technology-neutral discount rate. The financial data consists of a sample of domestic and global listed utility companies in developed economies, due to the scarcity of applicable Australian public companies. This is consistent with previous work completed by Synergies and CEPA.

The asset beta estimate of 0.5 is broadly aligned with the average asset beta observed from the survey results (0.6). The consistency of these findings over time suggests the sampled asset betas are not subject to a high degree of volatility.

3.5 DEBT RISK PREMIUM

The debt risk premium is the additional return lenders require to compensate for the credit risk of a borrower compared to a risk-free investment. It reflects the likelihood of default and is influenced by a borrower's credit rating, financial stability, and prevailing market conditions.

Fig. 13. Credit ratings

	Survey Respondent	Market Comparison	CEPA (2023)	Synergies (2022)
Average	Baa2 (Moodys), BBB (S&P)	Baa1 (Moodys), BBB+ (S&P)	BBB (S&P)	BBB (S&P)

Source: Oxford Economics (2024), CEPA (2023), Synergies (2022)

To determine the technology-neutral credit rating we use the financial market sample alongside the survey results. The average and median credit rating from survey respondents is BBB which aligns with the rating adopted by Synergies and CEPA in previous reports. The financial market sample's average and median credit rating is rated marginally higher at BBB+. We believe that a credit rating of BBB in line with our survey respondents and previous reports is appropriate given the only marginally higher results generated from financial market data since survey respondents provide answers based on prospective investments whereas credit ratings for our financial market sample reflect the credit risk of pre-existing assets.

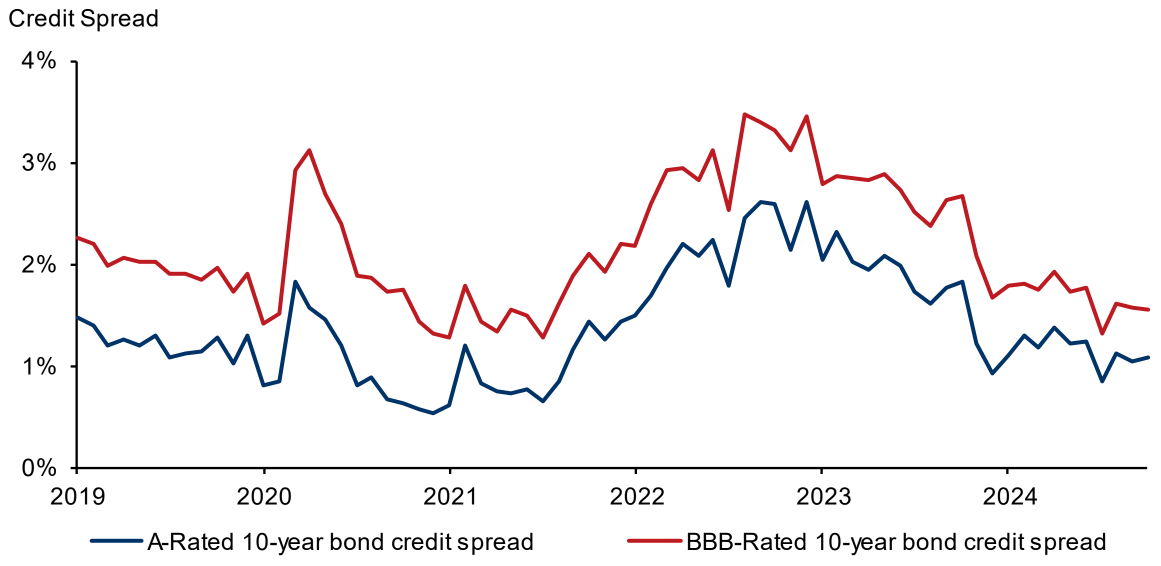
Fig. 14. Debt risk premium

	OE (2024)	CEPA (2023)	Synergies (2022)
Debt Risk Premium	1.55%	2.96%	2.58%

Source: Oxford Economics (2024), CEPA (2023), Synergies (2022)

A credit rating of BBB results in a debt risk premium of 1.55%. Despite our central credit rating being the same as in previous reports we have seen a compression of credit spreads over the last six months causing debt risk premiums to narrow. The RBA has attributed this compression to strong investor demand for Australian corporate bonds despite continued robust issuances by Australian corporations.[24]

Fig. 15. Corporate bond credit spreads by rating



Source: Haver Analytics, RBA

3.6 INFLATION EXPECTATIONS

Inflation is measured by the rate of change in the general level of prices for goods and services. To determine market expectations of inflation over our investment horizon we adopt the breakeven inflation method in line with Synergies and replicated by CEPA.

Fig. 16. Inflation expectations

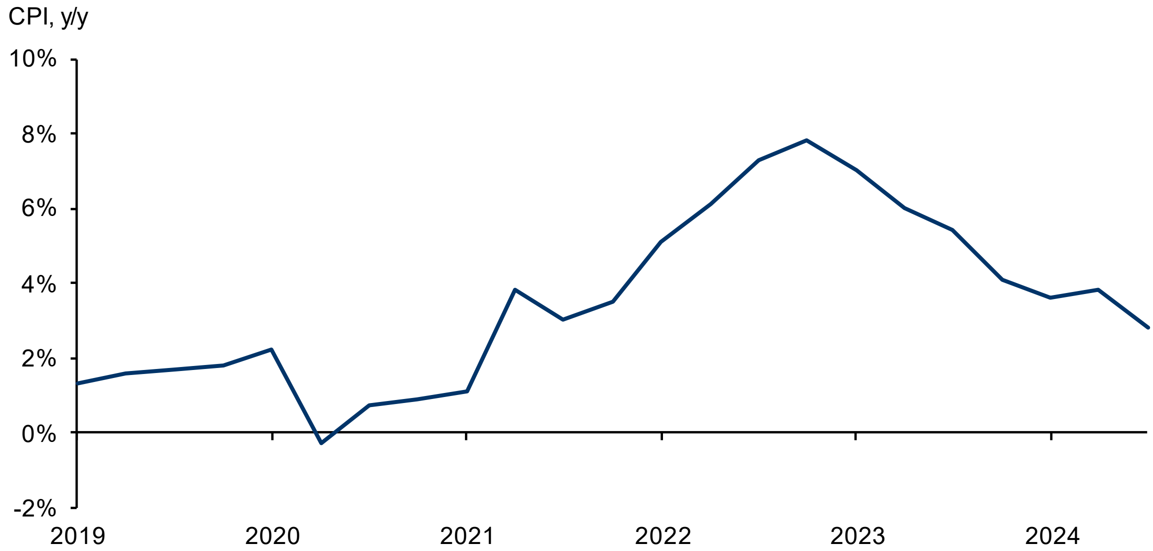
	OE (2024)	AER (2023)*	CEPA (2023)	Synergies (2022)
Inflation expectation	2.28%	2.90%	2.48%	2.96%

*The AER bases their estimate on a 5-year linear glide path methodology that differs from the breakeven method.
Source: Oxford Economics (2024), CEPA (2023), Synergies (2022)

Differences between our estimate of inflation expectations and prior reports reflect changes to the market outlook. Despite, our estimate being slightly below the RBA mid-point of 2.5% it sits within the 2-3% band targeted by the RBA and in line with previous estimates. Forward-looking market expectations for inflation have continued to fall on the back of lower economic growth and the continued normalisation of inflation.

[24] RBA (2024) *Statement on Monetary Policy – November 2024: 1. Financial Conditions.* Accessed November 2024. Available here.

Fig. 17. Consumer price index



Source: ABS

4. TECHNOLOGY-SPECIFIC WEIGHTED AVERAGE COST OF CAPITAL

This section presents the economic rationale for recommended weighted average cost of capital (WACC) estimates for a range of technologies.

The WACC estimates presented below are all real and pre-tax unless stated otherwise. Please see the Technical Appendix for further information on variable definitions and derivations.

4.1 OVERVIEW

Technology-specific WACC estimates inform the financing costs of different technologies included in the ISP.

To estimate a real, pre-tax WACC for each technology type we utilise survey data to generate technology-specific parameters (gearing ratio, asset beta, credit rating). Respondents were asked to provide technology-specific estimates for key components of the WACC calculation as well as the headline WACC to enable comparison and validation of the results.

Technology-neutral parameters such as the risk-free rate are consistent with estimates utilised for the technology-neutral discount rate discussed above and do not vary between technologies.

Fig. 18. Technology-specific WACC components

Parameter	Estimate	Methodology
Risk-free rate	Technology-neutral	Macroeconomic estimate
Gearing ratio	Technology-specific	Survey average
Gamma	Technology-neutral	Macroeconomic estimate
Corporate tax rate	Technology-neutral	Assumption
CAPM Parameters		
Market risk premium (MRP)	Technology-neutral	Macroeconomic estimate
Asset beta	Technology-specific	Calculation
Equity beta	Technology-specific	Survey average
SL CAPM return on equity	Calculation	Calculation
Debt Parameters		
Debt beta	Technology-neutral	Assumption
Credit rating	Technology-specific	Survey average
Debt risk premium*	Technology-specific	Macroeconomic estimate based on credit rating
Return on debt (pre-tax)	Calculation	Calculation
Expected inflation	Technology-neutral	Macroeconomic estimate

Nominal pre-tax WACC	Calculation	Calculation
Real pre-tax WACC	Calculation	Calculation

Source: Oxford Economics (2024)

This rationale for the recommended central WACC for each technology is discussed in turn below.

Fig. 19. Technology-specific WACC, central, lower & upper bound

Technology	Lower Bound	Central Estimate	Upper Bound
Electricity - Transmission & Distribution (Regulated)	3.0%	3.0%	4.5%
Electricity - Transmission & Distribution (Unregulated)	4.5%	6.5%	9.5%
Gas - Transmission & Distribution (Regulated)	3.0%	3.0%	4.5%
Gas - Transmission & Distribution (Unregulated)	5.5%	7.0%	10.5%
Utility-scale Solar	5.0%	7.0%	10.0%
Onshore Wind	5.5%	7.5%	10.5%
Offshore Wind	5.5%	7.5%	10.5%
Large-scale BESS	6.5%	8.0%	11.5%
Hydrogen Electrolysers	6.0%	8.0%	11.0%
Pumped Hydro Energy Storage	6.5%	8.5%	11.5%
Dual-Fuel OCGT	7.0%	9.0%	12.0%
CCGT	8.5%	10.5%	13.5%
Coal Generation	10.0%	12.0%	15.0%

Note: Estimates are conventionally rounded to the nearest 0.5 percentage points.
Source: Oxford Economics (2024), AER (2023)

We utilise survey data to calculate the upper & lower bounds. Survey respondents were asked to provide an upper & lower bound to their regulated & unregulated assets and we apply a simple average of these responses to the central estimate depending on whether technology type is regulated or unregulated.

Fig. 20. Upper & lower bound adjustments

	Lower	Upper
Technology-specific – regulated	Equal to AER determination	+1.5%
Technology-specific – unregulated	-1.9%	+3.1%

Source: Oxford Economics (2024)

4.2 ELECTRICITY TRANSMISSION & DISTRIBUTION

Electricity transmission and distribution are vital for delivering electricity around the NEM.[25] As the electricity generation sector transitions to renewable energy, around 34 transmission augmentation projects have been announced.[26]

Survey results and interviews highlighted that the WACC and risk profile for electricity transmission & distribution assets are broadly equivalent and as such we consider them together.

Fig. 21. Electricity transmission and distribution real pre-tax WACC estimates

	WACC (real, pre-tax)	
	Regulated	Unregulated
Recommended WACC	**3.0%**	**6.5%**
Estimated WACC	-	6.6%
Comparable benchmarks		
OE 2024 (Survey average)	4.4%	6.8%
AER determination	3.0%	-

Source: Oxford Economics (2024), AER (2023)

4.2.1 Regulated assets

We recommend a central WACC estimate of 3.0% for regulated electricity transmission and distribution assets equivalent (with a 0.5% rounding) to the inflation-adjusted simple average of the AER's most recent determinations published in September and November 2024.[27]

Survey responses consistently highlighted the AER's Rate of Return Instrument as a key point of reference for estimating WACC for regulated electricity transmission and distribution assets. Furthermore, interview respondents frequently mentioned that their expectations for returns on these assets are closely aligned with the AER's approach.

The simple average of the headline survey response for regulated electricity transmission & distribution assets is slightly higher but likely reflects previous determinations which were higher than current levels.

4.2.2 Unregulated assets

We recommend adopting a central WACC estimate of 6.5% for unregulated electricity transmission and distribution assets. [28]

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[25] Electricity transmission networks are responsible for carrying electricity from power plants to the distribution network, while distribution networks deliver electricity to end consumers.

[26] AEMO (2024) *Transmission augmentation information*. Accessed November 2024. Available here.

[27] The nominal vanilla rate of return from the three most recent determinations was converted to real rates using the 2.85% expected inflation cited in each: AER (2024) *Draft Decision: Jemena Gas Networks.* Accessed November 2024. Available here; AER (2024) *Draft Decision: SA Power Networks Electricity Distribution*. Accessed November 2024. Available here; AER (2024) *Draft Decision: Ergon Energy Electricity Distribution*. Accessed November 2024. Available here.

[28] We do not report individual WACC components for technologies with fewer than 5 underlying responses. The WACC for unregulated electricity transmission & distribution has 4 responses.

For the asset beta and credit rating the survey responses for technology-specific WACC components align with financial market benchmarks for listed electricity utilities. However, we do see a disparity in the gearing levels.

- The average asset beta implied in the survey is comparable to the electric utilities benchmark (0.48 vs. 0.51).
- The average credit rating reported was one rating higher in the survey than the market (A3/A– vs. Baa1/BBB+).
- Reported gearing levels are notably higher (60% vs. 43%). This is likely in part reflective of the fact our electric utilities market sample includes companies that are exposed to assets involved in generation and storage.

Survey results indicate that the real pre-tax WACC for unregulated electricity transmission assets is approximately 2 percentage points higher than for regulated distribution assets, resulting in an estimate of 6.50%. Interview respondents note this premium reflects greater merchant risk for unregulated assets compared to their regulated counterparts.

We therefore recommend a real, pre-tax WACC estimate of 6.5% for unregulated electricity transmission and distribution assets with a medium degree of confidence. Noting survey engagement with unregulated electricity distribution and transmission was lower than the engagement we had for regulated assets.

4.3 GAS TRANSMISSION & DISTRIBUTION

Gas transmission and distribution[29] are classified as either regulated or unregulated, with the former subject to oversight and charges set by the AER, while the latter operates on commercial terms with charges determined through arbitration.[30] Though there is some uncertainty over the future of gas, gas pipeline infrastructure continues to expand, highlighted by the stage 1 expansion of the South-West Queensland Pipeline.[31]

Survey results and interviews highlighted that the WACC and risk profile for gas transmission & distribution assets are broadly equivalent and as such we consider them together.

Fig. 22. Gas transmission and distribution real pre-tax WACC estimates

	WACC (real, pre-tax)	
	Regulated	Unregulated
Recommended WACC	**3.0%**	**7.0%**
Estimated WACC	-	7.0%
Comparable benchmarks		
OE 2024 (Survey average)	-	7.2%
AER determination	3.0%	-

Source: Oxford Economics 2024, AER (2023)

[29] Gas transmission pipeline refers to the transportation of gas from production facilities to the distribution network, while distribution pipeline involves delivering gas to end consumers. It does not include gas storage or import terminals.
[30] AER (2023) *State of the Energy Market 2023: Regulated Gas Pipelines*. Accessed November 2024. Available here.
[31] AEMO (2024) *2024 Gas Statement of Opportunities.* Accessed November 2024. Available here.

4.3.1 **Regulated**

Survey engagement for regulated gas transmission and distribution was very low.[32] Given the industry alignment with the AER's Rate of Return instrument we did not attempt to increase survey volumes through interviews and instead focused on other technologies with low responses.

We recommend adopting a central WACC estimate of 3.0% in line with AER's most recent determination for regulated assets.

4.3.2 Unregulated

We recommend a central WACC estimate of 7.0% for unregulated gas transmission and distribution.[33]

Technology-specific WACC components for unregulated gas transmission and distribution are not well-aligned to financial market benchmarks for gas utilities though there are a number of commercial reasons this may be the case. These trends are also reflected in the CCGT survey data which was well responded to (reducing the likelihood these trends are due to the small sample size for unregulated gas).

- Survey asset betas were higher than financial market benchmarks (0.58 vs 0.36) as well as credit ratings (BBB vs A2). Sample market comparators for the sub-industry of gas utilities was also small (n=4) which does give lower confidence in the values within our comparator sample. However, the higher survey values align with follow-up interviews which highlighted the policy risk surrounding the future of gas and therefore new investment in unregulated gas distribution and transmission infrastructure.
- The gearing ratio of our survey and financial market benchmarks broadly aligned (50% vs 54%).

Recent policy actions, including the restriction on new gas connections by the ACT, Victoria, and several councils in New South Wales, have contributed to increased policy risk for gas transmission & distribution assets. Respondents noted these restrictions were viewed as aiming to reduce the use of gas in the energy mix rather than looking to decarbonise gas. Indeed, respondents noted that recently implemented policies had the effect of excluding gas connections from greenfield developments and creating a more dispersed customer base in brownfield areas with new dwellings in these regions excluded from established gas networks.

We therefore recommend a real, pre-tax WACC estimate of 7.0% for unregulated gas transmission and distribution with medium confidence.

[32] The WACC for regulated gas transmission & distribution had only 1 response and therefore we do not report the estimated response.

[33] We do not report individual WACC components for technologies with fewer than 5 underlying responses. The WACC for unregulated gas transmission & distribution has 4 responses.

4.4 UTILITY-SCALE SOLAR

Utility-scale solar[34] is a mature and growing technology in the NEM. There are currently 197 utility-scale solar generation assets accounting for 14% of current capacity as well as a strong pipeline of future projects; 27 projects either firmly committed or in advanced planning and a further 216 that have been publicly announced representing roughly 17% of the NEM's pipeline capacity.[35]

Fig. 23. Utility-scale solar real pre-tax WACC estimates

	WACC (real, pre-tax)
Recommended WACC	**7.0%**
Estimated WACC	7.2%
Comparable benchmarks	
OE 2024 (Survey average)	6.4%
CEPA 2023 (Typical Revenue Model)	7.5%

Source: Oxford Economics 2024, CEPA 2023

We recommend adopting a central WACC estimate of 7.0% for utility-scale solar based on the following.

Fig. 24. Utility-scale solar WACC components

Parameter	Estimate	
Risk-free rate	4.20%	Technology-neutral
Gearing ratio	55%	Technology-specific
Gamma	0.25	Technology-neutral
Corporate tax rate	30%	Technology-neutral
CAPM Parameters		
Market risk premium (MRP)	5.87%	Technology-neutral
Asset beta	0.53	Technology-specific
Equity beta	1.18	Technology-specific
SL CAPM return on equity	14.3%	Calculation
Debt Parameters		
Debt beta	0	Technology-neutral
Credit rating	Baa2 (Moodys), BBB (S&P)	Technology-specific
Debt risk premium*	1.53%	Technology-specific
Return on debt (pre-tax)	5.73%	Calculation
Expected inflation	2.28%	Technology-neutral
Nominal pre-tax WACC	9.61%	Calculation
Real pre-tax WACC	7.16%	Calculation

[34] Utility scale solar refers to three main solar PV technologies – fixed, single axis tracking, and double axis tracking – and excludes rooftop PV installations.

[35] AEMO (2024) *NEM Generation Information July 2024.* Accessed November 2024. Available here.

The survey responses used to estimate technology-specific WACC components align with financial market benchmarks for renewable electricity companies. We adopt the survey averages for technology-specific components rather than the broader financial market benchmarks because the survey results better reflect the domestic market and utility-scale solar technology specifically. However, the consistency between the survey responses and the broader renewable energy market suggests that the technology-specific WACC components for utility-scale solar are reasonable.

- The average asset beta for utility-scale solar implied in the survey responses is comparable to the financial market benchmark for renewable electricity companies (0.53 vs. 0.51).
- Reported gearing levels are also within a comparable range (55% vs. 50%).
- The average credit rating reported for utility-scale solar is slightly higher in our survey sample (Baa2/BBB) relative to the average of the sampled renewable electricity companies (Baa3/BBB-) though aligns with the financial market benchmarking median (Baa2/BBB).

The recommended estimate of 7.0% is corroborated by the risk profile described by survey and interview participants who consistently agreed that utility-scale solar has a lower risk profile than other generation technologies. Utility-scale solar has reliable benchmarks, a well-understood development and construction pathway and lower construction, technology and policy risk. However, interview participants highlighted that there is a merchant risk premium for solar assets as the implications of negative pricing due to the 'Duck Curve'[36] makes post-PPA revenue flows uncertain.

The recommended WACC for utility-scale solar relative to other technologies is relatively consistent with international benchmarks. There are many differentiators of risk and financing cost between countries and technologies. However, the real, post-tax WACC[37] for utility scale solar has the lowest WACC of common renewable technologies in 70% of high income countries and 60% of benchmark countries[38] with mature renewable markets and policy support.[39]

The headline WACC survey average for utility-scale solar was 6.4%, 0.9% lower than the macroeconomic estimate. Utility-scale solar survey respondents have a lower view of technology-neutral WACC components which are replaced with a technology-neutral estimates in the recommended utility-scale solar WACC. Survey respondents reported:

- Lower market risk premium on average (5.7%) relative to the overall survey average MRP (6.0%).
- Lower risk-free rate (3.9%) vs. the full survey average of 4.0% and the current macroeconomic estimate of 4.2%.

[36] The Duck Curve – named for its duck-like shape – occurs when electricity demand for the grid traditionally peaks in the middle of the day. However, with the widespread adoption of solar PV, solar energy production can surpass grid demand during that time leading to negative prices.

[37] We use this data to consider intra-country differences so do not account for different tax rates between countries when comparing the relative ranks of different technologies. We assume that renewable technologies face the same tax rate within each country.

[38] IRENA (2022) *Country Rankings*. Accessed November 2024. Available here. Benchmark countries are Belgium, Brazil, Canada, China, Denmark, France, Germany, India, Italy, Japan, Norway, Poland, Spain, Sweden, Taiwan, UK, USA & Vietnam.

[39] IRENA (2023) *Renewable Power Generation Costs in 2023*. Accessed November 2024. Available here.

We therefore recommend a technology-specific estimate of 7.0% (7.16% rounded to the nearest 0.5%) for utility-scale solar with reasonable confidence.

4.5 ONSHORE WIND

Onshore wind[40] is currently contributing 17% of current generation capacity from 91 existing projects. There is a significant number of projects in the pipeline - 11 projects in advanced stages of progression and 129 more publicly announced representing 21% of the NEM's capacity pipeline.[41]

Fig. 25. Onshore wind real pre-tax WACC estimates

	WACC (real, pre-tax)
Recommended WACC	**7.5%**
Estimated WACC	7.6%
Comparable benchmarks	
OE 2024 (Survey average)	7.0%
CEPA 2023 (Typical Revenue Model)	7.5%

Source: Oxford Economics 2024, CEPA 2023

We recommend adopting a central WACC estimate of 7.5% for onshore wind based on the following parameters.

Fig. 26. Onshore wind WACC components

Parameter	Estimate	
Risk-free rate	4.20%	Technology-neutral
Gearing ratio	54%	Technology-specific
Gamma	0.25	Technology-neutral
Corporate tax rate	30%	Technology-neutral
CAPM Parameters		
Market risk premium (MRP)	5.87%	Technology-neutral
Asset beta	0.59	Technology-specific
Equity beta	1.28	Technology-specific
SL CAPM return on equity	15.11%	Calculation
Debt Parameters		
Debt beta	0	Technology-neutral
Credit rating	Baa2 (Moodys), BBB (S&P)	Technology-specific
Debt risk premium*	1.54%	Technology-specific
Return on debt (pre-tax)	5.74%	Calculation
Expected inflation	2.28%	Technology-neutral
Nominal pre-tax WACC	10.07%	Calculation

[40] Onshore wind refers to a group of wind turbines, often referred to as a wind farm, installed on land.
[41] AEMO (2024) *NEM Generation Information July 2024.* Accessed November 2024. Available here.

Real pre-tax WACC	7.61%	Calculation

Source: Oxford Economics (2024)

The survey responses used to estimate technology-specific WACC components align with financial market benchmarks for renewable electricity companies suggesting that the technology-specific WACC components for onshore wind are reasonable.

- The average asset beta for onshore wind implied in the survey responses is slightly above solar though still comparable to the broader renewable market benchmark (0.59 vs. 0.51).
- Reported gearing levels are also within a comparable range (54% vs. 50%).
- The average credit rating reported for onshore wind assets was higher in the survey (Baa2/BBB) than the financial market data for renewable companies (Baa3/BBB-) though in line with the market median (Baa2/BBB).

Similar to utility-scale solar, survey and interview participants consistently agreed onshore wind has a lower risk profile than other generation technologies given the prevalence of reliable benchmarks and a well-understood development and construction pathway. Participants noted that there was some construction risk for onshore wind assets driven by challenges importing & transporting large quantities of wind turbine equipment. The importance of contracted cash flows for project finance was highlighted for securing a favourable credit rating and increasing the share of a project that could be debt-financed.

International benchmarks suggest that the WACC should be similar or somewhat higher for onshore wind relative to utility-scale solar. The difference in real, post-tax WACC[42] between solar and onshore wind is 0.06% on average for high-income countries (a proxy for financial maturity and market-wide risk) and 0.02% on average for a selection of benchmark countries[43] with significant solar, onshore and offshore wind capacity (as a proxy for renewable market maturity and policy support).[44]

The survey results are aligned with this view. For some respondents the WACC for utility-scale solar and onshore wind are equivalent. However the headline survey averages suggests that in the Australian market the WACC for onshore wind is slightly higher than solar at present.

The headline survey average for onshore wind (7.0%) is somewhat below our estimated WACC of 7.6%. Similar to utility-scale solar, onshore wind respondents have a lower view of technology-neutral WACC components than the full survey sample. They reported;

- Lower market risk premium (5.8%) relative to the overall survey average MRP (6.0%).
- Slightly lower risk-free rate on average (4.0% vs. the current macroeconomic estimate of 4.2%).

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[42] We use this data to consider intra-country differences so do not account for different tax rates between countries when comparing the relative ranks of different technologies. We assume that renewable technologies face the same tax rate within each country.

[43] IRENA (2022) *Country Rankings*. Accessed November 2024. Available here. Benchmark countries are Belgium, Brazil, Canada, China, Denmark, France, Germany, India, Italy, Japan, Norway, Poland, Spain, Sweden, Taiwan, UK, USA & Vietnam.

[44] IRENA (2023) *Renewable Power Generation Costs in 2023*. Accessed November 2024. Available here.

We recommend a real, pre-tax WACC estimate of 7.5% (rounded to the nearest 0.5% from 7.6%) for onshore wind with reasonable confidence.

4.6 OFFSHORE WIND

Offshore wind[45] is an emerging technology and market in Australia. There are no existing offshore wind assets in the NEM though there is significant commercial and government interest in developing this technology given Australia's significant offshore wind resources. At present, there are 34 announced offshore wind projects which together account for 21% of the NEM's capacity pipeline.[46]

Fig. 27. Offshore wind real pre-tax WACC estimates

	WACC (real, pre-tax)
Recommended WACC	**7.5%**
Estimated WACC	7.5%
Comparable benchmarks	
OE 2024 (Survey average)	7.5%
CEPA 2023 (Typical Revenue Model)	8.5%

Source: Oxford Economics 2024, CEPA 2023

We recommend adopting a central WACC estimate of 7.5% for offshore wind.[47]

Survey and interview participants emphasised that the level of government support required to progress offshore wind assets is compressing the cost of capital at present. The technology-specific estimates from the survey and interviews, reflects the assumption that such support is met. Given this, we believe technology-specific WACC components for offshore wind are reasonable and reflect the current commercial reality.

- The average asset beta for offshore wind (0.55) implied in the survey responses is slightly below onshore wind (0.59) and within a comparable range to the broader renewable market benchmark (0.51).
- Reported gearing levels for offshore wind (61%) suggest a higher reliance on debt financing than onshore wind (54%) or renewable electricity companies in the financial market benchmarking sample (50%).
- The average credit rating reported for offshore wind assets was lower in the survey (Ba1/BB+) than the financial market data for renewable companies (Baa3/BBB-).

Follow-up interviews with participants highlighted the criticality of government support given there is still a high degree of uncertainty on the required returns for offshore wind given the lack of domestic benchmarks (merchant risk) as well as higher construction, technology and policy risk. When the difference between offshore and onshore wind was discussed in interviews it was the dependency on government support for offshore wind that was emphasised.

[45] Offshore wind turbines are fundamentally similar to onshore wind turbines, but they are installed in bodies of water and are larger in size, allowing them to generate greater capacity.

[46] AEMO (2024) *NEM Generation Information July 2024*. Accessed November 2024. Available here.

[47] We do not report individual WACC components for technologies with fewer than 5 underlying responses. The WACC for offshore wind has 4 responses.

International benchmarks suggest that the post-tax WACC[48] for offshore wind is 1.30% higher on average than onshore wind for countries with both assets[49] and 1.03% higher when only considering high income countries. However, we are reticent to artificially inflate the estimate for offshore wind based on this data given there is also international precedent for equivalent WACCs - roughly a third of countries with both assets have equivalent WACCs for onshore & offshore wind (Belgium, Denmark, Japan, Norway & Taiwan).

We recommend a real, pre-tax WACC estimate of 7.5% for offshore wind noting that it is based on a relatively small sample (given the lack of domestic benchmarks) and predicated on significant long-term government backed offtake agreements. If government support was withdrawn in future then the real pre-tax WACC will not remain at this level as merchant risk increases, though this may be offset by the lower technology and construction risk of a more mature market.

4.7 LARGE-SCALE BESS

Large-scale battery energy storage systems (BESS)[50] are rapidly entering the NEM. There are 25 existing assets and a substantial project pipeline - 36 projects in advanced stages and 295 publicly announced, contributing 29% of the NEM's capacity pipeline.[51]

Fig. 28. Large-scale BESS real pre-tax WACC estimates

	WACC (real, pre-tax)
Recommended WACC	**8.0%**
Estimated WACC	8.2%
Comparable benchmarks	
OE 2024 (Survey average)	7.7%
CEPA 2023 (Typical Revenue Model)	8.5%

Source: Oxford Economics 2024, CEPA 2023

Our recommended WACC of 8.0% for large-scale BESS is based on the following parameters.

Fig. 29. Large-scale BESS WACC components

Parameter	Estimate	
Risk-free rate	4.20%	Technology-neutral
Gearing ratio	53%	Technology-specific
Gamma	0.25	Technology-neutral
Corporate tax rate	30%	Technology-neutral
CAPM Parameters		

[48] We use after-tax WACC data to consider intra-country differences of different WACC assets and so do not account for different tax rates between countries. We assume that renewable technologies face the same tax rate within each country.
[49] Countries included are Belgium, China, Denmark, France, Germany, Italy, Japan, Norway, Poland, Sweden, Taiwan, UK, US & Vietnam. IRENA (2023) *Renewable Power Generation Costs in 2023*. Accessed November 2024. Available here.
[50] Large-scale BESS refers to a form of dispatchable power generation, where multiple battery modules store and release energy quickly in response to sudden spikes in demand.
[51] AEMO (2024) *NEM Generation Information July 2024.* Accessed November 2024. Available here.

Market risk premium (MRP)	5.87%	Technology-neutral
Asset beta	0.68	Technology-specific
Equity beta	1.44	Technology-specific
SL CAPM return on equity	16.32%	Calculation
Debt Parameters		
Debt beta	0	Technology-neutral
Credit rating	Baa2 (Moodys), BBB (S&P)	Technology-specific
Debt risk premium*	1.47%	Technology-specific
Return on debt (pre-tax)	5.67%	Calculation
Expected inflation	2.28%	Technology-neutral
Nominal pre-tax WACC	10.71%	Calculation
Real pre-tax WACC	8.23%	Calculation

Source: Oxford Economics (2024)

The survey responses used as inputs to the technology-specific WACC calculation broadly align with financial market benchmarks.

- The average asset beta for BESS implied in the survey responses is higher than the broader market benchmark for renewable electricity companies (0.71 vs. 0.51). However, our global sample also reflects renewable power producers with a high share of capacity in solar and onshore wind generation, alongside BESS capacity. We believe this mix of generation reduces the overall asset beta, as solar and wind investments tend to have lower asset betas than BESS projects in line with the insights from our industry survey.
- Reported gearing levels are within a comparable range (51% vs. 50%).
- The average credit rating is slightly higher in our survey sample (Baa2/BBB vs Baa3/BBB-) though aligns with the market benchmarking median (Baa2/BBB).

Interview respondents noted that a premium was necessary to account for the merchant risk inherent in the revenue model for large-scale BESS given the mechanisms to hedge merchant risk for BESS are quite short term and there are a large number of planned projects in the pipeline. Contracted offtake agreements were highlighted as critical in reducing the cost of capital by providing greater certainty over future cash flows in the event of an influx of storage capacity coming to market.

The uplift in WACC for large-scale BESS compared to utility-scale solar and onshore wind (without rounding) was 1.1% and 0.6%, respectively. These values align closely with previous estimates of the uplift by CEPA – 0.9% and 0.7% respectively.[52]

The difference between the headline survey average of 7.7% and our estimate of 8.3% cannot be explained by differences in survey respondents' views of technology-neutral parameters (MRP or risk-free rate) suggesting some incongruity between survey respondents' views of the underlying components and their overall reported WACC for large-scale BESS projects.

However, we recommend a real, pre-tax WACC estimate of 8.0% for BESS with reasonable confidence.

[52] CEPA (2023), pg. 33-34

4.8 PUMPED HYDRO ENERGY STORAGE

Pumped Hydro Energy Storage (PHES)[53] will provide deep storage capacity to the NEM. There are three assets currently operating, three additional projects in advanced stages and 21 publicly announced projects.[54]

Fig. 30. Pumped hydro energy storage real pre-tax WACC estimates

	WACC (real, pre-tax)
Recommended WACC	**8.5%**
Estimated WACC	8.4%
Comparable benchmarks	
OE 2024 (Survey average)	7.6%
CEPA 2023 (Typical Revenue Model)	10.0%

Source: Oxford Economics 2024, CEPA 2023

Our recommended WACC for PHES is based on the following parameters.

Fig. 31. Pumped hydro energy storage WACC components

Parameter	Estimate	
Risk-free rate	4.20%	Technology-neutral
Gearing ratio	48%	Technology-specific
Gamma	0.25	Technology-neutral
Corporate tax rate	30%	Technology-neutral
CAPM Parameters		
Market risk premium (MRP)	5.87%	Technology-neutral
Asset beta	0.70	Technology-specific
Equity beta	1.35	Technology-specific
SL CAPM return on equity	15.64%	Calculation
Debt Parameters		
Debt beta	0	Technology-neutral
Credit rating	Baa2 (Moodys), BBB (S&P)	Technology-specific
Debt risk premium*	1.55%	Technology-specific
Return on debt (pre-tax)	5.75%	Calculation
Expected inflation	2.28%	Technology-neutral
Nominal pre-tax WACC	10.87%	Calculation
Real pre-tax WACC	8.39%	Calculation

Source: Oxford Economics (2024)

[53] PHES is a form of energy storage that typically uses two water reservoirs at different elevations to store and release energy generated by turbines.

[54] AEMO (2024) *NEM Generation Information July 2024.* Accessed November 2024. Available here.

The survey responses used to estimate technology-specific WACC components broadly align with financial market benchmarks for renewable energy companies.

- The average asset beta for PHES implied in the survey responses is higher than the broader market benchmark for renewable electricity companies (0.70 vs. 0.51). However, our global sample also reflects renewable power producers with a high share of capacity in solar and onshore wind generation as this mix of generation tends to have lower asset betas in line with the insights from our industry survey.
- Reported gearing levels are within a comparable range (48% vs. 50%).
- The average credit rating is slightly higher in our survey sample (Baa2/BBB vs Baa3/BBB–) though aligns with the market benchmarking median (Baa2/BBB).

Survey and interview participants consistently agreed that PHES has a higher risk profile than other generation technologies which precludes it from market investment without significant government support. They emphasised that while the cost of capital estimates they provided reflect the returns required for investment in these projects, such ventures would not be viable without significant government backing. State support comes in several forms including the ability to access state-owned water assets, which can provide an essential foundation for these projects, and long-term offtake agreements which provide revenue certainty.

Respondents highlighted that the limited number benchmarks increases uncertainty for PHES. Construction risk, particularly geotechnical risk, was identified as a key concern as the inherent uncertainties associated with geotechnical challenges—such as variable ground conditions and potential delays—make the construction risk for pumped hydro projects particularly 'site-specific' and significantly more unpredictable compared to other types of energy infrastructure. These risks are compounded also by the large capital investment required for PHES relative to other technologies.

The difference between the headline survey average of 7.6% and our estimate of 8.4% cannot be explained by differences in survey respondents' views of technology-neutral parameters (MRP or risk-free rate) suggesting some incongruity between survey respondents' views of the underlying components and their overall reported WACC for large-scale BESS projects.

We recommend a real, pre-tax WACC estimate of 8.5% for PHES with medium confidence and the implicit commercial assumption that long-term offtake agreements from government are present. Despite sufficient survey responses some caution should be placed on the estimate due to the small number of PHES projects and low market activity.

4.9 DUAL-FUEL OCGT

Dual-fuel Open Cycle Gas Turbines (OCGT)[55] account for 11% of current capacity from 33 individual assets within the NEM. Reliance on OCGT technology is expected to reduce as renewables increase but will still play a role as a firming asset supported by the capability to substitute natural gas for

[55] Dual-fuel OCGT are power generation systems that can operate on two types of fuel, typically natural gas and oil, to produce electricity.

hydrogen in the future. OCGT projects represent just 1% of the NEM's future capacity with only 14 projects in the pipeline.[56]

Fig. 32. Dual-fuel OCGT real pre-tax WACC estimates

	WACC (real, pre-tax)
Recommended WACC	**9.0%**
Estimated WACC	8.8%
Comparable benchmarks	
OE 2024 (Survey average)	8.5%
CEPA 2023 (Typical Revenue Model)	8.5%

Source: Oxford Economics 2024, CEPA 2023

We recommend a WACC of 9.0% for OCGT based on the following.[57]

Dual-fuel OCGT was not well-responded to in the survey and follow-up interviews were used to collect required data.

Asset-specific WACC components for OCGT are not well-aligned to financial market benchmarks for independent power producers though there are a number of commercial reasons this may be the case. These trends are also reflected in the CCGT survey data which was well responded to (reducing the likelihood these trends are due to OCGT's small sample size).

- Survey asset betas were significantly higher than financial market benchmarks for independent power producers (0.73 vs 0.32) as was the average credit rating (Ba1/BB+ compared to Baa2/BBB). This disparity could reflect the domestic policy risk associated with new gas generation projects in Australia relative to existing assets captured in the financial market data as well as the revenue risk associated with an asset type that has a low and unpredictable utilisation rate.
- Reported gearing levels between the survey and financial market data (60% vs 54%) were in a comparable range.

Interviewed respondents noted the likely ongoing need for OCGT to provide firming capacity during periods of renewable energy drought—extended periods when wind and solar resources are unavailable – that extend beyond the current capabilities of large-scale battery energy storage systems (BESS). However, they emphasised that OCGT facilities have a long useful life introducing a longer payback period, increasing the exposure to policy risk. Additionally, there remains uncertainty around how lower-emission firming technologies, such as large-scale BESS and pumped hydro, are expected to increasingly compete with OCGT. Respondents felt this intensifies policy risk for more emissions-intensive firming options, further influencing the relative cost of capital for future OCGT projects.

Newer OCGT models are increasingly designed to operate with higher shares of hydrogen in the feed mix. However, respondents identified a significant challenge in building the necessary infrastructure to

[56] AEMO (2024) *NEM Generation Information July 2024.* Accessed November 2024. Available here.

[57] We do not report individual WACC components for technologies with fewer than 5 underlying responses. The WACC for dual-fuel OCGT has 3 responses.

support hydrogen integration into OCGT facilities and low confidence in future supply of hydrogen. Some respondents reported the availability of commercial green hydrogen has been lower than anticipated contributing to a slower rollout integrating the feedstock.

CEPA adopted an equivalent WACC for large-scale BESS & OCGT (8.5%).[58] Based on our estimates OCGT has a 0.5ppts premium compared to BESS (8.5%) which aligns with a heightened risk profile shared by interviewees however this is based on a small survey sample.

We therefore recommend a real, pre-tax WACC estimate of 9.0% for dual-fuel OCGT with medium confidence. We consider it unlikely that OCGT projects would be built today without the ability to transition to hydrogen and therefore responses likely reflect this market reality. However, caution should be placed on this estimate reflecting the WACC associated with dual-fuel OCGT specifically relative to traditional OCGT given the small number of responses.

4.10 CCGT

Combined Cycle Gas Turbines (CCGT)[59] have a limited role in the NEM, with 12 assets contributing 5% of current generation capacity. There is only one planned renewable-fuelled CCGT project expected to contribute to future generation capacity.[60]

Fig. 33. CCGT real pre-tax WACC estimates

	WACC (real, pre-tax)
Recommended WACC	**10.5%**
Estimated WACC	10.3%
Comparable benchmarks	
OE 2024 (Survey average)	9.6%

Source: Oxford Economics 2024

Our recommended WACC for CCGT of 10.5% is based on the following parameters.

Fig. 34. CCGT WACC components

Parameter	Estimate	
Risk-free rate	4.20%	Technology-neutral
Gearing ratio	51%	Technology-specific
Gamma	0.25	Technology-neutral
Corporate tax rate	30%	Technology-neutral
CAPM Parameters		
Market risk premium (MRP)	5.87%	Technology-neutral
Asset beta	0.95	Technology-specific
Equity beta	1.91	Technology-specific

[58] CEPA (2023), pg.5

[59] CCGT refers to a power generation system that uses both gas and steam turbines in tandem, effectively capturing waste heat to improve efficiency.

[60] AEMO (2024) *NEM Generation Information July 2024.* Accessed November 2024. Available here.

SL CAPM return on equity	19.90%	Calculation
Debt Parameters		
Debt beta	0	Technology-neutral
Credit rating	Ba1 (Moodys), BB+ (S&P)	Technology-specific
Debt risk premium*	1.74%	Technology-specific
Return on debt (pre-tax)	5.94%	Calculation
Expected inflation	2.28%	Technology-neutral
Nominal pre-tax WACC	12.85%	Calculation
Real pre-tax WACC	10.33%	Calculation

Source: Oxford Economics (2024)

Despite the relatively large survey sample, technology-specific WACC components for CCGT are not well-aligned to financial market benchmarks for independent power producers though there are a number of commercial reasons this may be the case.

- Survey asset betas were significantly higher than financial market benchmarks (0.95 vs 0.32). We believe the disparity reflects the current domestic environment and respondents' perception of high policy risk around the construction of new emission-intensive generation relative to the existing asset mix underpinning the market benchmarks. Respondents emphasised that cheaper alternatives for baseload generation exist and there are significant policy risks associated with operating such assets over their full useful life.
- The average credit rating is somewhat aligned and follows the trend that new emission-intensive assets are rated lower than financial market benchmarks (Baa3/BBB– vs Baa2/BBB).
- Reported gearing levels for CCGT (51% vs 54%) were in a comparable range.

The low level of market activity for CCGT, and therefore limited benchmarks and market participants, means our WACC should be treated with some caution. Our recommended WACC for CCGT is 10.5% (rounded to the nearest 0.5%), however, while respondents provided a cost of capital estimate in the survey, they emphasised during follow-up interviews these inputs were largely hypothetical. Many could not foresee a significant future role for gas in the baseload generation mix, citing market and policy trends that increasingly favour lower-emission alternatives.

AEMO requested that we consider CCGT with Carbon Capture Storage (CCS) as part of this study. There are 16 announced CCS projects in Australia in the mining and industrial sectors[61] and a number of combined CCGT with CCS projects being considered internationally.[62] However we didn't find evidence from the survey or interviews that CCGT with CCS technology was being seriously considered in Australia likely due to there being very few CCGT projects in the pipeline.

[61] Geoscience Australia (2024) *Australia's Energy Commodity Resources 2024*. Accessed November 2024. Available here.

[62] Honney T. (2023) *CCS + CCGT: a winning combination?* Accessed November 2024. Available here.

4.11 COAL GENERATION

Coal generation[63] is a waning technology in the NEM. As of 2024, it still leads as the top energy source, providing 33% of the total capacity powered by 15 assets. [64] However, with coal's heavy emissions and the rise of renewables, assets are quickly phasing out of the generation mix. Only one future coal project has been publicly announced – a low-emission power plant with a capacity of 990 MW, intended to provide firming capacity.[65]

Fig. 35. Coal generation real pre-tax WACC estimates

	WACC (real, pre-tax)
Recommended WACC	**12.0%**
Estimated WACC	11.8%
Comparable benchmarks	
OE 2024 (Survey average)	11.3%

Source: Oxford Economics 2024

Our recommended central WACC estimate is 12.0% for coal generation. [66]

Coal generation was not well-responded to in the survey and follow-up interviews emphasised that WACC estimates for coal were purely hypothetical given it is not expected to be a viable technology in the long term.

Technology-specific WACC components for coal generation are not well-aligned to financial market benchmarks for independent power producers though there are a number of commercial reasons this may be the case. These trends are also reflected in the CCGT survey data which was well responded to (reducing the likelihood these trends are due to coal generation's small sample size).

- Survey asset betas were significantly higher than financial market benchmarks (1.15 vs 0.32). We believe the disparity reflects the current domestic environment as interview respondents emphasised that cheaper alternatives for baseload generation exist as well as ESG commitments making them infeasible. Significant policy and merchant risks were also highlighted due to the likely utilisation rate of operating such assets over their full useful life.
- The average credit rating is somewhat aligned and follows the trend that new emission-intensive assets are rated lower than financial market benchmarks (Baa3/BBB– vs Baa2/BBB).
- Reported gearing levels (60% vs 54%) were in a comparable range.

Our recommended WACC for coal generation is 12.0% (rounded to the nearest 0.5%) with low confidence. The WACC for coal generation should be treated with caution as market participants do not see these assets as viable and the see a WACC for coal as largely hypothetical. Many could not

[63] Coal generation refers to burning coal to produce heat that converts water into steam, powering turbines to generate electricity.
[64] AEMO (2024) *NEM Generation Information July 2024.* Accessed November 2024. Available here.
[65] Shin Energy (2024) *Collinsville Power Plant Project.* Accessed November 2024. Available here.
[66] We do not report individual WACC components for technologies with fewer than 5 underlying responses. The WACC for coal generation has 3 responses.

foresee a project that they would pursue regardless of the WACC given ESG targets and a wealth of other viable projects without the equivalent risk.

4.12 HYDROGEN ELECTROLYSERS

Hydrogen electrolysers[67] are still in their infancy in Australia, with early projects focusing on improving cost efficiency. Australia is looking to be a global hydrogen leader with three projects under construction and 73 more publicly announced. That said, these projects tend to be more progressed for industrial and transport applications than for energy generation.[68]

Fig. 36. Hydrogen electrolysers real pre-tax WACC estimates

	WACC (real, pre-tax)
Recommended WACC	**8.0%**
Estimated WACC	7.8%
Comparable benchmarks	
OE 2024 (Survey average)	7.1%

Source: Oxford Economics 2024

Our recommended WACC for hydrogen electrolysers is 8.0%.[69]

Among respondents investigating dual-fuel operations in OCGT facilities—integrating green hydrogen into their feedstock mix—there was a clear acknowledgment that the commercial supply of green hydrogen has fallen short of expectations set several years ago as industry players have pulled out or paused plans.

Follow-up survey interviews and qualitative research into prospective hydrogen projects across Australia highlighted that industry priorities are currently focused on producing ammonia, urea, and hydrogen for fuel cell applications. This appears to have taken precedence over producing green hydrogen specifically as a feedstock for electricity generation. Some respondents expressed scepticism about the viability of green hydrogen as an alternative to natural gas, citing economic and logistical challenges.

Our recommended WACC for hydrogen electrolysers is 8.0% (rounded to the nearest 0.5%) however there was a lack of engagement from market participants directly involved in developing hydrogen electrolyser projects. Their current focus on industrial and transport applications may have led them to view the survey as less relevant to their operations. This combination of limited supply, industry priorities that diverge from electricity generation, and a lack of reliable benchmarks diminishes confidence in the estimates provided for hydrogen electrolysers.

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[67] Hydrogen electrolysers refers to the technology of separating water into hydrogen and oxygen, with the aim of efficiently producing hydrogen as a clean energy source.

[68] Geoscience Australia (2024) *Australia's Energy Commodity Resource 2024: Hydrogen*. Accessed November 2024. Available here.

[69] We do not report individual WACC components for technologies with fewer than 5 underlying responses. The WACC for hydrogen electrolysers has 3 responses.

4.13 GAS PLANT & PIPELINE

Gas plants[70] are well-established in Australia, but efforts to embrace renewable electricity such as the Victoria Gas Substitution Roadmap have led to a decline in gas consumption. While some gas facilities project increased production in 2024, others are scaling back as ageing wells are retired. Even so, gas remains a crucial input to gas generators and the energy transition, supporting renewables as they replace retiring coal plants. Progress on major new gas projects has been delayed by 1-2 years due to challenges in identifying new reserves and building support infrastructure such as gas pipelines.[71]

We are unable to make a recommendation for gas plants and pipelines. The survey received no engagement from key industry players. We believe the lack of responses may be attributed, in part, to the perceived disconnect between the operators of gas plants and pipelines and the broader energy market. These operators play a role in the extraction, refinement, and delivery of gas to transmission operators, however, their relative distance from the NEM may have led them to view the survey as less relevant to their operations.

[70] Gas plants refers to facilities where natural gas is sourced and processed before being transmitted through pipelines to transmission & distribution networks.

[71] AEMO (2024) *Gas Statement of Opportunities: March 2024*. Accessed November 2024. Available here.

5. FORWARD-LOOKING WACCS

This section considers how the recommended weighted average cost of capital (WACC) may change over time under different macroeconomic environments.

The WACC estimates presented below should be considered as forward-looking sensitivities given changes to the risk-free rate and expected inflation under different macroeconomic scenarios. All other market variables remain unchanged.

The technology-neutral discount rate and technology-specific WACCs are projected over the forecast period by flexing the risk-free rate and expected inflation components of the WACC calculation. The risk-free rate is proxied by the 10-year Commonwealth bond which reflects market expectations for growth and inflation – both of which vary under different scenarios.[72]

In the central Step Change scenario, "the demographic and economic drivers of Australia's economy follow a moderate path" whereas the Green Energy Exports scenario assumes that "the domestic population and economy are larger and grow faster...A surge in clean energy technology and active participation from consumers and businesses result in Australia meeting its net-zero commitment well before 2050."[73]

Conversely under the Progressive Change scenario, "…the global economy grows at a slower pace and climate change policy is less coordinated. Australia's demographic and economic drivers follow a slower growth path and domestic efforts to decarbonise do not accelerate beyond the current rate." [74]

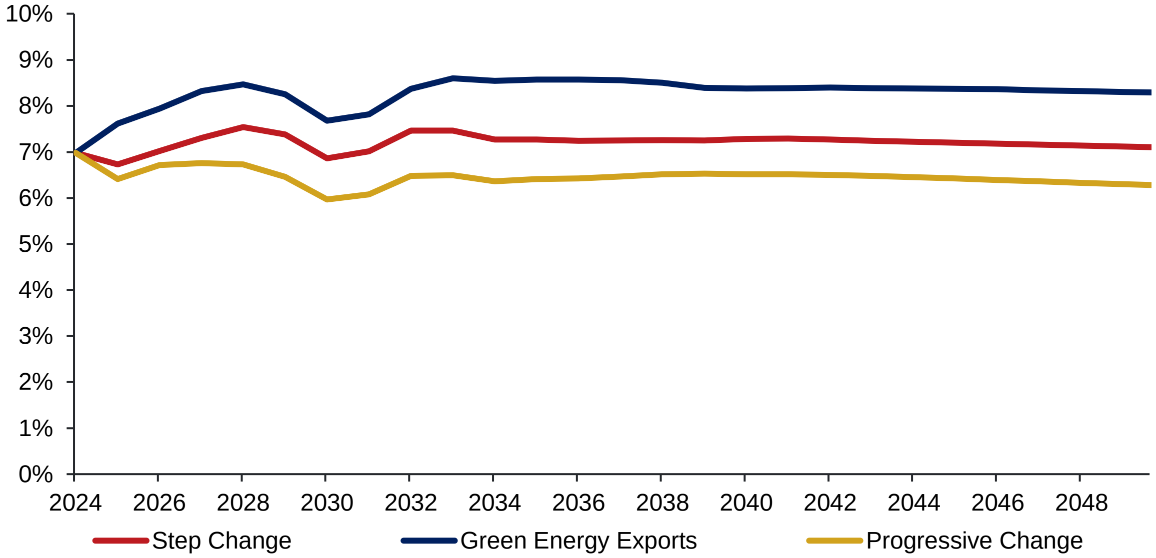
The impact of different economic growth and inflation expectations on the technology-neutral discount rate can be seen in Fig. 37. Under the moderate growth path of the Step Change scenario there is not significant movement in the technology-neutral discount rate – it remains within a 0.5% range above and below the long-term average of 7.2% - suggesting that the trade-off between current and future costs and benefits will remain similar to the present environment.

[72] Long-term commonwealth bond yields were not modelled by Deloitte in their work for AEMO so we use a conventional proxy of Nominal GDP to estimate growth in the 10-year Commonwealth bond yield over time. Expected inflation is measured by the breakeven method in 2024 and the change in the 10 year forward average (AER's expected inflation method) in forecast years.

[73] Deloitte (2024) *Economic forecasts 2023/24*. Currently unpublished.

[74] Deloitte (2024) *Economic forecasts 2023/24*. Currently unpublished.

Fig. 37. Technology-neutral discount rate by scenario



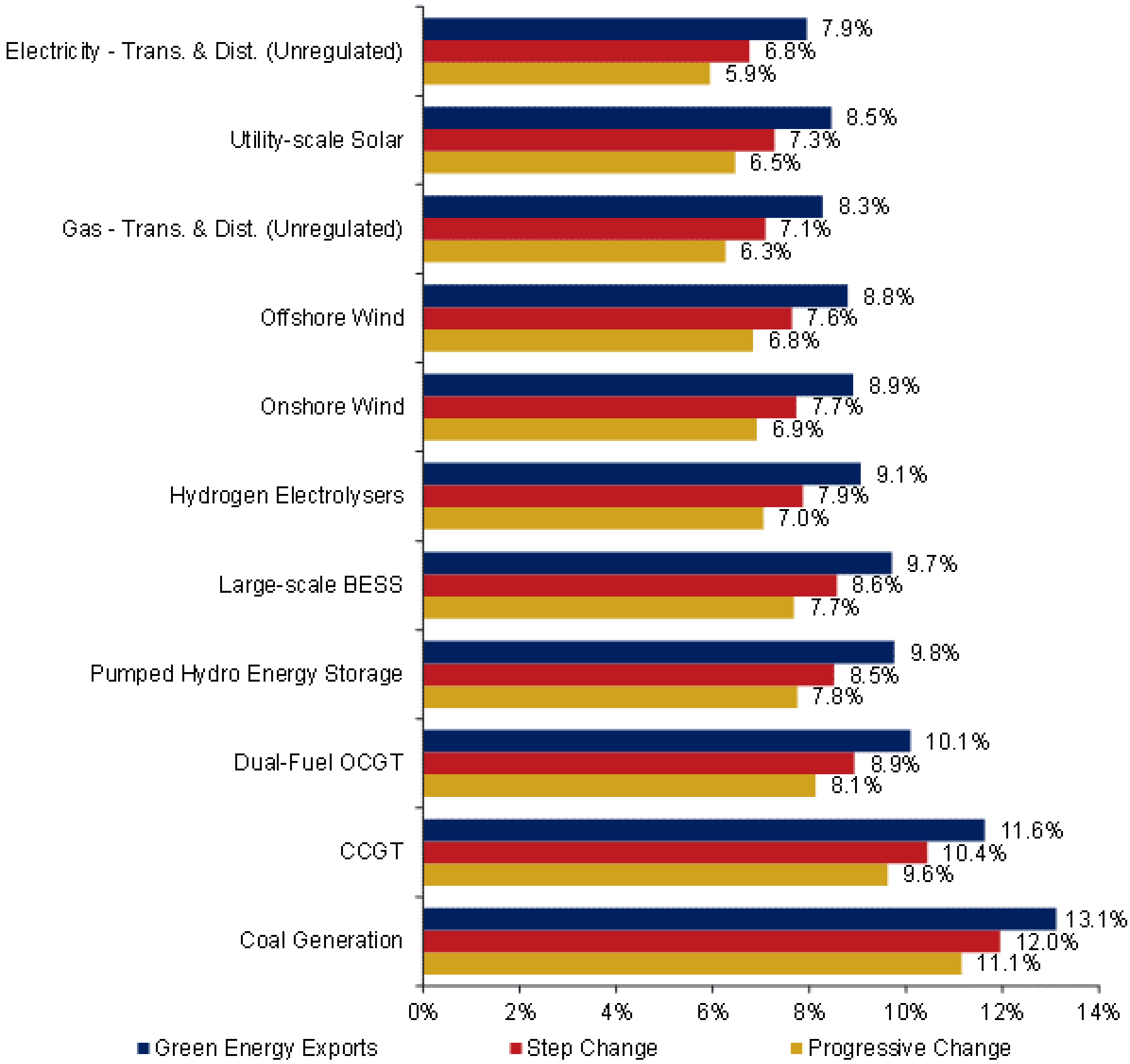
Source: Oxford Economics (2024)

Under a Green Energy Exports scenario there is a greater discount placed on future cash flows as the market competes for capital in a buoyant economic environment. The impact is moderated by higher expected inflation but not by enough to dampen a structurally higher discount rate which averages 8.3% over the forecast period. Conversely, under the progressive change scenario lower economic activity reduces the risk-free rate leading future cash flows to be discounted less severely. The technology neutral discount rate averages 6.4% under the Progressive Change scenario.

Applying the same assumptions to the macroeconomic estimates of the technology-specific WACCs produces the following estimates in 2050.

These estimates do not capture the effects of emerging technologies becoming better understood in the domestic market which may place downward pressure on the WACCs for technologies like offshore wind and large-scale BESS. Similarly greater policy certainty could be expected over time which would reduce the WACC of some technologies, while future removal of government support may increase the WACC of other technologies. The impact of offtake agreements may also change over time which would have different impacts on different technologies.

Fig. 38. Technology-specific WACCs in 2050 by scenario



Source: Oxford Economics (2024)

6. CONCLUSION

The technology-neutral discount rate determines the present value of future costs and benefits related to energy provision in the Integrated System Plan (ISP). The rate is expressed in terms of a real pre-tax WACC. We recommend the following central, lower and upper bound technology-neutral discount rates:

- Lower bound - 3.0%[75]
- Central - 7.0%
- Upper bound – 9.5%

The technology-specific weighted average cost of capital is used to estimate the financing costs for projects across various technologies considered in the ISP. Regulated assets attract the lowest WACC and the narrowest bounds. On the other hand, emerging technologies and those with greater levels of merchant risk attract higher financing costs. Coal tops the list given the sustainability concerns from the use of this technology.

Fig. 39. Technology-specific real, pre-tax WACC by asset

Technology	Lower Bound	Central Estimate	Upper Bound
Electricity - Transmission & Distribution (Regulated)	3.0%	3.0%	4.5%
Electricity - Transmission & Distribution (Unregulated)	4.5%	6.5%	9.5%
Gas - Transmission & Distribution (Regulated)	3.0%	3.0%	4.5%
Gas - Transmission & Distribution (Unregulated)	5.5%	7.0%	10.5%
Utility-scale Solar	5.0%	7.0%	10.0%
Onshore Wind	5.5%	7.5%	10.5%
Offshore Wind	5.5%	7.5%	10.5%
Large-scale BESS	6.5%	8.0%	11.5%
Hydrogen Electrolysers	6.0%	8.0%	11.0%
Pumped Hydro Energy Storage	6.5%	8.5%	11.5%
Dual-Fuel OCGT	7.0%	9.0%	12.0%
CCGT	8.5%	10.5%	13.5%
Coal Generation	10.0%	12.0%	15.0%

Note: Estimates are conventionally rounded to the nearest 0.5 percentage points.
Source: Oxford Economics (2024), AER (2023)

[75] Per AER's most recent determinations. Ergon Energy (20 September 2024), SA Power Networks (20 September 2024), Jamina Gas Network (20 November 2024). Available here, here and here.

7. TECHNICAL APPENDIX

7.1 PRE-TAX REAL WACC

Consistent with the methodology used in the ISP modelling, AEMO requires the WACC estimate to be expressed in pre-tax real terms. The pre-tax nominal WACC is expressed as:

$$\text{Pre} - \text{tax nominal WACC} = Ke * \frac{1}{\{1 - t * (1 - \gamma)\}} * \frac{E}{V} + Kd * \frac{D}{V}$$

And adjusted for inflation:

$$Pre - tax\ real\ WACC = \left\{\frac{1 + Pre - tax\ nominal\ WACC}{1 + CPI}\right\} - 1$$

Where:

$Ke =$ post − tax return on equity

$Kd =$ post − tax return on debt

$E/V =$ proportion of equity within the capital structure

$D/V =$ proportion of debt (gearing)within the capital structure

$t =$ corporate tax rate

$\gamma =$ value of imputation credits

7.2 COST OF EQUITY

The cost of equity is estimated using the Sharpe-Lintner Capital Asset Pricing Model (SLCAPM), which is expressed as:

$$Ke = Rf + \beta e * \{Rm - Rf\}$$

Where:

Rf = the risk free rate of return

Rm = return on the market

$(Rm - Rf)$ = the market risk premium

βe = equity beta

7.2.1 Risk-free rate

The nominal risk-free rate is used as a benchmark to compare the required return on risk-bearing assets. The nominal risk-free rate refers to the return on an asset that has no default risk. In practice, government bond rates are commonly used as a proxy for the risk-free rate of return, because sovereign default risk (particularly for OECD countries) is generally considered to be notional.

In Australia's case, this is a robust assumption as the sovereign credit rating is assessed to be the highest rating (AAA) available by credit rating agency Standard & Poor's. This credit rating reflects the lowest default risk.

We estimate the risk-free rate based on a 20-day average of the 10-year Commonwealth Government bond yield. As of 24 October 2024, the estimated yield was 4.20%. This approach aligns to previous work completed by Synergies[76] and subsequently followed by CEPA.[77]

7.2.2 Market risk premium (MRP)

The Market Risk Premium (MRP) refers to the premium on the required rate of return on equity, above the risk-free rate.

Oxford Economics has adopted a macroeconomic approach to estimating the MRP in conjunction with a survey sent to private enterprise developers, operators, financiers, and investors to understand market participants' estimates of the MRP. The MRP used in the WACC calculation is a simple average of:

- Ibbotson approach: deriving a historical long-run MRP based on observed market returns.
- Siegel approach: adjusting the Ibbotson approach for unexpected inflation.
- Survey approach: Surveying market participants' view of the MRP.

Fig. 40. MRP by methodology

	Survey	Ibbotson	Seigel	Average
MRP	6.0%	5.8%	5.9%	5.9%

Source: Oxford Economics (2024)

Ibbotson approach

The Ibbotson approach to estimating the MRP draws on a variant of the general Capital Asset Pricing Model (CAPM) expressed as:

$$Ke = Rf + \beta e(Rm + U * Dm * \frac{ICm}{DIVm} - Rf)$$

Where:

Rf = the risk free rate of return

βe = equity beta

Rm = return on the market

U = Utilisation rate of imputation credit

Dm = Market dividend yield

[76] Synergies (2021) *Discount rates for use in cost benefit analysis of AEMO's 2022 Integrated System Plan*. Accessed November 2024. Available here.

[77] CEPA (2023) *WACC Assumptions*. Accessed November 2024. Available here.

ICm = Imputation credits claimed by eligible investors

$DIVm$ = Market dividends claimed

This model adjusts the market return to account for the benefits of claiming imputation credits generated by the equity investment. The term in the brackets represents the market risk premium:

$$MRP = Rm + U * Dm * \frac{ICm}{DIVm} - Rf$$

We sourced data from AER's update to the 2022 Rate of Return instrument.[78] In line with the 2018 determination by AER,[79] we have shortened the sampling period for returns to 1988 onwards. In their original estimate of the MRP Synergies utilise data from Brailsford, Handley & Maheshwaran (BHM) to determine historical returns from 1883 onwards.[80] Both AER and the Queensland Competition Authority (QCA) have noted concerns about the data quality in the earlier years. Concerns include; the number of listed equities, potential survivorship bias, changes to the market portfolio's characteristics over time and the BHM dataset being constructed from a series of distinct indexes to allow for estimates back to 1883.[81]

Despite these concerns about the quality of the early data, regulators do not agree on when data should be relied upon to estimate an MRP. QCA in their 2021 rate of return review adopted 1958 as the starting point when the Sydney All Ordinaries Index began being calculated daily.[82] AER adopted in 2018 and reaffirmed in 2022 the view that 1988 onwards is representative of modern macroeconomic conditions and current investor expectations. AER highlight that during this time a series of major macroeconomic and market reforms took place including the dollar being floated (1984), the system of imputation tax beginning (1987), and the RBA's inflation-targeting regime of 2-3% beginning in the early 1990s and being formalised in 1996.

We agree with AER that current market conditions are more reflective of the period from 1988 than 1958 onwards. This view is supported by the average MRP reported by survey respondents (6.0%) which aligned within with the MRP estimate generated by the post-1988 sample (5.8%).

Siegel approach

The Siegel approach builds on the Ibbotson estimate and adjusts for unexpected inflation. The theoretical basis for this approach is that bond yields inherently reflect inflation shocks while equity returns do not and therefore in the absence of adjustment, debt may look artificially more or less attractive.

$$MRP_S = MRP_I + (\bar{R}_f - R_f^e)$$

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[78] AER (2023) *Rate of Return Annual Update 2023*. Accessed November 2024. Available here.

[79] AER (2023) *Rate of Return Instrument: Explanatory Statement, p. 141*. Accessed November 2024. Available here.

[80] Tim Brailsford (2012) *The Historical Equity Risk Premium in Australia: Post-GFC and 128 years of Data.* Accessed November 2024. Available here..

[81] The Securities Industry Research Centre of Asia-Pacific (2012) *Review of Regime Switching Framework and Critique of Survey Evidence, p. 19.* Accessed November 2024. Available here.

[82] QCA (2021) *Rate of Return Review, p. 60.* Accessed November 2024. Available here.

Where:

MRP_I = Ibbotson Market Risk Premium

$\bar{R}_f$ = Real long − run interest rate

R_f^e = Expected Long − run bond yield rate

We have used the Commonwealth Government Indexed bonds and the accompanying nominal 10-year Commonwealth Government bonds converted to real, published by the Reserve Bank of Australia.

On average, our estimation of the unexpected inflation adjustment was 0.1% which is added to the Ibbotson MRP to give a MRP of 5.9%.

7.2.3 Value of imputation credits (Gamma)

Tax imputation credits are generated when dividends are issued to shareholders and corporate tax is paid. Investors are then able to claim back tax by redeeming these credits when paying their income tax, to avoid double taxation. Australia is one of the few countries that currently has a dividend imputation system, which came into effect in 1987.

Dividend imputations has a distortionary effect on the market risk premium by providing additional benefit to the shareholder above the observed market return. Therefore, an adjustment must be made to account for this in the WACC.

The value of the imputation tax credits is referred to as Gamma.

Gamma is defined as follows:

$$\gamma = Distribution\ Rate * Utilisation\ Rate$$

Where:

$Distribution\ Rate$ = The ratio of imputation credits distributed against tax paid by a company in a year

$Utilisation\ Rate$ = The proportion of eligible investors that claim the imputation tax benefit

Intuitively, this captures the *effective* value of imputation credits, i.e. the value is only realised after the franking credits have been generated and claimed by the investor.

We have adopted a central gamma of 0.25 based on NSW IPART's current estimate of gamma, which uses a market-based approach informed by dividend drop-off studies and assumed a distribution rate of 0.7 and a utilisation rate of 0.35.[83]

[83] NSW IPART (2018) *Review of our WACC method.* Accessed November 2024. Available here.

7.2.4 Beta and gearing

The beta and gearing parameters are estimated using market data for the technology-neutral discount rate and survey data for the technology-specific WACC. The discussion below relates to the market estimates used in the technology neutral discount rate.

Comparator Selection

Financial information from publicly listed companies is used to estimate beta and gearing ratios for the technology-neutral discount rate (and as a benchmark for technology-specific parameters).

A list of comparator companies is sourced from the Utilities sector of the MSCI Global Industry Classification Standard (GICS). To incorporate the additional requirement of estimating the real pre-tax WACC by asset type we have included the following sub-industries:

- Electric Utilities
- Gas Utilities
- Independent Power Producers
- Renewable Electricity

The sample was restricted to:

- Firms from countries with an FTSE-developed classification.
- Firms with a market capitalisation of more than $US200 million to avoid thinly traded firms that may have unreliable beta estimates.
- Applied two statistical significance filters removing firms with an R-squared of less than 0.1 and a t-statistic of less than 2.

44 comparator companies remained for the analysis.

Fig. 41. Comparator companies by sub-industry

	Electricity Utilities	Gas Utilities	Independent Power Producers	Renewable Electricity
International	21	4	6	13

Source: Oxford Economics (2024), Bloomberg data, CEPA (2023), Synergies (2021 & 2022)

Comparator Asset Beta

Systematic risk measures the extent to which a company's stock returns move in relation to the overall market returns. Two primary factors influence a firm's equity beta:

- **Business risk**, reflects the sensitivity of a company's cash flows to changes in economic conditions. Firms with more cyclical cash flows tend to have higher betas.
- **Financial risk**, stemming from the company's capital structure. Greater reliance on debt and the obligations it entails increases financial risk, leading to a higher beta.

To observe a firm asset beta that only includes business risk we convert the equity beta to an asset beta using the Brealey Myers approach:

$$\beta_e = \beta_a * (1 + \frac{D}{E})$$

Where:

β_e = Equity Beta

β_a = Asset Beta

$\frac{D}{E}$ = Debt to equity ratio

Data for equity betas was sourced from Bloomberg using weekly data over two years. The resulting asset betas at the average, median and 75th percentile are presented below.

Fig. 42. Asset beta estimates by sub-industry

	Total	Electric Utilities	Gas Utilities	Independent Power Producers	Renewable Electricity
Average	0.47	0.51	0.36	0.32	0.51
Median	0.41	0.42	0.35	0.40	0.41
75th percentile	0.55	0.68	0.39	0.43	0.65

Source: Oxford Economics (2024), Bloomberg data, CEPA (2023), Synergies (2021 & 2022)

Under our central case scenario, we adopt the average for the technology-neutral asset beta resulting in 0.5 (after rounding).

When benchmarking the survey results against the market data to assess the reasonableness of the survey responses we classify the technologies under the broader GICS categories as follows.

Fig. 43. AEMO technology type to GICS concordance table

AEMO Asset Type	GICS sub-industry
Electricity - Transmission	Electric Utilities
Electricity - Distribution	Electric Utilities
Gas - Transmission	Gas Utilities
Gas - Distribution	Gas Utilities
Utility Scale Solar	Renewable Electricity
Onshore Wind Generation	Renewable Electricity
Offshore Wind Generation	Renewable Electricity
Gas Powered Generation	Independent Power Producers
Hydrogen Reciprocating Engine	Independent Power Producers
Coal Generation	Independent Power Producers
Large-scale BESS	Renewable Electricity
Pumped Hydro Energy Storage	Renewable Electricity
Hydrogen Electrolysers	Independent Power Producers
Gas Plant	Gas Utilities
Gas Pipeline	Gas Utilities

Source: Oxford Economics (2024), Bloomberg data

Gearing

The same comparator set was used to estimate gearing for the technology-neutral discount rate.

Fig. 44. Gearing comparator estimates by sub-industry

	Total	Electric Utilities	Gas Utilities	Independent Power Producers	Renewable Electricity
Average	48%	43%	54%	61%	50%
Median	49%	43%	54%	57%	52%

Source: Oxford Economics (2024), Bloomberg data, CEPA (2023), Synergies (2021 & 2022)

The average and median gearing ratios were 48% and 49% respectively. Across all sub-industries, we observed a similar clustering of average and median debt levels. Consistent with Synergies and CEPA we have adopted the gearing ratios of 50% for both the central and upper bound estimate.

7.3 COST OF DEBT

An on-the-day estimate of debt is used to determine the cost of debt.

$$K_d = R_f + DRP$$

Where:

K_d = Cost of debt

R_f = Risk − free rate

DRP = Debt risk premium

7.3.1 Debt risk premium

The debt risk premium refers to the required return for holding a bond on a risk-bearing asset above the risk-free rate. We proxy the yields reported on credit ratings to determine the appropriate debt risk premium to apply to our technology-neutral discount rate and technology-specific WACCs.

To determine our technology-neutral credit rating we utilise our market sample alongside our survey respondents. The average and median credit rating from survey respondents is BBB in line with what has been recommended by Synergies and CEPA in previous reports. Historically, the lowest credit rating that is considered investment grade is BBB.

Our market sample's average and median credit rating is rated marginally higher at BBB+. We believe that a credit rating of BBB in line with our survey respondents and previous reports is appropriate given the only marginally higher results generated from our market sample. Furthermore, survey respondents provided answers based on prospective investments whereas credit ratings for our market sample reflect the credit risk of pre-existing assets.

Fig. 45. Credit ratings

	Survey Respondent	Market Comparison
Average	Baa2 (Moodys), BBB (S&P)	Baa1 (Moodys), BBB+ (S&P)

Source: Oxford Economics (2024), Bloomberg data, CEPA (2023), Synergies (2021 & 2022)

However, we have allowed the credits ratings to vary by technology to allow for differences in the cost of debt that are reflective of differences in default risk for the technology-specific WACCs. Credit ratings by technology are taken of the average reported by survey respondents.

To calculate the credit spread, we have used RBA bond yield data and constructed a proxy BBB+ and A- band using the Australia Energy Regulator method, as follows:[84]

$$BBB+ = \frac{1}{3} * RBA_A + \frac{2}{3} * RBA_{BBB}$$

Term to maturity

For our analysis, we use a term to maturity of 10 years, which is the typical term for bonds issued by regulated assets and is also consistent with the approach outlined in Synergies and adopted by CEPA. To be consistent with the corporate bond yield, 10-year Commonwealth Government bonds are used as the nominal risk-free rate when calculating the debt risk premium.

7.3.2 Expected Inflation

OEA has adopted the breakeven methodology for estimating expected inflation in line with Synergies and CEPA. The breakeven method estimates inflation as the difference between forward-looking yields on nominal long-term government bonds and on indexed bonds utilising the Fisher Equation.[85] The RBA publishes daily yields for both series. To ensure consistency with the risk-free rate and debt risk premium we adopt a 20-day averaging approach to 24 October 2024.[86]

7.4 UPPER & LOWER BOUNDS

For the technology-neutral discount rate the lower bound, per the AER's guidelines, "…should be the regulated cost of capital, based on the AER's most recent regulatory determination at the time of the final ISP. If there is more than one option (for example, if there were two 'most recent regulatory determinations' that were published simultaneously), AEMO should choose a value between the options that best reflects the requirement."[87]

We utilise survey data to calculate the upper & lower bounds. Survey respondents were asked to provide an upper & lower bound to their regulated & unregulated assets and we apply a simple average of these responses to the central estimate.

[84] AER (2023) *Rate of Return Instrument: Explanatory Statement.* Accessed November 2024. Available here.
[85] AER (2017) *Regulatory treatment of inflation: discussion paper.* Accessed November 2024. Available here.
[86] Data can be found in the RBA's "Capital Market Yields – Government Bonds – Daily – F2" data series. Accessed November 2024. Available here.
[87] AER (2024) *Cost benefit analysis guidelines.* Accessed November 2024. Available here.

The technology-neutral upper bound (+2.6%) is smaller in magnitude than what was used for the 2024 ISP (+3.3%). The difference is primarily because we recommend using an average of both regulated and non-regulated assets for the technology-neutral upper bound while AEMO chose to use an upper bound based only non-regulated asset responses for the 2024 ISP.

Fig. 46. Upper & lower bound adjustments

	Lower	Upper
Technology-neutral discount rate	Equal to AER determination	+2.6%
Technology-specific – regulated	Equal to AER determination	+1.5%
Technology-specific – unregulated	-1.9%	+3.1%

Source: Oxford Economics (2024)

An alternative approach to calculating the upper bound adjusts the parameters for gamma and the asset beta which is the methodology set out by Synergies and also adopted by CEPA. This generates an upper bound estimate of 8.0% for the technology-neutral discount rate. By reducing the Ibbotson sample to post-1988, the differential between the central estimate and the upper bound is compressed to only 1.0%. Using data back to 1883 softens the impact on the MRP of a change to gamma[88] as giving less value to imputation credits only has implications for approximately 25% of the sample. We agree with AER that current market conditions and subsequently market returns are more reflective of the period from 1988 onwards and are comfortable with the methodological change adopted for the central. We therefore adopt the survey methodology for estimating the lower and upper bounds.

7.5 SURVEY

The aim of the survey was to inform a pre-tax real weighted average cost of capital estimation and understand the main risks and drivers associated with the cost of capital estimates as well as calculate technology-specific WACC parameters. Further interviews were also conducted alongside the surveys to provide a further understanding of the survey responses, risks and drivers across various technologies & organisational types.

7.5.1 Survey design

The survey questions were developed by Oxford Economics Australia, with input from AEMO. To maximise survey engagement, the survey was limited to 13 questions comprised of multiple-choice and free-form responses. Participants were also informed that their responses are protected by applicable federal and state privacy and confidentiality laws.

There were three main sections to the survey.

The first section aimed to inform a pre-tax real weighted average cost of capital and to understand the sensitivity around this figure.

[88] A lower gamma reduces the MRP by giving less value to imputation credits.

1. What is the pre-tax weighted average cost of capital you currently use for evaluating future energy asset investment? What is the assumed term to maturity of asset in the above WACC response? If you have multiple assets, please specify by asset type, term to maturity and the state in which the asset operates. If you are a Network Service Provider, please list your WACC for regulated assets and unregulated assets separately.
2. What is your assumed inflation rate for FY24, FY25 and long term?
3. What was your view of the pre-tax weighted average cost of capital 12 months ago?
4. What do you see as realistic upper and lower bound variation around your weighted average cost of capital assumptions selected in Question 1? If you are a network service provider, please answer this for your unregulated assets. If you are a network service provider, what do you see as realistic upper and lower bound variation around your weighted average cost of capital assumptions for your regulated assets?

The second section delves into the main components of the weighted average cost of capital, focusing on the equity risk premium, debt risk premium and asset beta.

5. What is your assumed risk free rate underpinning the WACC reported in Q1?
6. What is your debt-to-equity ratio for your asset? If you have multiple assets, please provide an answer for each asset type.
7. What is your assumed market risk premium?
8. What is the risk premium above the market risk premium that you would apply for the following assets? This question is intended to help in understand market view around the unlevered asset beta for a given project. Is there anything else you would like to add?
9. For debt financing, based on your assessment, what credit rating would you assign to the following assets? Please select using the scale from AAA (Prime) to D (In default). Is there anything else you would like to add?

The third section aimed to understand the risks associated with the weighted average cost of capital. The questions focused on how various risk premiums are applied to the reported weighted average cost of capital, and the effect of various energy policies and subsidies on the weighted average cost of capital.

10. Which of these risks have the largest bearing on your weighted average cost of capital? What is the premium associated with this uncertainty?
    - Land acquisition risk
    - Planning risk
    - Social licensing
    - Construction risk (incl. connection risk)
    - Operational risk (incl. congestion risk)
    - Policy risk
    - Merchant risk
    - Other risk, please specify
11. What is the minimum percentage of contracted offtake that you require for this project? Is this for energy output or capacity?
12. What is the length of your PPA agreement contract (in years, on average), if you have one for this project?

13. Is there anything else that you would like to add for consideration?

7.5.2 Survey response

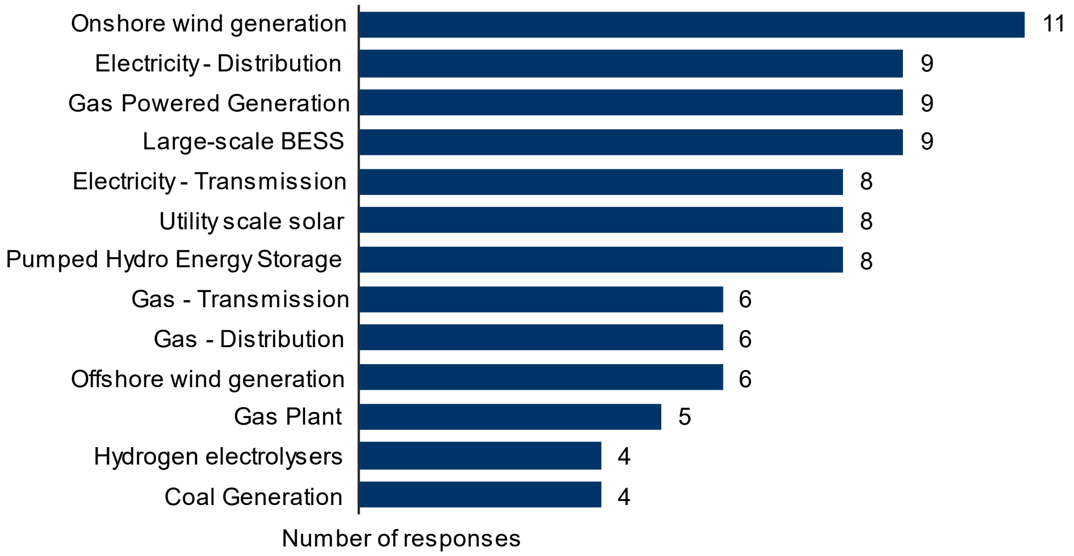
The survey and interviews were conducted over a seven-week window during October & November 2024.

The survey was sent to 108 companies active in the energy market covering:

- Asset developers
- Asset owners
- Network service providers
- Lenders and investors
- Independent bodies.

Of these, 21 participants took part in the survey, 12 participants provided survey results only and 9 participants responded with both the survey and follow-up interview. They survey received a total of 93 responses across technologies.

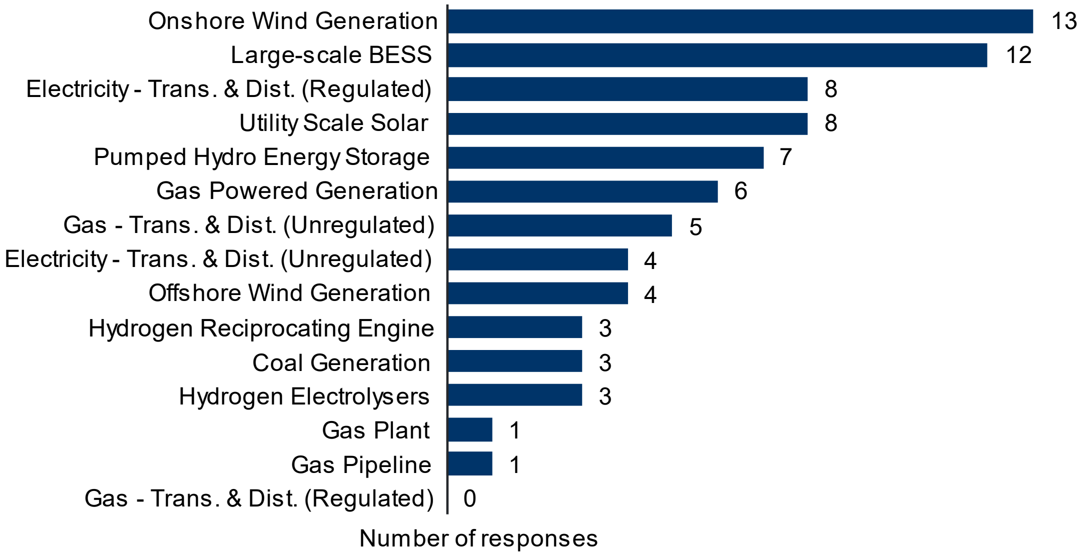
Fig. 47. Survey responses by technology (any survey response)



Source: Oxford Economics (2024)

However not all respondents provided sufficient information to inform the technology-specific parameters. The final response count technology-specific parameters calculated from the survey are given in the table below.

Fig. 48. Survey responses by technology (final count)



Source: Oxford Economics (2024)

Overall, the exercise has produced rich and valuable insights into the weighted average cost of capital and various other considerations faced by the renewable energy investment market. It should be noted that while the key findings above provide a good view within the sample of participants, it does not necessarily reflect the full population due to the small sample size especially in some technologies. We have benchmarked survey results against market data and international benchmarks to provide confidence in estimates generated from small sample sizes. Where sufficient confidence in the results can not be generated this is highlighted in chapter 2 and 3.

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