CEPA
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Hurdle rate estimates for electricity sector technologies

DESNZ

30 July 2025

FINAL REPORT

Important notice

Contents

Figures

Tables

Glossary

Acronym	Description	Acronym	Description
ACT	Advanced conversion technologies	GDP	Gross domestic product
AD	Anaerobic digestion	H2P	Hydrogen to power
AGT	Advanced gasification technology	HPBM	Hydrogen to power business model
AMRs	Advanced modular reactors	HRT	Higher regulatory threshold
AR6	Allocation Round 6	ILG	Indexed-linked gilt
BECCS	Bioenergy Carbon Capture and Storage	IRENA	International Renewable Energy Agency
BESS	Battery energy storage system	IRR	Internal rate of return
BICs	Bloomberg Industry Classifications	LAES	Liquid air energy storage
BM	Business model	LCOE	Levelised cost of energy
BOE	Bank of England	LDES	Long duration electricity storage
CAES	Compressed air energy storage	LRT	Lower regulatory threshold
CAPM	Capital asset pricing model	MRP	Market risk premium
CCGT	Combined cycle gas turbine	NREL	National Renewable Energy Laboratory
CCHT	Combined cycle hydrogen turbine	NOAK	Nth of a kind
CCUS	Carbon capture use and storage	NPV	Net present value
CfD	Contract for difference	OBR	Office of Budgetary Responsibility
CHP	Combined heat and power	OCGT	Open cycle gas turbine
CM	Capacity market	OCHT	Open cycle hydrogen turbine
CMA	Competition and Markets Authority	OEM	Original Equipment Manufacturer
CPI	Consumer price index	PHES	Pumped hydro energy storage
CPIH	Consumer Prices Index including owner occupiers' housing costs	RAB	Regulated asset base
DESNZ	Department for Energy Security and Net Zero	REMA	Review of Electricity Market Arrangements
DPA	Dispatchable Power Agreement	RPI	Retail price index
EBITDA	Earnings before interest, depreciation and amortisation	SEM Committee	Single Electricity Market Committee
EE	Europe Economics	SMRs	Small modular reactors
EfW	Energy from waste	T&S	Transport and storage
ERP	Equity risk premium	TMR	Total market return
ESO	Electricity System Operator	TNUoS	Transmission Network Use of Service
ETR	Effective tax rate	TRL	Technology readiness level
ETS	Emissions trading scheme	UK	United Kingdom
FLOW	Floating offshore wind	UKRN	UK Regulators' Network

Acronym	Description	Acronym	Description
FLOWMIS	Floating Offshore Wind Manufacturing Investment Scheme	**US**	United States
FOAK	First of a kind	**WACC**	Weighted average cost of capital
GB	Great Britain		

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EXECUTIVE SUMMARY

Note: The 'headline' hurdle rate estimates reported in this executive summary are the product of specific assumptions (for example, in relation to capital structure). Any single estimate may, therefore, require adjustment in order to reflect the particular characteristics of a specific investment or use case. Users of this report should take account of this context when using or referring to the hurdle rate estimates.

Terms of reference

CEPA has been engaged by the Department for Energy Security and Net Zero (DESNZ) to develop estimates of hurdle rates for a range of different electricity generation technologies. The hurdle rate assumptions may be used by DESNZ across a range of policy areas.

Our scope is to establish hurdle rate assumptions for a **wide range of electricity sector technologies**, including renewable generation, other low carbon generation, thermal generation (both with and without carbon capture use and storage, or CCUS), storage technologies, interconnectors, hydrogen electrolysers, and demand response.

The context in which DESNZ will use the hurdle rate estimates requires that these reflect the return required over the life of the project: a **'whole-of-life' hurdle rate**. This differs from the return that may be required at a specific stage of project development. In addition, the 'base case' hurdle rate estimates for each technology are also associated with an assumed **revenue model**. This means that the estimated hurdle rates presented in this report reflect risk differences that result from both the underlying technology characteristics and the effect of the revenue model. As a sensitivity, we have also considered how hurdle rates would change for certain technologies if they instead operated under a **merchant revenue model** (i.e., assuming that the project does not have a long-term contract that underpins its future revenue stream and is, therefore, exposed to wholesale electricity market risks).

Our terms of reference also require:

- Hurdle rate estimates that **apply in 2025**. These should capture changes in the electricity and financial market context since the previous hurdle rate study conducted for DESNZ by Europe Economics in 2018.[1] For example, since that time there have been changes in relation to: technology and supply chain maturity; the support mechanisms that have been put in place to bring forward deployment; and interest rates and inflation expectations. The hurdle rates set out in this report are estimated at 31 December 2024.
- Hurdle rates that reflect **current policy settings**. For example, the estimates assume that reforms being considered through the Review of Electricity Market Arrangements (REMA) are not implemented – i.e., that these hurdle rates provide a baseline as of 31 December 2024, which is before the announcement of a REMA decision.
- Hurdle rates that are expressed in both **pre- / post-tax** and **real / nominal** terms.
- Advice on how DESNZ can best **"future proof"** the hurdle rate estimates through a process of periodic updates.

Finally, the analysis contained in this report was undertaken prior to recent developments regarding international trade policy and related impacts on financial markets. DESNZ may wish to monitor the potential implications of these developments for hurdle rates in future.

Challenges

Estimating hurdle rates is a challenging task and necessarily involves judgement. The primary difficulty lies in there rarely being comparators that precisely match the risk characteristics of the investment being assessed. In practice,

[1] Europe Economics (2018), *Cost of Capital Update for Electricity Generation, Storage and Demand Side Response Technologies*, November.

the required return for any individual investment is also likely to reflect a range of specific features, such as the risk allocation reflected in any support mechanism and/or embedded in its contracting arrangements (i.e., the extent of risk that the project developer has been able to pass through to its supply chain or other agents). These features may differ across technologies, but there is also considerable variation *within* the same technology type. Debt and equity providers may also hold differing views on the required return for a particular set of risks. Further, perceptions of risk are not fixed and may evolve over time. Overall, the evidence available to inform judgements on hurdle rates is limited, and sometimes contradictory.

These challenges are exacerbated when we try to accommodate differences in financial structures. We see a range of levels of gearing between and within technology types. Whilst there are techniques that aim to control for these differences in order to show hurdle rates on a common basis, there is no guarantee that the results will be intuitive or that they will reconcile easily with benchmarks developed in a different way.

The level of precision involved in this analysis is therefore low. In this context, we consider that the approach to developing hurdle rate estimates should acknowledge these challenges by:

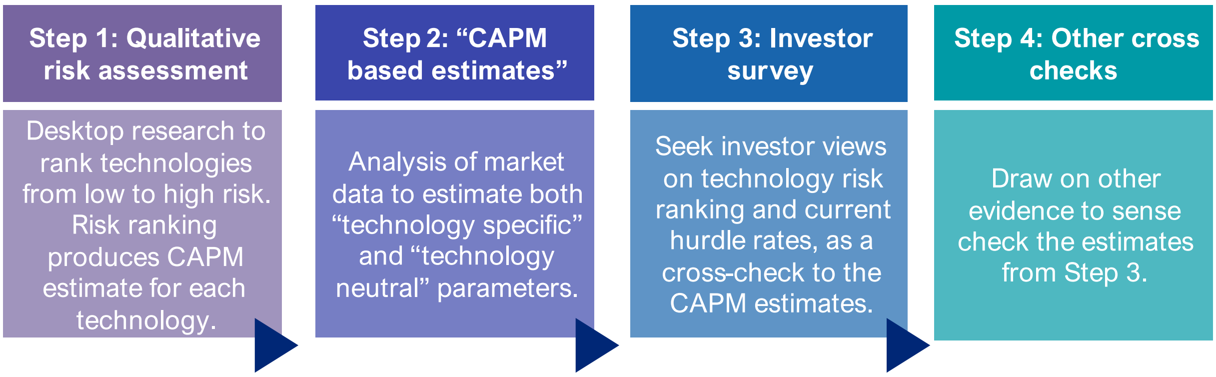
- Adopting well-accepted estimation methods, while recognising that in practice investors use a range of alternative approaches to select hurdle rates.
- Developing estimates that are intuitive and – as far as possible – internally consistent.
- Avoiding spurious levels of precision.
- Providing transparency around the inherent uncertainties and limitations.
- Using cross-checks where available.

The hurdle rate estimates set out in this report reflect our judgement on reasonable assumptions in light of these challenges. Given the inherent uncertainty, we have reported the hurdle rate assumptions as ranges (with a mid-point) and have tested sensitivities on key variables. These ranges mitigate, but do not eliminate, the challenges in estimation – and remain subject to the need for careful interpretation, discussed further below.

Approach

The figure below summarises the four-step approach we have adopted, with the discussion above in mind.

Figure E.1: Overview of CEPA's estimation approach



In **Step 1,** we conducted a qualitative risk assessment of the technologies, capturing differences related to their technical characteristics and assumed revenue model. Each technology received an overall risk rating of 'low', 'low-medium', 'medium', 'medium-high', or 'high'. The risk assessment has been discussed with DESNZ, drawing on internal DESNZ expertise in the technologies and revenue models that are covered by this study.

In **Step 2**, we developed a set of hurdle rate estimates based on the capital asset pricing model (CAPM) framework.[2] Within this framework, we use the asset beta and credit rating parameters to reflect underlying differences in risk for each technology, as assessed in Step 1. Each risk rating has an associated asset beta and credit rating – for example, a technology rated 'high' risk is assigned a higher asset beta than one rated 'low' risk. The asset beta and credit rating assumptions assigned to each risk level reflect judgements on where the technologies of interest sit relative to a set of listed comparator firms. For example, because the comparator sample is primarily comprised of companies that invest in mature generation technologies (mainly onshore wind and solar PV, and to a lesser extent offshore wind, hydropower and natural gas) with a relatively high proportion of revenues under long-term contracts, we have positioned the risk categories such that "low-medium risk" technologies are assigned an asset beta around the median of the comparator sample. The "low risk" technologies then sit below this, and the higher risk categories above.

In **Step 3**, we conducted a survey of investors. This provided both qualitative and quantitative evidence that we used as a cross check to the CAPM-based estimates derived in Step 2.

In **Step 4**, we considered a range of other cross checks, including investor surveys conducted in the past, or in other countries, other published reports commenting on hurdle rates, and the hurdle rates set out in company communications to their investors.[3]

Interpretation

We are aware that the hurdle rate estimates set out in this report may be used for a wide range of purposes. Users of this report should bear in mind that the estimates relate to a 'generic' project under the assumptions we have stated. **Any single estimate may, therefore, require adjustment in order to reflect the particular characteristics of a specific investment or use case**.

The following examples illustrate this point:

- **We have applied simplifying assumptions for a range of parameters that may impact hurdle rates.** For example, we have assumed that a common effective tax rate (the standard corporate tax rate) applies to all technologies. This reflects our view that there is insufficient evidence to robustly determine a different effective tax rate assumption for specific technologies. In practice, there are many reasons why effective tax rates will vary across investments.
- **The assessed hurdle rates consider the underlying technical risks of each technology, which may not be entirely borne by investors.** For example, gas generation with carbon capture, use and storage (CCUS) is considered to have a higher level of construction and operating risk relative to unabated gas, which is reflected in a higher risk rating and hurdle rate. In practice, the way that a gas CCUS project is structured may mean that its investors do not fully bear this difference in risk. For example, the original equipment manufacturers (OEMs) involved in the project may agree to provide warranties that extend to the capture elements. This may increase the capital and/or operating *cost* of the project but reduce the level of *risk* for the project sponsors (i.e., because the OEM has agreed to take on this risk). In this circumstance, setting a higher hurdle rate for gas with CCUS compared to unabated gas may overstate the returns investors actually require.
- **The hurdle rates reflect assumptions on how the revenue model for each technology mitigates risk, which is uncertain.** For some technologies, the assumed revenue model was still being developed at the time our analysis was conducted (e.g., the business model for hydrogen to power projects). For others, the

[2] Refer to Section 1.5 for an overview of the CAPM. In practice, because DESNZ has asked us to develop hurdle rate estimates, we have taken account of risks that would not typically be considered relevant to a 'pure' CAPM cost of capital. This is explained in Section 3.1.2.

[3] In considering this evidence, we have taken the context into account – for example, to reflect that hurdle rates are likely to vary across countries in absolute terms due to underlying differences in interest rates, taxation regimes and other factors.

degree of risk mitigation will ultimately be subject to the outcome of negotiations between the UK Government and the project developer and/or future regulatory decisions. For example:

  - The degree of revenue stabilisation provided by the gas CCUS dispatchable power agreement (DPA) will depend on the proportion of total revenues that are provided by the availability payment, as opposed to merchant revenues. This may impact the overall risk classification for gas with CCUS. However, at the time of preparing this report CEPA did not have visibility of what this proportion is likely to be.
  - Under the nuclear regulated asset base (RAB) framework, the degree of construction cost risk for a given project will in part depend on the level at which capital cost thresholds are set. As evidence of this was not available to inform this report, the level of construction risk faced by a specific nuclear RAB project may be different to what CEPA has assumed.

  More generally, there will be numerous details associated with each revenue model that can impact hurdle rates, but that are not practical or possible to capture given the breadth of this study. Deriving hurdle rates for negotiated projects would, therefore, require more detailed consideration of the relevant commercial arrangements.

- **There are many ways that hurdle rates can be derived and expressed.** We have attempted to transparently present how the hurdle rate estimates contained in this report have been built up. However, this is not the only way that hurdle rates could be developed or expressed. For example, we have expressed hurdle rates in 'vanilla' terms – i.e., that do not capture the effect of the interest tax shield.[4] This means that our estimates may not be strictly comparable with hurdle rates that are presented or used in other contexts.

Results

Table E.1 overleaf presents the assumed risk rating and associated hurdle rate for each technology, assuming:

- **The proposed mid-point assumptions** for asset beta and credit rating.
- **A 'whole life' hurdle rate.** As explained above, this differs from the return that may be required at a specific stage of project development.
- **The "base case" revenue model.** As indicated, the assumed revenue model varies across technologies. Section 2 describes the assumptions we have made.
- **An assumed capital structure** of 50% debt and 50% equity (i.e., 50% gearing).
- **Pre-tax real (CPI) hurdle rates.** A pre-tax hurdle rate reflects the returns that an investor would require before accounting for tax payments. A real hurdle rate reflects the returns that an investor would require before accounting for the impact of inflation. A real CPI hurdle rate means that the hurdle rate has been calculated using an expected future value of inflation as measured by the Consumer Price Index (CPI).

[4] The interest tax shield refers to the fact that in the United Kingdom (UK), debt interest payments are tax deductible. Accordingly, the higher the level of debt used to finance a project, the greater the tax deduction.

Table E.1 Risk ratings and whole-life hurdle rates (pre-tax real CPI, base revenue model) – 31 December 2024

Technology	Base revenue model	Risk rating	Lead scenario (mid-point, 50% gearing)
Solar PV	CfD	L-M	7.60%
Onshore wind		L-M	7.60%
Offshore wind		M	8.90%
Remote island wind		M	8.90%
Floating offshore wind		H	11.40%
Hydropower		M	8.90%
Advanced conversion technologies (ACT)		M-H	10.10%
Anaerobic digestion (AD)		L-M	7.60%
Sewage gas		L-M	7.60%
Landfill gas		L-M	7.60%
Energy from waste		M	8.90%
Biomass – unabated		M	8.90%
Deep geothermal		M-H	10.10%
Wave		H	11.40%
Tidal stream		H	11.40%
Tidal range[1]	None	H	12.90%
Biomass – with CCUS – mature[2]	BECCs BM	M	8.90%
Biomass – with CCUS – maturing[2]		M-H	10.10%
Large-scale nuclear	Nuclear RAB	L-M	7.60%
Small modular reactors (SMRs)		M	8.90%
Advanced modular reactors (AMRs)		M	8.90%
Pumped hydro energy storage (PHES)	LDES cap & floor	M	8.90%
Novel long duration energy storage (LDES)		M-H	10.10%
Lithium batteries	CM contract[3]	M	8.90%
New compound batteries[1]		H	12.90%
Demand response aggregators		M	8.90%
Gas generation – unabated		M	8.90%
Gas generation – CCUS – mature[2]	Power CCUS BM	M	8.90%
Gas generation – CCUS – maturing[2]		M-H	10.10%
Hydrogen CCHT / OCHT – mature[2]	H2P BM	M	8.90%
Hydrogen CCHT / OCHT – emerging[2]		M-H	10.10%
Hydrogen electrolyser	HPBM	M-H	10.10%
Interconnectors	Cap & floor	L-M	7.60%

Source: CEPA analysis. Notes: (1) Reflects uplift to capture differences between the other 'high risk' technologies – see Section 4.6. (2) Given the uncertainties around nascent CCUS and hydrogen to power (H2P) technologies, we have included a wide indicative range that will be refined at a future date. (3) Lithium batteries may also be eligible for the LDES cap & floor scheme if they meet the relevant criteria – see Section 2.2. This may reduce the assumed risk rating and hurdle rate compared to the level shown in this table.

The footnotes to Table E.1 above explain that we have provided a wide range of hurdle rate estimates for technologies with CCUS (gas and biomass) and for hydrogen to power (H2P). This reflects both the emerging nature of these technologies, and the wide range of technical specifications that could be considered. For example, for H2P it is expected that small turbines, firing less than 100% hydrogen, combined with revenue support covering a significant proportion of capital and operating expenditure would attract a hurdle rate at the lower bound of the estimate shown.

There is a considerable uncertainty band around the 'headline' hurdle rate estimates set out in Table E.1, particularly for those technologies where there is very limited evidence. Accordingly, Table E.2 below sets out:

- **An overall uncertainty range.** This reflects the combined impact of the upper-bound and lower-bound assumptions we have proposed for the asset beta, credit rating and gearing. This reflects that there is a band of uncertainty around the proposed mid-point estimate.[5]
- **An unlevered hurdle rate scenario.** That is, the mid-point hurdle rate assumptions that result from adjusting our calculations to a capital structure that is 100% equity. This is provided as a point of reference that may be more relevant to some users of this report, compared to the levered hurdle rates in Table E.1.[6]

Table E.2: Hurdle rate sensitivities (pre-tax real CPI, base revenue model) – 31 December 2024

Risk rating	Lead scenario (mid-point, 50% gearing)	Unlevered scenario (mid-point, 0% gearing)	Uncertainty range (high/low asset beta, credit rating and gearing assumptions) [2]	
			Low	High
L	6.70%	5.60%	-0.9%	+1.2%
L-M	7.60%	6.30%	-1.1%	+1.3%
M	8.90%	7.40%	-1.6%	+1.7%
M-H	10.10%	8.40%	-1.6%	+1.9%
H	11.40% (12.90%)[1]	9.50% (11.0%)	-1.8%	+1.9%

Source: CEPA analysis. Notes: (1) Applies to tidal range and new compound batteries. (2) Please refer to Section 4.3.1 (asset beta), Section 4.3.2 (credit rating) and Section 4.4.5 (gearing) for a discussion of the low / high assumptions.

The report also considers other formulations of the hurdle rates, including:

- A sensitivity that assumes a merchant revenue model.
- Hurdle rates that:
  - are expressed in pre- and post-tax terms – i.e., expressing the level of returns that investors would require before and after tax;
  - are expressed in real and nominal terms – i.e., expressing the level of the returns that are required before and after accounting for the impact of inflation; or
  - use different measures of inflation. In particular, we have considered estimates using both CPI and the GDP deflator. CPI inflation is the rate at which the prices of goods and services bought by UK households rise and fall. The GDP deflator measures changes in the prices of all domestically produced goods and services in the economy.

[5] The impact of varying the asset beta, credit rating and gearing assumptions individually is set out in Appendix F.

[6] These may not be comparable to unlevered hurdle rates estimated under a different methodology (see Appendix D.2.5).

1. INTRODUCTION

1.1. Context

CEPA has been engaged by the Department for Energy Security and Net Zero (DESNZ) to develop estimates of hurdle rates for a range of different electricity generation technologies.

The hurdle rate assumptions may be used by DESNZ across several areas, including to support:

- Modelling of the levelised cost of energy (LCOE) for generation technologies, as part of the generation cost reports.
- The determination of payment streams that projects can receive through government revenue support mechanisms, including the administrative strike price for contract for difference (CfD) allocation rounds, the capacity market (CM), and potentially the carbon capture usage and storage (CCUS) dispatchable power agreement arrangements.
- Whole of system energy modelling.
- Analysis of potential policy reforms, for example those being considered under the Review of Electricity Market Arrangements (REMA).
- A range of other purposes, including strategic analysis (e.g., Power Sector Optimisation) and business case appraisals.

CEPA understands that the hurdle rate assumptions will not be used to inform negotiations between the UK Government/DESNZ and the proponents of specific projects (for example, nuclear or carbon capture and storage projects). This would require more detailed consideration of the relevant commercial arrangements for each project under negotiation. As we explain in Section 6, there are several reasons why the hurdle rates presented in this report may differ from hurdle rates agreed via a negotiated process.

1.2. Hurdle rates

A hurdle rate represents the minimum project internal rate of return (IRR) at which an investment will proceed. If the projected future cashflows of the project are discounted at the hurdle rate, the net present value (NPV) of those cash flows should be at least zero for the project to move ahead.

When making investment decisions, the hurdle rate can be determined by estimating the project's weighted average cost of capital (WACC): the weighted average of the project's cost of debt and cost of equity, where the weighting is determined by the level of gearing (the proportion of debt and equity within the overall capital structure). A common approach, at least in regulatory contexts, is to estimate the cost of equity using the capital asset pricing model (CAPM) framework. The CAPM rests on several assumptions, for example in relation to the distribution of expected returns and the preferences of investors. A key implication of the CAPM is that investors will hold a diversified portfolio of investments and thus require remuneration in proportion to 'systematic risk' – which cannot be eliminated by diversification (see Box 1).

In practice, investors may not necessarily adopt a CAPM-based WACC when determining the hurdle rate used to determine whether a project goes ahead. For example, sometimes investors may choose to reflect certain non-systematic risks in the hurdle rate, rather than account for these directly in the project's forecast cash flows. Engagement with investors during this project allows us to explore whether CAPM-based estimates are consistent with reported hurdle rates.

Box 1 – The CAPM and systematic risk

The CAPM is an asset pricing model widely used by UK regulators to set the allowed return on equity in RAB-regulated industries. It relates the cost of equity to a 'risk-free rate', the expected return on a market-wide portfolio of investments, and the equity beta. The beta term captures investors' exposure to risk which cannot be eliminated through diversification (systematic risk), measured as the covariance of changes in an asset's value and changes in the value of the market index. The asset beta is the equity beta of the firm removing the effect of gearing, which allows for more precise comparisons of systematic risk across firms with different capital structures.

The CAPM framework rests on several assumptions regarding the nature of risk and investors. For example, the CAPM assumes a normal and symmetrical distribution of returns around the mean.

A further assumption of the CAPM is that investors will hold a diversified portfolio of investments. This means that only risks which cannot be eliminated through diversification are relevant for determining what returns equity investors require. This means that the CAPM framework distinguishes between:

- **Business-specific risks**, which are unique to a particular investment. Equity investors can eliminate their exposure to such risks by holding a diversified portfolio. In a sufficiently diversified portfolio, on average, business-specific risks that cause lower returns for one investment will be offset by different business-specific risks that create higher returns for another investment.
- **Systematic risk**, which is the variability in returns that cannot be removed through diversification. Systematic risk is associated with factors that impact all investments in the portfolio. A diversified investor requires an overall return that is commensurate with the risk of its portfolio as a whole.

We can use an example of a gold prospecting company to demonstrate the difference between individual business risk and systematic risk. The likelihood of striking gold is low, but if gold is found returns are substantial. This means the variability of returns is very high and by extension business-specific risk is very high. However, whether a company strikes gold or not is unrelated to the performance of other investments within a diversified portfolio. To invest in the prospecting company, a diversified investor would therefore require a return that reflects the relationship between the company's returns and their portfolio's returns: that is, the element of variability in the company's returns that cannot be diversified away. The risk that the company will fail to strike gold may be material and potentially have a considerable impact on the company's cash flow. This risk is known to the diversified investor, however under the CAPM framework they do not require a higher return for this, because the risk is diversifiable.

As noted above, in practice investors might still sometimes choose to reflect business specific risks in their choice of hurdle rate. Examples in our gold prospecting case could be an investor deciding to add a risk premium to account for:

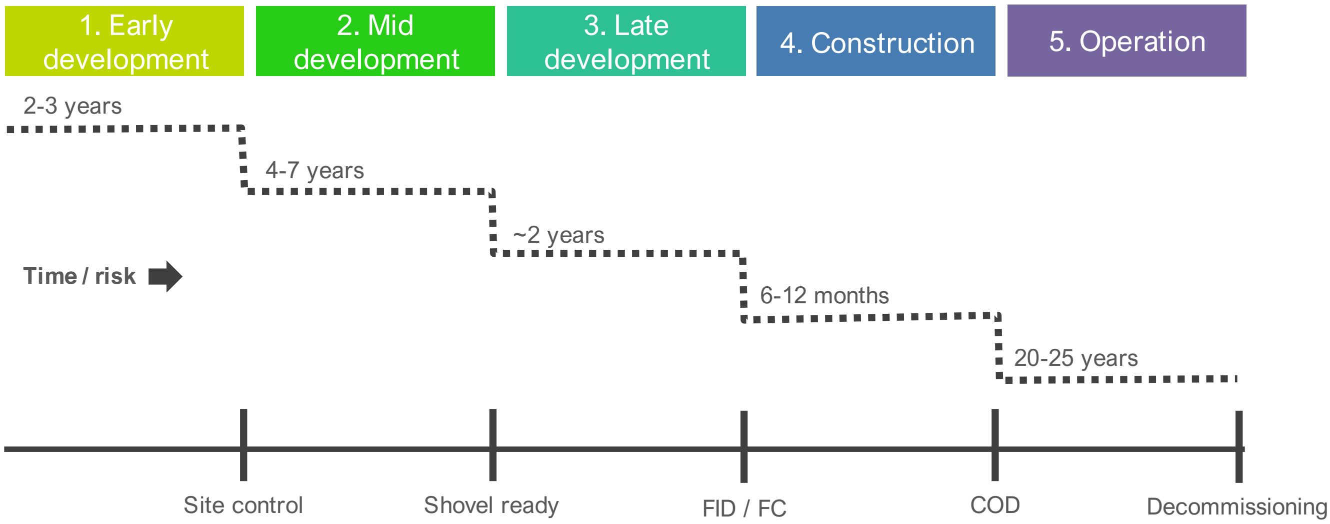
- the risk of their mining operation being halted by potential changes in environmental legislation (e.g., an asymmetric downside risk); and/or
- uncertainty around drilling costs during the exploration phase (e.g., if this uncertainty is not considered to be adequately reflected in projected cash flows for the project).

Premia applied to CAPM-based WACC estimates may not necessarily reflect specific identified risks, but may also be applied as a general 'buffer' against uncertainty.

1.3. Scope

The context in which DESNZ will use the hurdle rate estimates requires that these reflect the return required over the life of the project: a **'whole-of-life' hurdle rate**. This differs from the return that may be required at a specific stage of project development. As illustrated in Figure 1.1, this is because the nature of the risks associated with a project will typically change over time. For example, if the overall level of risk falls over time, then the required return on equity would be lower in the construction period than the development period, and lower still once the project commences operation. Conceptually, we can think of a whole-of-life hurdle rate as representing the weighted average of the returns required at different stages of a project's lifecycle.

Figure 1.1: Illustration of project risk profile (offshore wind)



Source: Adapted from https://green-giraffe.com/wp-content/uploads/2021/02/190122_5th_asia_ow_conference_-_early_development_stage_funding_for_ow_projects_vfinal_sent.pdf.

Our scope is to establish hurdle rate assumptions for a **wide range of electricity sector technologies**, including renewable generation, other low carbon generation, thermal generation (both with and without carbon capture use and storage, or CCUS), storage technologies, interconnectors, hydrogen electrolysers, and demand response.

The 'base case' hurdle rate estimates for each technology are also associated with an assumed **revenue model**. The means that the estimated hurdle rates presented in this report reflect risk differences that result from both the underlying technology characteristics and the effect of the revenue model. As a sensitivity, we have also considered how hurdle rates would change for certain technologies if they instead operated under a **merchant revenue model** (i.e., assuming that the project does not have a long-term contract that underpins its future revenue stream and is, therefore, exposed to wholesale electricity market risks).

Our terms of reference also require:

- Hurdle rate estimates that **apply in 2025**. These should capture changes in the electricity and financial market context since the previous hurdle rate study conducted for DESNZ by Europe Economics in 2018.[7] For example, since that time there have been changes in relation to: technology and supply chain maturity; the support mechanisms that have been put in place to bring forward deployment; and interest rates and inflation expectations. The hurdle rates set out in this report are estimated at 31 December 2024.
- Hurdle rates that reflect **current policy settings**. For example, the estimates assume that reforms being considered through the Review of Electricity Market Arrangements (REMA) are not implemented – i.e., that these hurdle rates provide a baseline as of 31 December 2024 which is before the announcement of a REMA decision.[8]

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[7] Europe Economics (2018).

[8] There have been policy developments between 31 December 2024 and the finalisation of this report. For example, in July 2025 the outcome of the REMA programme was published and DESNZ also released a decision to increase the CfD contract length from 15 year to 20 years for solar PV, onshore wind, offshore wind and floating offshore wind. These, and other policy developments since 31 December 2024, have not been taken into account in this report – but would be considered as part of any future update. For more information on the REMA and CfD contract length decisions, see: DESNZ (2025), *REMA Summer update*,10 July 2025, available at https://www.gov.uk/government/publications/review-of-electricity-market-arrangements-rema-summer-update-2025/review-of-electricity-market-arrangements-rema-summer-update-2025-accessible-webpage; and DESNZ

- Hurdle rates that are expressed in both **pre- / post-tax** and **real / nominal** terms.
- Advice on how DESNZ can best **"future proof"** the hurdle rate estimates through a process of periodic updates.

Finally, the analysis contained in this report was undertaken prior to recent developments regarding international trade policy and related impacts on financial markets. DESNZ may wish to monitor the potential implications of these developments for hurdle rates in future.

1.4. Challenges

Estimating hurdle rates is a challenging task and necessarily involves judgement. The primary difficulty lies in there rarely being comparators that precisely match the risk characteristics of the assets being assessed. In practice, the cost of capital for any individual asset is also likely to reflect a range of specific features, such as the risk allocation reflected in any support mechanism and/or embedded in its contracting arrangements (i.e., the extent of risk that the project developer has been able to pass through to its supply chain or other agents). These features may differ across technologies, but there is also variation *within* the same technology type. Debt and equity providers may also hold differing views on the required return for a particular set of risks. Further, perceptions of risk are not fixed and may evolve over time. Overall, the evidence available to inform judgements on hurdle rates is limited, and sometimes contradictory.

The level of precision involved in this analysis is, therefore, low. In this context, we consider that the approach to developing hurdle rate estimates should acknowledge the limitations in the evidence by:

- **Adopting well-accepted estimation methods.** We have considered the UK Regulator's Network (UKRN) 2023 guidance on the cost of capital to inform our estimation approach.[9] While this provides a helpful guide, it does not comment on every estimation choice. Accordingly, some additional judgement is needed. When exercising this judgement, we have sought to achieve a reasonable balance between theoretical robustness and ease of implementation by DESNZ in future.
- **Developing estimates that are intuitive and internally consistent.** The estimates should reflect rational judgements on risk that can be explained to stakeholders. Accordingly, we think it is important that there is a clear line of sight between qualitative assessments of risk, and the hurdle rate estimates for each technology. A straightforward way to achieve this is to constrain judgements on technology-specific differences to certain key parameters, namely the asset beta and credit rating. Further, we have aimed to reflect only reasonably well-evidenced and material differences between technologies in the estimates for these parameters.
- **Avoiding spurious levels of precision.** We appreciate that what may appear to be 'small' movements in hurdle rate assumptions can have a significant impact on the outcomes of DESNZ's analysis. On the other hand, a wide range of estimates could potentially be considered reasonable and representative of the hurdle rates that different investors may adopt, depending on their individual perceptions of risk and expectations of future economic conditions. For example, it is not uncommon for hurdle rates reported through investor surveys (including the survey conducted to inform this report) to have ranges around the midpoint of >3 percentage points, for assets of the same technology. Accordingly, we have favoured simple methods where these are, on balance, likely to provide broadly reasonable estimates.

(2025), *Contracts for Difference – Methodology used to set Administrative Strike Prices for CfD Allocation Round 7*, July 2025 available at https://www.gov.uk/government/publications/contracts-for-difference-cfd-allocation-round-7-administrative-strike-prices-methodology-note.

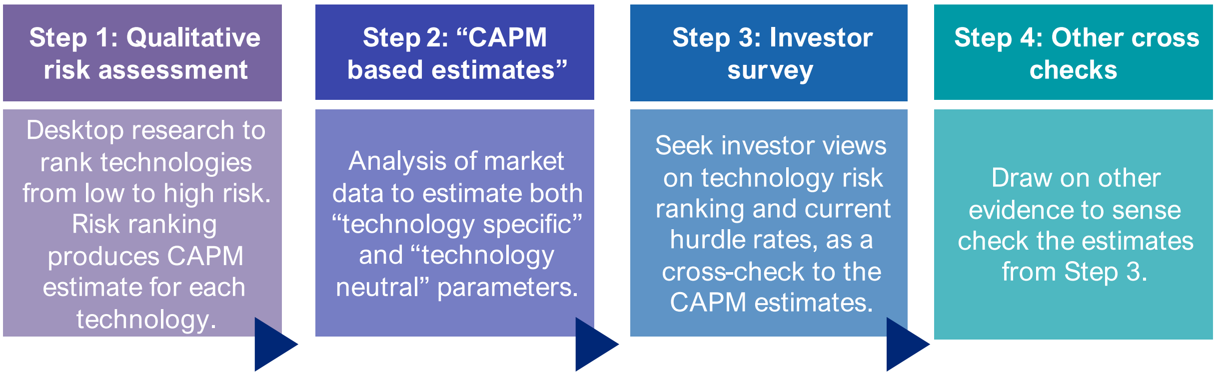
[9] UKRN (2023), *UKRN guidance for regulators on the methodology for setting the cost of capital*, 23 March 2023.

- **Using cross-checks where available.** The estimates set out in this report have drawn on multiple sources of evidence, including analysis of financial market data, a desktop study of technology risks, and an investor survey. Where available, we have also used other evidence to sense check our estimates.

1.5. Approach

Figure 1.2 below summarises the four-step approach we have adopted.

Figure 1.2: Overview of CEPA's estimation approach



In **Step 1,** we conducted a qualitative risk assessment of the technologies, capturing differences related to their technical characteristics and assumed revenue model. Each technology received an overall risk rating of 'low', 'low-medium', 'medium', 'medium-high', or 'high'.

In **Step 2**, we developed a set of hurdle rate estimates based on the CAPM framework. These were derived by estimating a set of parameters that we have divided into "technology neutral" and "technology-specific" categories:

- We assume that the **technology neutral parameters** do not vary across the different projects we are considering. These parameters are the risk-free rate, total market return, gearing, debt beta, tax rate and expected inflation.[10]
- The **technology-specific parameters** are the asset beta and credit rating (and by extension, the cost of debt). We use these parameters to reflect underlying differences in risk for each technology, as assessed in Step 1. Each risk rating has an associated asset beta and credit rating – for example, a technology rated 'high' risk is assigned a higher asset beta than one rated 'low' risk.

In practice, there are some differences between our estimation approach and a 'pure' CAPM cost of capital:

- Because DESNZ has asked us to develop hurdle rate estimates, we have taken account of risks that would not typically be considered relevant under the CAPM framework. This is explained in Section 3.1.2.
- We estimate the return on debt with reference to corporate bond benchmark indices. While this is a very common approach in the UK context, it differs from the CAPM. This is explained in Section 4.1.

In **Step 3**, we conducted a survey of investors. This provided both qualitative and quantitative evidence that we used as a cross check to the CAPM-based estimates derived in Step 2. For example, we used the survey results to consider questions such as:

- Had we identified the most relevant risks for each technology?

[10] These include 'market wide parameters' – the risk-free rate, total market return, and expected inflation – that we would expect to be the same for all projects within the UK. We have also assumed that gearing (the proportion of debt and equity within a project's overall capital structure), debt beta and the tax rate do not vary by technology. While there are reasons why these parameters may differ across technologies in practice, in Section 4.4 we explain why adopting constant assumptions is more appropriate in the context of this advice.

- Did the risk ranking of the technologies make sense?
- Were the CAPM based estimates aligned to the hurdle rates that survey respondents reported?

In **Step 4**, we considered a range of other cross checks, including:

- Investor surveys conducted in the past, or in other countries.
- Other published reports commenting on hurdle rates.
- Hurdle rates set out in company communications to their investors.

In considering this evidence, we have taken differences in context into account – for example, to reflect that hurdle rates are likely to vary across countries in absolute terms due to underlying differences in interest rates, taxation regimes and other factors.

The hurdle rate estimates set out in this report reflect our judgement on reasonable assumptions, drawing on the evidence outlined above. Given the inherent uncertainty, we have reported the hurdle rate assumptions as ranges (with a mid-point) and have tested sensitivities on key variables.

1.6. Interpretation

We are aware that the hurdle rate estimates set out in this report may be used for a wide range of purposes. Users of this report should bear in mind that the estimates relate to a 'generic' project under the assumptions we have stated. **Any single estimate may, therefore, require adjustment in order to reflect the particular characteristics of a specific investment or use case**.

The following examples illustrate this point:

- **We have applied simplifying assumptions for a range of parameters that may impact hurdle rates.** For example, we have assumed that a common effective tax rate (the standard corporate tax rate) applies to all technologies. This reflects our view that there is insufficient evidence to robustly determine a different effective tax rate assumption for specific technologies. In practice, there are many reasons why effective tax rates will vary across investments.
- **The assessed hurdle rates consider the underlying technical risks of each technology, which may not be entirely borne by investors.** For example, gas generation with carbon capture, use and storage (CCUS) is considered to have a higher level of construction and operating risk relative to unabated gas, which is reflected in a higher risk rating and hurdle rate. In practice, the way that a gas CCUS project is structured may mean that its investors do not fully bear this difference in risk. For example, the original equipment manufacturers (OEMs) involved in the project may agree to provide warranties that extend to the capture elements. This may increase the capital and/or operating *cost* of the project but reduce the level of *risk* for the project sponsors (i.e., because the OEM has agreed to take on this risk). In this circumstance, setting a higher hurdle rate for gas with CCUS compared to unabated gas may overstate the returns investors actually require.
- **The hurdle rates reflect assumptions on how the revenue model for each technology mitigates risk, which is uncertain.** For some technologies, the assumed revenue model was still being developed at the time our analysis was conducted (e.g., the business model for hydrogen to power projects). For others, the degree of risk mitigation will ultimately be subject to the outcome of negotiations between the UK Government and the project developer and/or future regulatory decisions. For example:
    - The degree of revenue stabilisation provided by the gas CCUS dispatchable power agreement (DPA) will depend on the proportion of total revenues that are provided by the availability payment, as opposed to merchant revenues. This may impact the overall risk classification for gas with CCUS. However, at the time of preparing this report CEPA did not have visibility of what this proportion is likely to be.

- Under the nuclear regulated asset base (RAB) framework, the degree of construction cost risk for a given project will in part depend on the level at which capital cost thresholds are set. As evidence of this was not available to inform this report, the level of construction risk faced by a specific nuclear RAB project may be different from what CEPA has assumed.[11]

More generally, there will be numerous details associated with each revenue model that can impact hurdle rates, but that are not practical or possible to capture given the breadth of this study. Deriving hurdle rates for negotiated projects would, therefore, require more detailed consideration of the relevant commercial arrangements.

- **There are many ways that hurdle rates can be derived and expressed.** We have attempted to transparently present how the hurdle rate estimates contained in this report have been built up. However, this is not the only way that hurdle rates could be developed or expressed. For example, we have expressed hurdle rates in 'vanilla' terms – i.e., that do not capture the effect of the interest tax shield.[12] This means that our estimates may not be strictly comparable with hurdle rates that are presented or used in other contexts.

1.7. Structure of this report

The remainder of this report is structured as follows:

- Section 2 describes each technology within our scope, and the assumed revenue model.
- Section 3 summarises the qualitative risk assessment for the technologies. Here, we also report on how the investor survey results differed from our initial risk assessment and how we have accounted for this.
- Section 4 explains the CAPM-based methodology we have applied to develop estimates for each of the hurdle rate parameters and sets out the resulting hurdle rate estimates.
- Section 5 compares the estimates to (i) the quantitative investor survey results and (ii) other cross checks. For some technologies, this results in an adjustment to the final hurdle rate assumption.
- Section 6 compares the hurdle rate estimates to assumptions that have been used by DESNZ in the past.
- Section 7 provides recommendations on how DESNZ could update the hurdle rate estimates in future.

Further detail is available in the appendices:

- Appendix A provides more detail on the technologies and their characteristics.
- Appendix B provides more detail on the assumed revenue models.
- Appendix C provides more detail on the risks covered in our qualitative analysis.
- Appendix D sets out additional information on the CAPM-based methodology described in Section 4. In particular, we highlight alternative choices that we could have made and discuss their implications.
- Appendix E contains more detail on the cross-checks we have considered.
- Appendix F contains hurdle rate estimates under alternative real/nominal, pre-/post-tax, inflation, and gearing assumptions.

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[11] As discussed in Section 5.1.12, evidence from the July 2025 announcement of a final investment decision in Sizewell C was not available when the risk analysis presented in this report was undertaken.

[12] The interest tax shield refers to the fact that in the United Kingdom (UK), debt interest payments are tax deductible. Accordingly, the higher the level of debt used to finance a project, the greater the tax deduction.

2. TECHNOLOGIES AND REVENUE MODELS

This section introduces the technologies and revenue model assumptions.

2.1. TECHNOLOGY CHARACTERISTICS

Among other factors, the risk assessment in Section 3 depends substantially on both the technical characteristics of each technology and its level of maturity. We have classified each of the technologies based on these features using the categories shown in Table 2.1.

Table 2.1: Classification of electricity sector technologies: technical characteristics and development status

Technical characteristics	
Renewable (variable)	Output varies with availability of the renewable resource.
Renewable (uncorrelated)	Variable renewable, but output is uncorrelated with wind and solar PV.
Renewable (predictable)	Variable renewable, but output is fully predictable and uncorrelated with wind and solar PV.
Baseload	Provides a consistent volume of baseload energy.
Dispatchable	Output is fully controllable / flexible.
Other	Does not produce electricity (i.e., hydrogen electrolysers, interconnectors)

Maturity level	
Mature	Technology has been widely deployed at commercial scale.
Maturing	Some examples of commercial-scale developments exist or are under construction.
Emerging	Has not been deployed at commercial scale.

Source: CEPA analysis.

The assessment of technology maturity primarily reflects the development status of the technology in the UK. In Table 2.3 (which applies this categorisation to each technology), some technologies span more than one category. This reflects that for some technologies:

- There is a wide range of potential technical specifications, which range from more to less mature.[13]
- The approach to project structuring may mean that the level of maturity (as assessed by the current state of deployment) becomes less relevant to the hurdle rate.[14]

For some technologies, there are also variants. In particular:

- Some technologies can be equipped to provide **combined heat and power (CHP)**. This applies to the geothermal, ACT, AD, energy from waste, natural gas, biomass and hydrogen to power technologies.

[13] See discussion of hydrogen to power technologies in Section 3.2.1.

[14] See discussion of CCUS-enabled biomass and gas plants in Section 3.2.4.

- Some technologies can either be developed on greenfield sites, or alternatively as **repowered** projects. This applies to solar PV and the wind technologies.

The analysis in Sections 3 and 4 assumes that the project does not have CHP and is a greenfield development. In Section 5.3, we consider whether a different hurdle rate should apply for projects with CHP and for repowered projects.

2.2. Revenue model overview

The risk assessment in Section 3 also reflects an assumed "base case" revenue model for each technology. The different support mechanisms take a variety of forms and imply different risk allocations between the project's investors and UK consumers. This means that differences in hurdle rates will be driven not only by factors related to the technical characteristics of each technology (e.g., maturity, intermittency, etc) but also how the various support mechanisms impact these underlying risks.

It is important to note that some of the revenue models have not yet been fully developed or implemented and are still subject to a detailed design process. In other cases, certain key details may not be in the public domain, or may only be finalised through negotiations between the UK Government and the project developer. Our risk assessment, therefore, reflects the assumptions stated in this report – which may be different from the final implementation of each revenue model in practice.

The revenue models that we have assumed for each technology are:

- A UK Government contract for difference (CfD) applies for eligible technologies.
- The nuclear regulated asset base (RAB) model applies to all nuclear technologies.
- The Hydrogen Production Business Model (HPBM) supports hydrogen electrolysers.
- The cap and floor regime applies to interconnectors.
- The proposed long-duration energy storage (LDES) cap and floor regime applies to pumped hydro energy storage and the novel LDES technologies. We understand that lithium BESS projects could also participate in the LDES cap and floor scheme, if they meet the relevant eligibility requirements. Hurdle rates for lithium BESS under the cap and floor scheme would likely differ from a project that is assumed to have a capacity market contract but no other source of long-term revenue certainty.
- The proposed business model for power Bioenergy Carbon Capture and Storage (BECCs) applies to biomass (dedicated and conversions) with carbon capture usage and storage (CCUS) capability with a firm dependable capacity above 100MW.
- The proposed Dispatchable Power Agreement (DPA) business model – with or without a variable payment – applies to hydrogen-powered CCHT / OCHT.
- The proposed business model for Power CCUS (i.e., the DPA) applies to gas generation (CCGT, OCGT, reciprocating engine) with CCUS capability.
- A Capacity Market (CM) contract is awarded to unabated gas fired energy generation, demand-side response aggregators, short-duration storage (lithium BESS and new compound batteries), and interconnectors. While interconnectors are also assumed to operate under the cap and floor regime, we assume that the other technologies do not have any other form of contract that provides long-term revenue certainty.

The revenue support mechanisms listed above have different assumed durations. The analysis set out in this report assumes that after the relevant mechanism has expired, the project operates on a merchant basis.[15]

The key features that we have assumed for the revenue models considered in this report are summarised in Table 2.2 overleaf, with more detail provided in Appendix B. The summary focusses on whether each revenue model mitigates the technology's exposure to construction risk, volume risk, and market price risk. As explained further in Section 3, these are key drivers of risk differences between the technologies.

2.3. Technology summary

Table 2.3 overleaf provides a brief description of each technology and summarises its generation characteristics, how established it is in the UK, and the assumed revenue model.

Appendix A provides more detail on the basis for the classifications.

[15] Our engagement with UK developers / investors for this project suggests that in practice new projects are often evaluated using this assumption. This is because while some projects will be able to secure a new contract after their CfD expires, this is not considered sufficiently certain at the time of making the investment.

Table 2.2: Revenue models – assumed key features

Revenue model	Duration	Construction risk mitigation	Volume risk mitigation	Operating cost risk mitigation	Price risk mitigation
Nuclear RAB	Construction through to decommissioning.	Yes, efficient capex can be included in the RAB (subject to capex incentive framework).	Yes, via a regulated revenue stream (subject to performance obligations).	Yes, via regular reviews of efficient opex.	Yes, via a regulated revenue stream (subject to basis risk / buy-back risk via market price incentive).
Interconnector cap and floor	25 years.	Yes, efficient capex can be included in the RAB at the post-construction review.	Yes, via the revenue floor (subject to performance obligations).	Partly, via one-off opex reopener.	Yes, only exposed to price risk within revenue cap and floor.
LDES cap and floor	Up to 25 years, or first refurbishment.	Yes, efficient capex can be included in the RAB at the post-construction review.	Yes, via the revenue floor (subject to performance obligations).	Partly, via one-off opex reopener.	Yes, only exposed to price risk within revenue cap and floor.
Power CCUS / H2P business model (dispatchable power agreement)	10-15 years.	Partly, in relation to delays associated with the CCUS / hydrogen transport and storage (T&S) network.	Yes, through availability payment structure (subject to performance obligations).	Partly, in relation to T&S network charges.	Yes, through availability payment structure (lower proportion of total revenue driven by wholesale price).
Renewable CfD	15 years.	No.	No.	No.	Yes, through CfD structure (basis risk remains).
BECCS business model	10-15 years.	Partly, in relation to delays associated with the CCUS T&S network.	Partly, in relation to the disruptions on the CCUS T&S network.	Partly, in relation to T&S network charges.	Yes, through dual CfD structure (basis risk remains).
Hydrogen production business model	15 years.	No.	Limited through a sliding scale top up amount to address loss of offtake beyond the control of the producer	No.	Yes, although some basis risk remains.
Capacity market contract	15 years for new build storage / generation; 1 year for demand response.	No.	No.	No.	Partly, through capacity payments (similar to availability payment above)

Table 2.3: Overview of the electricity sector technologies

Technology	Description	Maturity level	Generation characteristics	Revenue model
Solar PV	Large-scale solar PV (>5MW) comprises ground-mounted solar systems that generate utility-scale solar electricity	Mature	Renewable (variable)	CfD
Onshore wind	Large-scale onshore wind farms (>5MW) consist of multiple wind turbines installed on land to generate electricity from wind energy.	Mature	Renewable (variable)	CfD
Offshore wind	Large-scale offshore wind farms (>5MW) have wind turbines constructed in bodies of water, typically in the ocean, to take advantage of stronger and more consistent winds offshore compared to on land.	Mature	Renewable (variable)	CfD
Remote island wind	Large-scale onshore wind projects situated on the remote islands of Great Britain, particularly in Scotland.	Mature	Renewable (variable)	CfD
Floating offshore wind (FLOW)	Floating offshore wind farms comprise wind turbines installed on floating platforms (substructures) anchored to the seabed by means of flexible anchors, chains or steel cables. FLOW can be deployed in deeper waters where wind speeds are more consistent.	Emerging	Renewable (variable)	CfD
Hydropower	Energy derived from flowing water used to drive turbines. The plants are either with or without dams and reservoirs, which determines the scale of generation and storage capability.	Mature	Dispatchable (Assuming a small reservoir)	CfD
Advanced conversion technologies (ACT)	ACTs generate electricity using a gas or liquid that is formed by the gasification or pyrolysis of biomass or waste.	Maturing	Dispatchable	CfD
Anaerobic digestion (AD)	AD is the breakdown of organic material by microorganisms in the absence of air. Biogas produced by AD can be combusted to produce electricity.	Mature	Dispatchable	CfD
Sewage gas	Sewage gas is a specific type of AD.	Mature	Dispatchable	CfD
Landfill gas	Gas, produced during the anaerobic decomposition of biodegradable waste sent to landfill, is used to generate electricity.	Mature	Baseload	CfD

Technology	Description	Maturity level	Generation characteristics	Revenue model
Energy from waste (EfW)	EfW diverts waste from landfill and turns it into a useable form of energy.	Mature	Dispatchable	CfD
Biomass – unabated	Biomass involves the use of solid biomass, such as plant or animal matter, which can be directly combusted to produce hot flue gases and steam. These pass through turbines to produce electricity with the residual heat recovered and used for industrial processes. Plants can be either dedicated, or conversions.	Mature	Dispatchable	CfD
Deep geothermal	Energy generated and stored, in the form of heat, in rocks and soils beneath the surface of the solid earth. The focus of this study is deep geothermal systems, where the heat is of a high enough temperature to be converted into usable electricity.	Maturing	Dispatchable	CfD
Tidal stream	Tidal stream generates electricity by harvesting kinetic energy from flowing water driven by tidal currents.	Emerging	Renewable (predictable)	CfD
Tidal range	Tidal range captures the potential energy created by differences in water levels at high and low tide.	Emerging	Renewable (predictable)	None
Wave	Converts the energy within ocean waves into electricity.	Emerging	Renewable (uncorrelated)	CfD
Biomass – with CCUS	See “Biomass – unabated”. Carbon capture use and storage (CCUS) captures and stores carbon dioxide emissions produced by the generator.	Mature / Maturing (Mature assumes that project structuring mitigates FOAK risk – see Section 3.2.4)	Dispatchable	BECCS BM
Large-scale nuclear	New GW-scale nuclear developments, such as Hinkley Point C and Sizewell C. All currently operating commercial reactors are considered Generation II reactors. Most new reactors under development are considered Generation III+, with enhanced safety and fuel efficiency.	Mature	Baseload	Nuclear RAB

Technology	Description	Maturity level	Generation characteristics	Revenue model
Small modular nuclear reactors (SMRs)	SMRs are similar to existing water-cooled nuclear reactors (Generation III+), but on a smaller scale and applying modular building principles.	Emerging	Baseload	Nuclear RAB
Advanced modular nuclear reactors (AMRs)	AMRs use novel cooling systems or fuels, but share the same modular build principles as SMRs. AMRs are considered the newest technology, forming generation IV. AMRs are yet to reach the demonstration stage.	Emerging	Baseload (potential to be dispatchable)	Nuclear RAB
Pumped hydro energy storage (PHES)	PHES uses two water reservoirs at different elevations to store and generate electricity. During periods of low demand, water is pumped to the higher reservoir using excess electricity, and during high demand, water is released to the lower reservoir through turbines to generate power. Storage durations range from 8-32 hours.	Mature	Dispatchable	LDES cap and floor
Novel long-duration energy storage (novel LDES)	This category captures a range of less established long-duration storage technologies including: • **Liquid air energy storage (LAES)** stores electricity by liquefying air into tanks and generates electricity by expanding the liquefied air in a turbine (4-12 hours storage). • **Compressed air energy storage (CAES)** compresses and stores air in underground caverns using surplus or off-peak power. During times of peak power usage, air is heated which drives a turbine to generate power (4-8 hours storage). • **Flow batteries** generate energy through the controlled reaction of redox pairs, two substances which undergo electrochemical reactions in which electrons are transferred between them. The capacity of the battery is based on the size of the tanks, making flow batteries easily scalable (duration range 4-8 hours). • **Gravitational** energy storage stores potential energy, by using electricity to raise large masses to a certain height over the charge cycle (6-10 hour duration).	Maturing	Dispatchable	LDES cap and floor

Technology	Description	Maturity level	Generation characteristics	Revenue model
Lithium-based battery storage	Stores electrical energy using lithium electrodes. Lithium-ion batteries have been extensively used in the consumer energy and EV sectors, but can also be scaled to provide grid storage. Storage durations range from 1-8 hours.	Mature	Dispatchable	CM contract[16]
New compound battery storage	This group includes other types of battery storage technologies with lower technology readiness levels (i.e., still in the development and early demonstration phase). For example, these include technologies such as sulphur-bromide.	Emerging	Dispatchable	CM contract
Gas generation – unabated	This category includes: • **Combined cycle gas turbines (CCGT)**, which use both gas and steam turbines to generate electricity. CCGT is highly efficient and can adjust output relatively quickly. • **Open cycle gas turbines (OCGT)**, or single cycle gas turbines, use only gas turbines to generate electricity. They have lower efficiency, but higher ramp rates compared to CCGT. • **Gas reciprocating engines** are internal combustion engines that use the reciprocating motion of pistons to convert energy from the combustion of gaseous fuels into mechanical energy, which is then used to generate electricity. Many gas reciprocating engines have faster ramp rates and greater efficiency than OCGT technologies. In Section 4.6, we consider evidence for whether a different hurdle rate should apply to each of these technologies.	Mature	Dispatchable	CM contract

[16] As noted in Section 2.2, some lithium BESS projects may also be eligible for the LDES cap and floor scheme.

Technology	Description	Maturity level	Generation characteristics	Revenue model
Gas generation – with CCUS	See "Gas generation – unabated" and "Biomass – with CCUS".	Mature / Maturing (Mature assumes that project structuring mitigates FOAK risk – see Section 3.2.4)	Dispatchable	Power CCUS BM
Hydrogen CCHT / OCHT	CCHT / OCHT / reciprocating engine plants (see above) fired with hydrogen or hydrogen-natural gas blend). There are a wide range of specifications that could potentially apply to this technology group, in particular in relation to turbine size and hydrogen blending rates. Small turbines with lower blending rates can be considered relatively mature. However, there are no operating examples of larger turbines firing at 100% hydrogen.	Mature (small turbine, low % hydrogen) / Emerging (larger turbine, high % hydrogen)	Dispatchable	H2P BM
Hydrogen electrolyser	Hydrogen electrolysers split water into hydrogen and oxygen through electrolysis. The hydrogen produced can either be stored, or used to generate electricity.	Maturing	Other	HPBM

Technology	Description	Maturity level	Generation characteristics	Revenue model
Interconnectors	Electricity interconnectors are high-voltage cables that connect the electricity systems of neighbouring regions. Different types of interconnectors are being developed: • Point-to-point interconnectors connect GB to an electricity market in another jurisdiction. These have been the most common type of development in GB to date. • Multi-purpose interconnectors (MPIs) are projects that both (i) link GB and the connecting jurisdiction and (ii) provide transmission to offshore generation assets (located in GB and/or the connecting jurisdiction). • Non-standard interconnectors (NSIs) link GB and the connecting jurisdiction and provide transmission to offshore generators in the connecting jurisdiction only (and not in GB). The hurdle rate estimates in this report are focussed on point-to-point interconnectors. As noted in Appendix B.8, there may be differences in how the cap and floor regime is applied to MPIs and NSIs, compared to point-to-point interconnectors.	Mature	Other	Cap and floor / CM contract
Demand response aggregators	Demand response aggregators pool flexible demand resources and trade these via the wholesale and balancing markets. This requires investment in metering, aggregation systems / processes, and customer acquisition.	Mature	Other	CM contract

Source: CEPA analysis.

3. QUALITATIVE RISK ANALYSIS

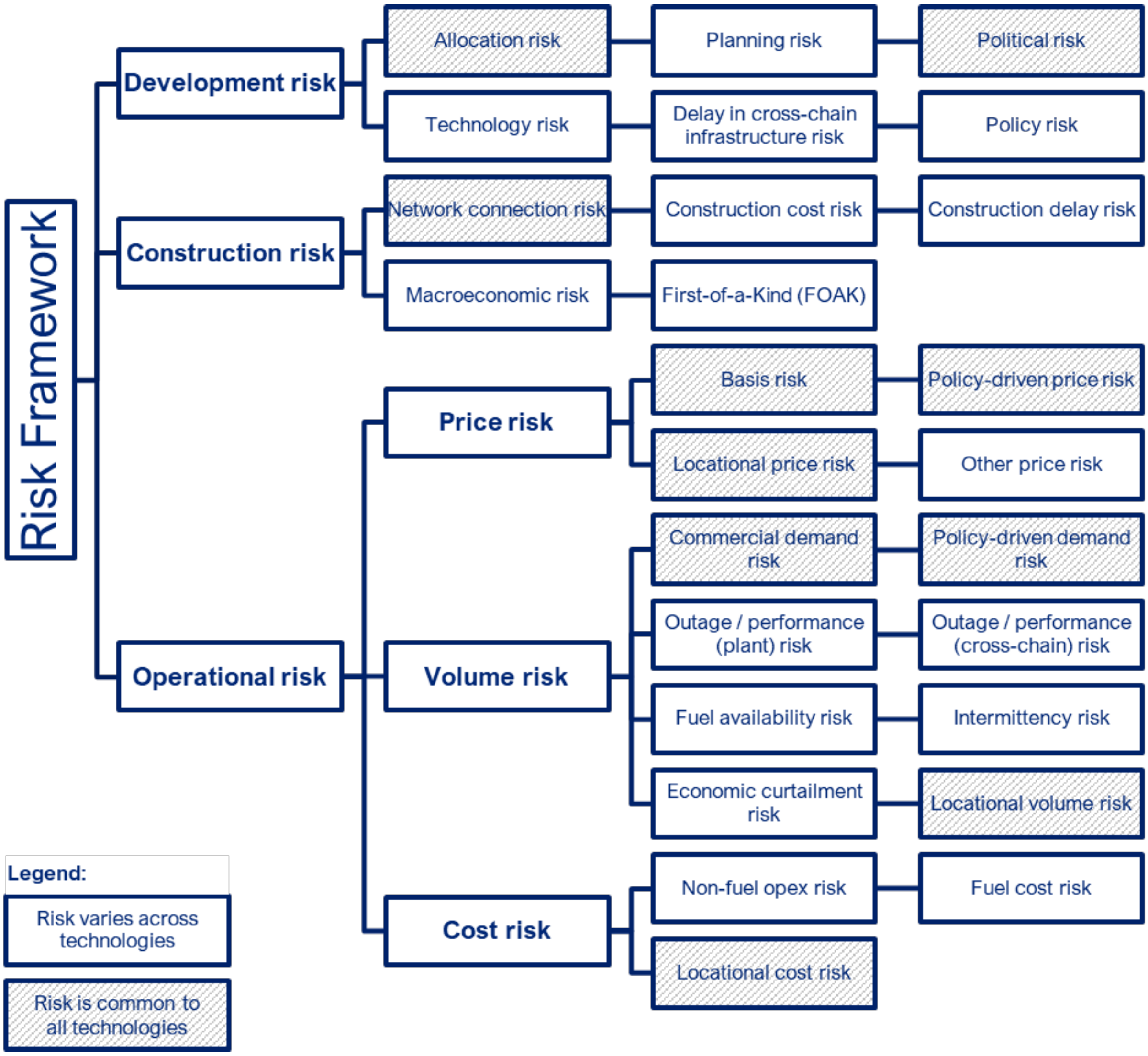
This section sets out the results of the qualitative risk assessment. The risk ratings each map to a quantitative assumption for the credit rating and asset beta that have been used to calculate the hurdle rate for each technology. For example, a technology with an overall 'high' risk rating will be assigned a relatively high asset beta. Below, we describe the risks considered, the assessment for each technology, and how we have weighted the various risks to assign an overall rating.

3.1. Approach

3.1.1. Risk categories

Our starting point was five risk categories (and 26 sub-categories) provided by DESNZ (Figure 3.1).[17]

Figure 3.1: Overview of risk framework



Source: DESNZ, REMA Risk Framework.

[17] We understand that DESNZ has used this framework to assess the impacts of potential reforms arising from REMA.

The diagram above distinguishes between risks that do and do not vary across the technologies. This is because our approach to setting the hurdle rate for each technology relies on an analysis of *relative* risk, with assessed differences in risk used to position each technology on a spectrum of low to high hurdle rate assumptions. This means that our focus is on those risks that differ across technologies. Other risks, that are broadly similar across technologies, are of course still part of the total risk level that is reflected in a hurdle rate. We would expect these 'common' risks to be reflected in the lowest hurdle rate assumption on the spectrum (noting that this is above the return on a risk-free asset).

For example, consider policy-driven demand risk, which is defined in DESNZ's risk framework as the risk that the average demand for electricity is lower than expected due to policy-driven factors. This is a risk that (broadly) all electricity technologies face, and we would expect it to be reflected in hurdle rates at the lower end of our spectrum. However, if it does not contribute to differences in risk between the technologies, then it does not help us to decide where on the spectrum each technology should be.[18]

Accordingly, our analysis has not considered risks that either do not vary by technology, or where there is insufficient evidence to assess the technology-specific impact. These risks are shaded in grey in the figure above. Further details are set out in Appendix C.

3.1.2. Relevance for the cost of capital

An initial question is whether all risks can be considered relevant for the cost of debt and cost of equity, noting that in theory different types of risk matter for each:

- Under the CAPM, only **systematic risks** which, due to their correlation with the economic cycle, cannot be eliminated through diversification, are considered relevant for determining required equity returns.
- The prevailing theories of cost of debt centre on financial distress costs and by extension the **probability of default**, which can be measured by an entity's credit rating. Debt providers are particularly concerned with downside risk, which increases the probability of default. Unlike equity investors, debt providers do not benefit from upside risk.

Broadly, we would expect all of the risks listed above to be relevant for the cost of debt – given that all may impact an asset's capacity to service debt over time. In relation to the cost of equity, it is more challenging to determine whether a given risk is definitively systematic or non-systematic.

In principle, some of the risk categories could have systematic elements. For example, supply-chain related disruptions that impact the cost and availability of critical materials, equipment and services may affect both the returns of generation assets and returns in the broader economy. Macroeconomic risks, considered as part of the construction phase assessment, are clearly relevant to systematic risk. Uncertainties around the future fuel and operating costs of generators may also have a systematic dimension, due to linkages with inflation, population growth (e.g., for waste-based feedstocks) and productivity trends.

In other cases, however, the link to wider economic conditions is less obvious and the risk may be asset specific rather than systematic (and therefore diversifiable). For example, such risks may include failure to obtain planning permission, uncertainty around wind speeds or irradiation, unsuccessful geothermal drilling, or the scope for cost overruns because a FOAK project experiences a hiccup in the design process. On the other hand, as noted in Section 1.5, investors may incorporate non-systematic risks in hurdle rates when assessing a project, if they consider that these are not adequately captured in the asset's projected future cash flows. More generally, investors may not always seek to draw fine distinctions between systematic and non-systematic risk when determining their required hurdle rate, and may adopt a more intuitive approach based on an overall assessment of

[18] As noted in Section 1.3, we have been asked to develop hurdle rate estimates that apply as of 31 December 2024, under current policy settings.

risk. Accordingly, the investor survey results are likely to reflect judgements on risk that are not based on a pure CAPM framework.

For these reasons, we have opted to consider the full set of risks in the risk rating that we use to determine both the cost of debt and cost of equity, rather than seek to assess the latter purely on risks that have the clearest systematic character. This approach does not mean that we reject the CAPM framework's careful distinction between systematic and non-systematic risk. Rather, our approach for this report is a pragmatic decision that reflects the specific context in which these estimates will be used.[19] Therefore, the cost of equity estimates set out in this report should be viewed as a reflection of both systematic risk and non-CAPM risk premia that an investor could potentially adopt when setting a hurdle rate for a given technology.

3.1.3. Approach to weighting the risk factors

The risk categories and sub-categories set out above provide a helpful way to identify potential drivers of differences in hurdle rates across the technologies. However, in several cases multiple risk sub-categories are being driven by similar factors. For example:

- The maturity of each technology and whether it is deployed in a more challenging environment (e.g., offshore, marine or remote) affects the ratings for: technology risk (development phase); construction cost and delay risk; volume risks related to outages and non-fuel cost risks (operation phase); and decommissioning.
- Typical generation profiles impact both price-related risks (e.g., exposure to low / negative prices) and volume-related risks (e.g., exposure to network congestion).
- Late delivery of cross-chain infrastructure (e.g. ports, roads, grid connections, hydrogen/CCUS transport and storage networks, etc) could cause cost overruns or delays in both the development and construction phases.

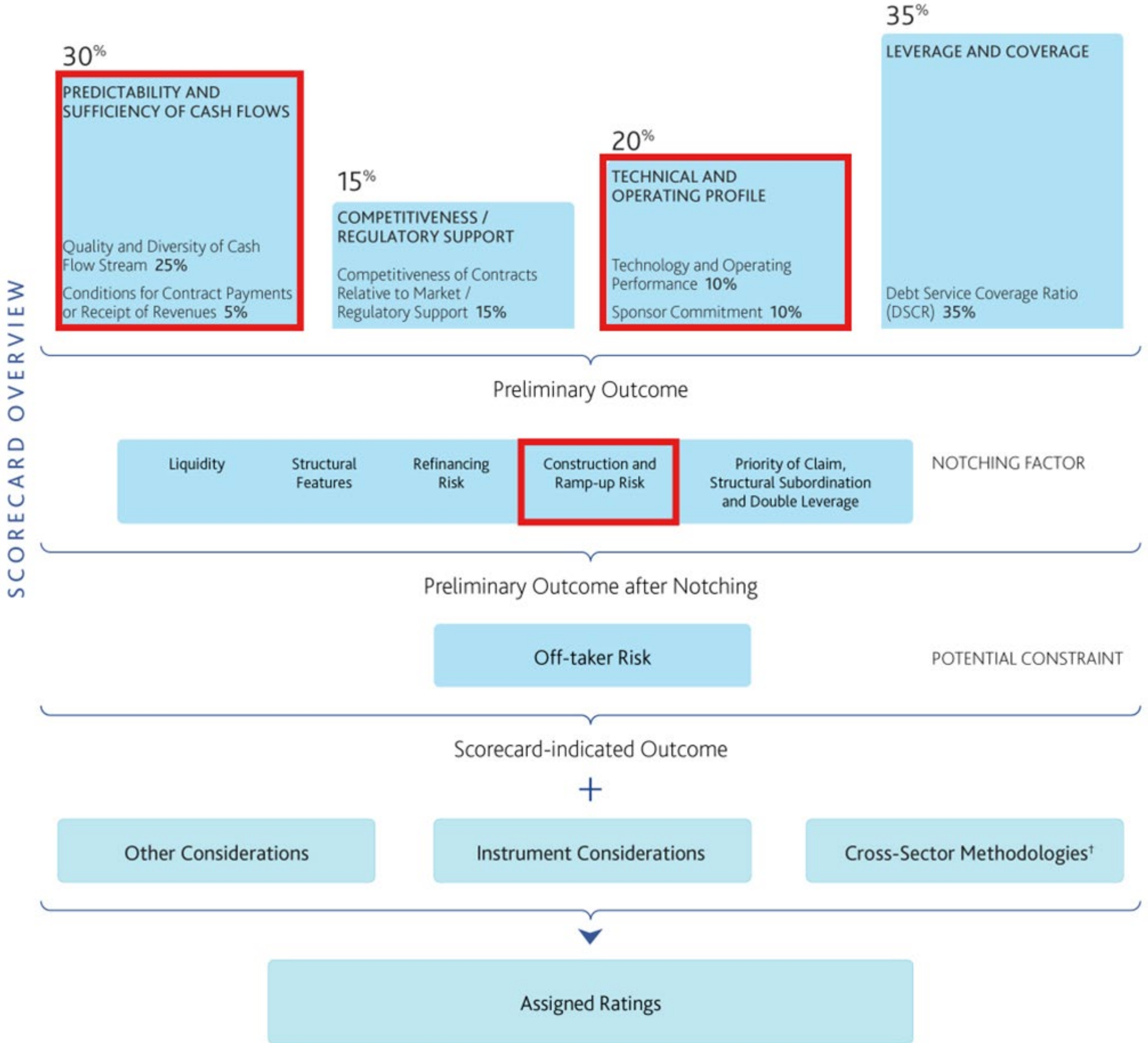
Accordingly, the way that we combine the various risks into an overall rating should avoid over-emphasizing certain characteristics simply due to the way that the risk categories have been specified. We consider that the approaches used by credit ratings agencies to determine an overall assessment of default risk can provide helpful guidance on this front. This is because rating methodologies have considered the materiality of different types of risk for an asset's overall cashflows and financial strength. For example, Moody's credit rating assessment process makes use of a scorecard approach, whereby certain asset characteristics considered relevant to the probability of default are individually scored and then combined to provide an initial indicative rating.[20]

Examination of Moody's ratings methodology for power generation projects (Figure 3.2 overleaf) provides a framework for weighting risks. The boxes outlined in red indicate three elements of the scorecard that we consider most relevant to an assessment of risk differences between technologies. There are alternative rating methodologies available – for example, those published by S&P Global and Fitch. We have focused on the Moody's methodology in this report because it provides more visibility of the weight given to different factors within the overall assessment.

[19] For example, we do not consider that this would be an appropriate approach in the context of an asset subject to economic regulation, because in such cases the regulatory framework may offer protections from many non-systematic risks and it is, therefore, important to avoid over-remunerating investors through regulatory allowances and the allowed rate of return.

[20] The scorecard-derived rating is not used mechanically, and judgement may be applied to determine the credit rating that the analyst considers most appropriate.

Figure 3.2: Illustration of Moody's power generation projects methodology framework (CEPA emphasis in red)



Source: Moody's (2023), Rating Methodology - Power Generation Projects, 22 June 2023, p.4. Available at: https://www.moodys.com/research/docid--PBC_1327762. The figure above refers to the fully amortising and contracted project structures framework.

The three elements are:

- **Quality and diversity of cash flows** – Contributes 25% to the scorecard rating. Moody's assessment considers the effect of contractual arrangements, counterparty creditworthiness, power market fundamentals, fuel supply risk (including risks related to renewable resources) and operating performance.
- **Technical and operating performance** – Contributes 10% to the scorecard assessment. Moody's differentiates between power generation projects on a spectrum, from those with a low operating risk profile (which typically use a simple, commercially proven technology with minimal moving components) to those with high operating risks (and typically a complex technology requiring specialised skills to operate). Moody's also considers whether a project has established a long-term service agreement (LTSA) with the original equipment manufacturer (OEM), and the level of performance support and warranties the OEM has agreed to provide. Finally, if the developer does not have experience of operating the technology, Moody's will also consider whether an operation and maintenance (O&M) agreement with an experienced and reputable operator is in place.

- **Construction and ramp up risk**[21] – This element is not assigned a particular weighting by Moody's, but can be applied as a 'notching factor'. This can reduce the credit rating indicated by the scorecard, which is oriented to a project with steady state operations. For example, if construction and ramp up risk is considered material for a project, Moody's may adjust the scorecard-indicated credit rating down by as much as three notches.[22] In cases where construction and ramp up risk is particularly severe, a significantly larger adjustment can be applied. This illustrates that the impact of this risk on the overall credit rating can be material (although may be reversed once a project has been completed and achieved steady state operation).

We have drawn on these elements, and the relative weight given to them in the Moody's framework, to group and weight the five overarching REMA risk categories (development, construction, price, volume and cost). Specifically:

- **Price risk – 40% weighting.** This captures many of the factors considered in the Moody's 'quality and diversity of cash flows' element, namely the effect of contractual arrangements, counterparty creditworthiness and power market fundamentals.
- **Volume and cost risk – 30% weighting.** The 30% weighting reflects the inclusion of factors from both the 'quality and diversity of cash flows' Moody's scorecard element (fuel supply risk, operating performance) and the 'technical and operating performance' element (operational complexity).
- **Development and construction risk – 30% weighting.** This recognises the material impact that this element may have on the overall credit rating.

In addition, we apply a separate adjustment to account for the impact of **first-of-a-kind (FOAK) risk**. This is due to the novelty of some of the technologies we are investigating, which may not be fully captured by the weighted categories above. The adjustment is to increase the risk category implied by the weighted criteria by one level (e.g., from "medium risk" to "medium-high risk") if the technology is a very early stage of deployment.

In Section 2.1, we characterised technologies as either "mature", "maturing" or "emerging" (Table 2.1). The term "FOAK" generally implies that the technology is new or novel, in contrast to an "nth of a kind" (NOAK) project that relies on standardised and repeatable technology.[23] The definition of, or distinction between, FOAK and NOAK is not necessarily precise – for example, in practice several commercial-scale implementations of a technology might be required to reach the point where it could be considered mature.[24] While recognising a degree of imprecision, we therefore propose to apply a FOAK adjustment to those technologies in the emerging and maturing categories. This includes projects for which there are no, or very few, examples of commercial-scale developments.

However, we also suggest that there is room for judgement to be applied, particularly in relation to technologies classed as maturing. This means that in certain circumstances, DESNZ might choose not to apply the FOAK adjustment for these technologies. This might be the case where the assumed hurdle rate is being applied to analyse projects that are assumed to benefit from mitigating factors – for example, the level of contingencies in the project capital cost estimates, or warranties from the OEM that extend to the more novel elements of the technology.

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[21] 'Ramp up risk' refers to difficulties associated within commissioning an asset as it ramps up to full power output.

[22] Notches refer to the increments that describe credit ratings. For example, S&P's framework establishes broad rating bands of AAA, AA, A, BBB, BB, BB etc. There are three credit ratings within each broad band – e.g., within the BBB band, either BBB+, BBB, or BBB-. BBB is one 'notch' lower than BBB+.

[23] For example, see National Nuclear Laboratory (2016), *SMR Techno-Economic Assessment: Assessment of Emerging SMR Technologies Summary Report*, 15 March 2016, p.5 and p.7. Available at: https://assets.publishing.service.gov.uk/media/5a74bc45e5274a3f93b48639/TEA_Project_3_-_Assessment_of_Emerging_SMR_Technologies.pdf.

[24] For example, see National Energy Technology Laboratory (2013), *Technology Learning Curve (FOAK to NOAK)*, August 2013, pp.2-3. Available at: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=b40ad5366a7491bde1bfbb9f5f4d0c4c60e56060.

Table 3.1: Application of FOAK adjustment

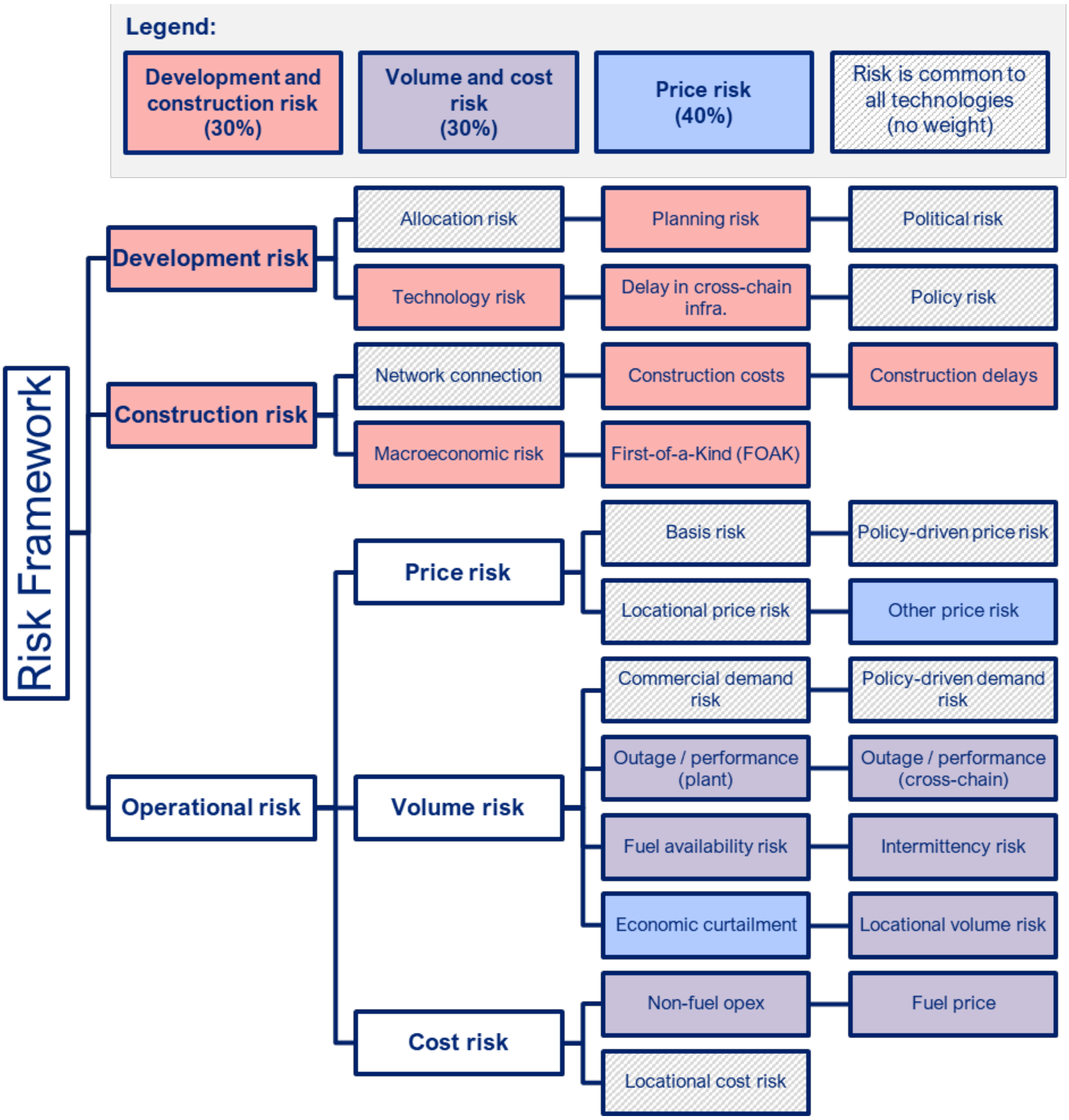
Classification	Definition	FOAK adjustment applies?
Mature	Technology has been widely deployed at commercial scale.	No
Maturing	Some examples of commercial-scale developments exist or are under construction.	Yes (with scope for judgement)
Emerging	Has not been deployed at commercial scale.	Yes

Source: CEPA analysis.

This approach reflects some specific considerations around how we have translated the risk levels to technology-specific asset beta and credit rating assumptions. For example, as described in Section 4.3.2, there is a single "notch" difference between each risk level (e.g., "low risk" is assigned a credit rating of BBB and "low-medium risk" a credit rating of BBB-, one notch below). However, Moody's framework describes applying an adjustment of 3+ notches where construction and ramp up risks are particularly severe. Applying a separate FOAK adjustment to the risk ratings allows us to broadly capture this effect for the less mature technologies, without disrupting how the risk weighting differentiates between the more mature technologies. This also reflects some of the comments received in the investor survey, which noted that FOAK risk may produce very substantial differences in financing costs.

We appreciate that while we have attempted to broadly anchor the risk weightings to a well-understood framework for assessing financial risk, there is nonetheless considerable judgement involved. Accordingly, we consider it is appropriate to use this framework as a guide, rather than apply it mechanically. As we discuss in Section 4.6, we have used the investor survey as a cross-check to the overall risk rankings that we derive for each technology.

Table 3.2: Risk mapping and weighting



Source: CEPA analysis.

3.1.4. Approach to analysing the risk factors

It is important to highlight several aspects of our assessment approach.

Firstly, the risk assessment reflects differences in both the underlying characteristics of each technology and the specific revenue model that is assumed to apply. For transparency, we provide the risk assessment both before and after overlaying the assumed effect of the revenue model. The risk assessment has been discussed with DESNZ, drawing on the Department's internal expertise in the technologies and revenue models of interest. However, the assumptions are CEPA's and should not be interpreted as the Department's position.

Secondly, the risk assessment has focused on differences in technology risk. In practice, the contractual and/or financial structuring of the project may mean that this is different from the risk that is ultimately borne by the debt and/or equity investors in the project. For example:

- Less mature technologies are generally assessed as facing higher development and construction risk – because the more limited experience with their deployment means that there is a greater likelihood of unforeseen challenges affecting construction time and/or cost. However, the financial and/or contract structures that apply to any given project may allow the project's investors to pass some technology risk to other parties. For example, heightened construction risk could be passed through to the buyer of the project's electricity generation via a larger contingency allowance being built into the agreed offtake price.

- Similar considerations apply to volume and operating cost risk. For example, while a less mature technology might be considered more susceptible to unforced outages or higher than anticipated maintenance costs, in some cases this risk might be mitigated via warranties provided by the OEMs. Although this might increase the cost of the project, it would reduce uncertainty – and therefore risk.
- Under the hurdle rate framework we have developed, a higher degree of risk is reflected in *both* the return on debt and the return on equity. However, the project's financial structure and/or revenue model may mean that technology-related risks are not borne by both debt and equity investors. This may mean that in practice, the hurdle rate estimates we derive accurately reflect the degree of technology risk, but not how it is allocated between debt and equity.

The risk assessment discussed in the following sections has *partly* accounted these types of effects by reflecting the assumed impact of each revenue model. Still, because we do not have enough information to consider the detailed structuring approach for different types of projects, this is only partial. Considering nuclear technologies, for example:

- In the development and construction risk assessment, large scale nuclear projects have been assessed as "medium risk" after accounting for the impact of the nuclear RAB regime, compared to "high risk" without. In practice the way that the regime is applied – e.g., the extent of contingency that is built into the regulatory thresholds[25] – could mean that a lower risk rating would be more appropriate.[26] However, CEPA does not have sufficient visibility of this process to make a detailed assessment.
- Although large scale nuclear, SMR and AMR projects are each assumed to be developed under the nuclear RAB model, we have proposed a different risk rating for large scale nuclear compared to SMRs and AMRs. This reflects an assumption that the support framework does not fully remove technology risk differences. However, in practice it may be that any residual additional technology risk difference for SMRs and AMRs is either:
    - Borne by equity investors, rather than debt investors. As a result, while the overall hurdle rates proposed for SMRs and AMRs could be correct, the cost of debt should potentially <u>not</u> differ across the nuclear technologies. However, it is not practical to account for such specific impacts within a hurdle rate framework that needs to apply across a wide range of projects.
    - Borne by the UK Government (and by extension consumers), rather than the project's investors, via the protections offered by the support mechanism. In this scenario, our assumption that the RAB framework does not remove risk differences across the nuclear technologies would be incorrect – suggesting that the hurdle rate for an SMR or AMR project should be the same as for a large-scale nuclear development.

Finally, we need to consider the risk ratings in the context of the sample of comparator firms that we are using to set the asset beta and credit rating. The ratings we select ultimately need to make sense when comparing each technology to this sample, as well as when comparing the technologies to one another. As we discuss in Section 4.1, the sample is primarily comprised of companies that invest in mature generation technologies (mainly onshore

[25] Under the nuclear RAB regime, a capex incentive framework aims to encourage the company to minimise construction costs. The strength of the incentive (and the degree of construction cost risk borne by investors) is set through the application of cost thresholds and the proportion of overruns that will be shared with consumers. See Appendix B.2.

[26] For example, see Appendix 4.3.1, Table D.4 for a discussion of cross-checks to that could potentially support a "low" rather than "low-medium" asset beta assumption for nuclear RAB projects.

wind and solar PV, and to a less extent offshore wind, hydropower and natural gas) with a relatively high proportion of revenues under long-term contracts. We have positioned the risk categories such that "low-medium risk" technologies are assigned an asset beta around the median of the comparator sample. Given the composition of the sample, we consider this to be a reasonable assumption for a new-build onshore wind project with a 15-year UK Government CfD. "Low risk" technologies would then sit below this, and the higher risk categories above. Section 4.1 explains how we have positioned the risk ratings on the spectrum of evidence from the comparator sample.

3.2. Analysis

The following sections describe the overall risk ratings that we have determined for each technology based on the grouping, weighting and analytical approach set out above. We use the three elements from Section 3.1.3 – (i) development and construction risk, (ii) volume and cost risk, and (iii) price risk – to structure the discussion.

3.2.1. Development and construction risk

This element combines our assessment of the development and construction phase risks identified in the risk framework (Section 3.1.1). These include: planning risk; risk of delays in cross-chain infrastructure (e.g., supporting infrastructure such as ports and roads); construction costs and delays (with higher risk linked to higher capital intensity, longer and/or more complex construction periods and a lower degree of technology maturity); and macroeconomic conditions (with higher risk linked to higher capital intensity, greater supply chain complexity, longer construction duration and reliance on imported components).

Our overall ranking of the technologies is set out in the table below, both before and after overlaying the effect of the assumed revenue model. The assessment reflects the assumed construction cost risk mitigations provided by the nuclear RAB regime (large scale nuclear, SMRs, AMRs) and the cap & floor regime (interconnectors, pumped hydro, novel LDES). Consistent with the assumptions stated in Appendix B, we assume that the RAB regime has a more significant impact on construction risk compared to the cap & floor regime.

Table 3.3: Summary of development and construction risk

Rating	Technology – Before revenue model risk mitigations	Technology – After revenue model risk mitigations
Low	Solar PV, AD/sewage gas, landfill gas.	Solar PV, AD/sewage gas, landfill gas.
Low-medium	Onshore wind, lithium batteries, demand response aggregators.	Onshore wind, lithium batteries, demand response aggregators, **interconnectors, pumped hydro energy storage.**
Medium	Offshore wind, remote island wind, hydro, ACT, biomass (unabated), EfW, gas (unabated), H2P (mature), **interconnectors, pumped hydro energy storage.**	Offshore wind, remote island wind, hydro, ACT, biomass (unabated), EfW, gas (unabated), H2P (mature), **novel LDES**, **large-scale nuclear**, **SMRs, AMR**s.
Medium-high	Geothermal, biomass (CCUS), gas (CCUS), hydrogen electrolysers, H2P (emerging), **novel LDES**.	Geothermal, biomass (CCUS), gas (CCUS), hydrogen electrolysers, H2P (emerging).
High risk	Floating offshore wind, tidal stream, tidal range, wave, new compound batteries, **large-scale nuclear**, **SMRs**, **AMRs**.	Floating offshore wind, tidal stream, tidal range, wave, new compound batteries.

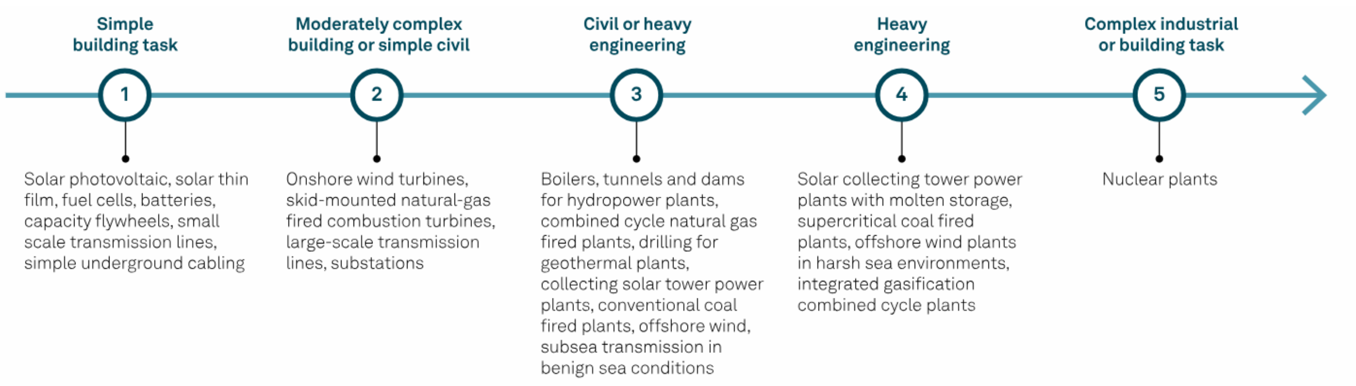
Source: CEPA analysis.

The rationale for each technology is set out below. Our assessment is broadly consistent with credit rating agency S&P Global's summary of the level of construction difficulty for various generation technologies (Figure 3.3). One exception is geothermal, which in our assessment sits above offshore wind. This reflects feedback from DESNZ that drilling risk may be more pronounced in the UK compared to other jurisdictions, given the limited number of potential sites.

We also understand that the S&P Global scale reflects the underlying construction complexity of each technology, rather than after mitigations that might be provided by the revenue model. This is why our post-revenue model assessment does not place nuclear technologies in the highest risk category. We also note that even if the revenue model does not explicitly mitigate construction cost risk, if it supports the inclusion of sufficient contingency in the project's capital budget, this is also a key mitigant. As we do not have visibility of what contingency level the various revenue models might provide, we have not been able to consider this in the assessment. However, it is a reason why the level of construction risk (and therefore hurdle rate) for a specific project could be lower than we have assumed here.

The S&P Global assessment also does not comment on some of the more novel technologies, such as tidal, wave, H2P, and emerging storage technologies. It is, therefore, possible that (absent revenue model effects) these should be ranked above the relatively complex but mature technologies, such as nuclear. We have accounted for this in the application of the FOAK adjustment (see Section 3.2.4).

Figure 3.3: S&P Global - Typical construction difficulty assessments for power



Source: S&P Global, Sector-Specific Project Finance Rating Methodology – Section 1: Power Projects.[27]

Low risk technologies

Solar PV, AD/sewage gas, landfill gas.

These are established, mature technologies in the UK and no material concerns have been identified in relation to delays related to planning and cross-chain infrastructure constraints. The assessment reflects a relatively short and simple construction period.

For **solar PV**, planning applications are generally processed quickly (<4 months) [28], albeit with some risk of delays due to local opposition[29]. There appears to be a low risk of delays due to cross-chain infrastructure, given significant investments in production infrastructure globally, albeit predominantly in China. [30]

Low-medium risk technologies

Onshore wind, lithium batteries, demand response aggregators, interconnectors, pumped hydro energy storage.

[27] S&P Global (2022), *Criteria – Infrastructure – General: Sector-Specific Project Finance Rating Methodology*, 14 December 2022. Available at: https://disclosure.spglobal.com/ratings/en/regulatory/article/-/view/type/HTML/id/3191551.

[28] Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy (2022), *Mission Zero: Independent Review of Net Zero,*https://assets.publishing.service.gov.uk/media/63c0299ee90e0771c128965b/mission-zero-independent-review.pdf September, p. 87.

[29] House of Commons (2024), *Planning for Solar Farms Research Briefing*, May, p. 12.

[30] Baringa (2024), *UK renewables deployment supply chain readiness* study, April, pg. 34.

These are established mature technologies in the UK.

Onshore wind sits in the low-medium risk category. Although it is a mature technology, this reflects a longer and slightly more complex development and construction phase than solar PV. Recently, planning for onshore wind has been a significant barrier in England and Wales[31], but the UK Government has proposed to improve this[32]. If we assume this is successful, planning risk may be similar to solar PV.[33] Onshore wind has some cross-chain infrastructure constraints, related largely to the production of some components, but these are seen as less severe than for offshore wind. This is due to less complex foundations and installation processes, and shorter lead times for components.[34]

Lithium batteries are considered to have a low degree of construction difficulty, similar to solar PV, as indicated by the S&P Global assessment. However, supply chain issues have been highlighted for battery storage, given the complexity and volatility of critical mineral supply chains necessary for their construction. For example, risks to lithium supply networks are considered to include trade restrictions, economic sanctions and local conflicts where extraction occurs.[35]

Unlikely many of the technologies covered in this report, **demand response aggregation** does not require substantial capital investments or complex construction. However, the aggregator does need to develop aggregation systems and processes, in addition to acquiring and establishing contracts with customers. While this is less capital intensive than the low-risk technologies, it may still involve a relatively high degree of complexity and non-standardisation.

While there is now substantial experience of constructing **interconnectors** between the UK and neighbouring markets, installation of the sub-sea cables takes place in a marine environment that can be challenging. In addition, interconnectors may experience some unique challenges due to the requirement to obtain planning consents in multiple jurisdictions. As a result, the S&P Global construction difficulty assessment (Figure 3.3) places interconnectors on the middle of the scale, similar to offshore wind. However, relative to an offshore wind project with a CfD, the interconnector cap & floor regime provides some mitigation of construction cost risk through the post-construction review process that sets the final RAB for the project. Accordingly, we have placed interconnectors in the low-medium, rather than medium, construction risk category.

Pumped hydro energy storage (PHES) is an established mature technology, with no material concerns identified in relation to planning and cross-chain infrastructure. Construction can be subject to site-specific geological conditions. Responses to the UK Government's 2024 consultation on the policy framework for long duration energy storage considered that construction risk is more pronounced for PHES compared to interconnectors.[36] However, hydropower and subsea transmission cables sit in the same position in the S&P Global construction difficulty assessment. Further, we have assumed that the PHES cap and floor regime provides similar mitigations for construction cost risk as for interconnectors. For this reason, both PHES and interconnectors have been given a similar development and construction risk ranking – rather than PHES falling into the medium risk category.

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[31] Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy (2022), *Mission Zero: Independent Review of Net Zero,*https://assets.publishing.service.gov.uk/media/63c0299ee90e0771c128965b/mission-zero-independent-review.pdf September, p. 93.

[32] House of Commons (2024), *Planning for Onshore Wind Research Briefing,* May, p. 34.

[33] In practice, the degree of planning is likely to be highly dependent on the specific project location and the planning issues that are present there – such as environmental requirements, bird habitats, noise impacts, and interactions with aviation and defence activities. These local factors may outweigh technology-specific impacts.

[34] Baringa (2024), *UK renewables deployment supply chain readiness* study, April, p. 27.

[35] Wang, J. et al (2025), *Critical risks in an industry chain-based global lithium supply networks: Static structure and dynamic propagation*, Process Safety and Environmental Protection, Volume 198, June 2025, 107137.

[36] DESNZ (2024a), *Long duration electricity storage consultation: Government Response*, October 2024, p.32. Available at: https://assets.publishing.service.gov.uk/media/670660eb366f494ab2e7b57a/LDES-consultation-government-response.pdf.

Medium risk technologies

Offshore wind, remote island wind, hydro, ACT, biomass (unabated), EfW, large-scale nuclear, SMRs, AMRs, gas (unabated), H2P (mature), novel LDES.

Relative to onshore wind, **offshore wind** has a longer planning and development phase.[37] While there is significant UK construction experience with this established and mature technology, the offshore environment is inherently challenging. Seabed conditions can be difficult to predict, and weather and sea conditions can cause delays during transportation and installation of components.[38, 39] This is reflected in the S&P Global assessment, which places offshore wind projects that are located in relatively benign marine conditions in the middle of the spectrum (although those in harsher sea environments sit one level above).

Construction of offshore wind projects is heavily dependent upon a range of specialised vessels that are used to transport and assemble large and heavy components. Recently, offshore wind projects have experienced severe cross-chain infrastructure and supply chain constraints, in particular related to export cables for the offshore network, all types of installation vessels, ports, and production of components (e.g., monopiles).[40, 41, 42]

We would expect some of these constraints (e.g., ports, vessels) to apply in a similar way to **remote island wind**. Construction of onshore wind assets in remote locations may face similar risks of cost increases and delays through sourcing components and labour. Components will also need to be constructed and transported to the remote locations, which raises risks similar to offshore wind in terms of exposure to weather and sea conditions.

Like PHES, **hydro** is an established mature technology, with no material concerns identified in relation to planning and cross-chain infrastructure. However, the construction of hydropower projects can be subject to site-specific geological conditions, and there may be challenges associated with the impacts of seasonal weather and managing environmental impacts (e.g., impacts on river flows). Further, unlike the cap and floor regime for PHES, the CfD regime does not provide construction risk mitigations – pointing to hydro sitting above the low-medium risk category on this factor.

The **unabated gas** technologies (CCGT, OCGT, reciprocating engines) are all established, mature technologies, with strong supply chain and developer experience in the UK. The S&P Global construction difficulty assessment places these in the middle of the spectrum, above solar PV and onshore wind, and similar to offshore wind. A 2023 review identified some development and construction phase risks for new unabated gas, including that obtaining planning consents for new unabated gas plants is challenging (although the reasons were not stated) and that new gas developments may be impacted by contractor shortages, reflecting competition with other engineering areas

[37] The Crown Estate, *Offshore Wind Leasing Round 4*, accessed 18 June 2024. Available at: https://www.thecrownestate.co.uk/our-business/marine/Round4.

[38] White & Case (2020), *Offshore wind projects: delays during construction,* accessed 4 July 2024. Available at https://www.whitecase.com/insight-alert/offshore-wind-projects-delays-during-construction.

[39] Offshore Wind Biz (2024), *Dogger Bank A May Not Be Fully Operational Until 2025, SSE Says,* accessed 4 July 2024. Available at: https://www.offshorewind.biz/2024/02/08/dogger-bank-a-may-not-be-fully-operational-until-2025-sse-says/.

[40] Baringa (2024), *Floating Offshore Wind: The quest for scale,* February, p. 7.

[41] The Guardian (2024), *Port infrastructure delays threaten UK's transition to net zero, industry says,* accessed 4 July 2024. Available at: https://www.theguardian.com/environment/article/2024/jul/02/port-infrastructure-delays-threaten-uks-transition-to-net-zero-industry-says.

[42] Wind Europe (2022), *Offshore wind vessel availability until 2030: Baltic Sea and Polish Perspective*, June 2022, pp. 59-61. Available at: https://windeurope.org/wp-content/uploads/files/policy/topics/offshore/Offshore-wind-vessel-avaiability-until-2030-report-june-2022.pdf.

(e.g., renewables construction).[43] Further, recent reports refer to tightening turbine supply chains.[44] However, we have not identified evidence that supply chain constraints for gas generation projects are any more severe than, for example, wind developments – which are also included in the medium risk category.

As noted in Section 2.1, there are a wide range of possible specifications for **hydrogen to power (H2P)** in terms of turbine size and hydrogen blending rates, spanning both relatively mature and emerging technologies. Accordingly, for the risk assessment we have indicated a 'mature' and 'emerging' rating for H2P. Given the similarity of basic turbine technology and likely range of revenue support mechanisms we have selected a hurdle rate range that is equivalent to unabated gas at the lower bound and gas CCUS at the upper bound. The lower bound - H2P (mature) – reflects a project that is assumed to deploy smaller turbines and lower hydrogen blending, placing it in the medium risk category.

Due to underlying similarities in the technology, we have given **ACT**, **biomass (unabated)** and **EfW** the same ranking as unabated gas on this factor. However, a higher ranking could potentially be justified for ACT and EfW, given the more limited experience with developing these technologies. Further while no material planning constraints have been identified for ACT and biomass (unabated), EfW may face a higher level of planning risk, given that the previous Government announced a ban on new EfW permits in 2024 and the new Government's intentions are (we understand) not yet known.[45] There have also been recent reports of material construction time and cost overruns for EfW projects in the UK.

Large-scale nuclear, **SMRs** and **AMRs** have been assigned the same medium-risk rating for this factor. The construction complexity of nuclear is high, as evidenced by the S&P Global construction difficulty assessment which places nuclear at the highest end of the spectrum of technologies it considers. While large-scale nuclear can be considered a mature technology, recent UK construction experience (e.g., Hinkley Point C) indicates that the scope for unforeseen construction costs and delays is material. This risk is broadly recognised for nuclear projects internationally. For example, specific risks have been identified in relation to: supply chain delays; design changes that occur after the start of construction (e.g., to meet changes in regulatory requirements, such as following the Fukushima disaster in 2011); complex and lengthy requirements in relation to regulatory oversight by nuclear safety authorities; and complex and lengthy procurement, manufacturing and installation processes for the plant's components and systems.[46] The impact of construction cost uncertainty may be significant. For example, a 2020 review of nuclear plant costs in the United States found that project costs had repeatedly exceeded projections, to the point that "nth-of-a-kind" plants were found to have been more, rather than less, costly than first-of-a-kind plants.[47]

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[43] DESNZ (2024b), *Assessing the deployment potential of flexible capacity in Great Britain – an interim report*, DESNZ research paper number: 2023/051, February 2024, p.33. Available at: https://assets.publishing.service.gov.uk/media/65e3a3a32f2b3bbc587cd767/8-assessing-deployment-potential-flexible-capacity-gb-interim-report.pdf.

[44] Power Magazine (2025), *Gas Power's Boom Sparks a Turbine Supply Crunch*, 1 April 2025. Available at: https://www.powermag.com/gas-powers-boom-sparks-a-turbine-supply-crunch/.

[45] Let's Recycle (2024), *Opinion: 'Key policies to watch under the new Labour government'*, 11 July 2024. Available at: https://www.letsrecycle.com/news/opinion-key-policies-to-watch-under-the-new-labour-government/. CMS Law-Now (2024), *Temporary ban on Environmental Permits for New Energy from Waste Plants in England*, 9 April 2024. Available at: https://cms-lawnow.com/en/ealerts/2024/04/temporary-ban-on-environmental-permits-for-new-energy-from-waste-plants-in-england.

[46] For example refer to Synapse Energy Economics (2007), *The Risks of Building New Nuclear Power Plants*, 19 September 2007, pp.2-3. Available at: https://www.synapse-energy.com/sites/default/files/SynapsePresentation.2008-06.0.Are-there-Nukes-in-our-Future.S0049-2007%20Version.pdf. International Bar Association (2024), *Managing risk in nuclear construction projects*¸ 26 July 2024. Available at: https://prod-bo.ibanet.org/clint-june-2024-feature-1#:~:text=Nuclear%20construction%20projects%20are%20also,be%20anticipated%20well%20in%20advance.

[47] Eash-Gates, P. et al (2020), *Sources of Cost Overrun in Nuclear Power Plant Construction Call for a New Approach to Engineering Design*, Joule, Volume 4, Issue 11p2348-2373November 18, 2020. Available at:

Although SMRs may, in future, face lower development and construction risks related to their size and modular nature, they remain an emerging technology. This presents additional risks, compared to large-scale nuclear projects, related to the procurement, manufacture and installation of equipment with limited prior operating experience. AMRs are in the early stages of research and development.

The medium-risk rating reflects that the assumed revenue model for nuclear projects (of all types) contains significant mitigations related to construction risk. Indeed, reducing financing cost by sharing construction risk between the project developer and consumers is a key part of the rationale for developing the nuclear RAB regime. Specifically, the RAB regime will determine a “lower regulatory threshold” (LRT) and “higher regulatory threshold” (HRT). The LRT is expected to be set at a level about the prevailing best estimate of the project cost, while the HRT is intended to reflect a significantly remote scenario above the licensee’s view of an extreme outturn cost outcome. If the project is delivered for less than the LRT, the licensee will be able to earn a return on a portion of the underspend. However, if instead delivery costs exceed the LRT, only a portion of the exceedance will be added to the RAB. The LRT is expected to be set at a level above the prevailing best estimate of the project’s cost. If the HRT is reached, the licensee can apply to add expenditure above the HRT to the RAB. The Secretary of State (SoS) can decide whether to allow this, or fund further investment from the UK Treasury. If the SoS elects to discontinue the project, it will provide compensation to debt and equity providers under a Discontinuation and Compensation Agreement.

Given these provisions of the RAB regime (outlined in more detail in Appendix B), we have placed the nuclear technologies in the “medium” rather than “high” risk category on this factor. This reflects an assumption that the degree of mitigation provided by the RAB regime will be more substantial than for, say, a PHES project under the cap and floor regime. However, it also reflects an assumption that construction risk exposure remains higher than for the technologies included in the “low” and “low-medium” risk categories. In practice, this will depend substantially on how the nuclear RAB regime is applied – i.e., how the LRT and HRT are calibrated, and what the risk sharing percentage is. If in future the regime is applied in a way that reduces construction risk for nuclear projects to the point where the risk is comparable to the technologies in the “low” or “low-medium” risk categories, the assumption set out in this report should be adjusted.

Finally, there is a question around whether the application of the RAB regime should result in large-scale nuclear, SMRs and AMRs being placed in the same risk category for this factor, despite the underlying difference in risk noted above. The RAB regime retains some construction risk exposure for investors, to incentivise timely and efficient delivery. The cost thresholds that bound the incentive regime could be considered more likely to bind for the less mature nuclear technologies – although this depends on how the thresholds are calibrated (i.e., whether Ofgem sets the thresholds to achieve the same level of construction risk across the different types of nuclear). On balance, we have proposed to place all three technologies in the medium-risk category for this factor. However, as discussed in Section 3.2.4 we propose a FOAK adjustment for SMR and AMR projects, which impacts the overall risk rating.

The **Novel LDES** group includes storage projects with far more limited supply chain and developer experience in the UK, reflected in lower assessed technology readiness levels (TRLs) for these technologies, relative to lithium batteries and PHES. This means that there are fewer benchmarks with which to assess construction costs and timelines, contributing to greater uncertainty around these parameters. Unlike the new compound batteries included in the high-risk category below, there are some operational examples and/or grid-scale developments underway for the technologies included in this group. Further, we assume that the cap and floor regime for novel LDES provides some degree of construction risk mitigation through the inclusion of efficient capex in the RAB – which also points to novel LDES sitting below the medium-high risk rating on this factor (which is where we would have placed it absent the mitigations of the revenue model).

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https://www.cell.com/joule/fulltext/S2542-4351(20)30458-X#:~:text=Analysis%20of%20nuclear%20power%20plant%20construction%20costs&text=Since%20the%201990s%2C%20two%20nuclear,are%20anticipated%20to%20rise%20further.&text=Gold%2C%20R.

Indeed, assumed similarities between the regulatory regimes for PHES and novel LDES, with respect to the allocation of construction risk, could provide an argument for giving the two technologies the same rating for this factor (i.e., low-medium risk). We have chosen to maintain a difference between the PHES / novel LDES ratings that reflects the underlying difference in construction risk. In part, this reflects a judgement that the cap and floor regime for long duration storage is not yet developed or applied, and it is possible that it may not have the effect of equalising construction risk exposure across the technologies. This assumption should be revisited as further information on the storage cap and floor regime and its application becomes available.

Medium-high risk technologies

Geothermal, biomass (CCUS), gas (CCUS), H2P (emerging), hydrogen electrolysers.

The S&P Global construction difficulty assessment places **geothermal** in the middle part of the spectrum, together with offshore wind. However, deployment in the UK has been more limited than other locations internationally. The planning process for a geothermal project may take 15-36 months, considerably longer than solar PV but less than offshore wind. [48] There is relatively limited deployment of deep geothermal technology in the UK suggesting a lower degree of maturity. Finally, there is reported to be a lack of supply-chain coordination due to the limited number of deep geothermal projects developed in the UK to date. [49] Accordingly, we have positioned geothermal in a higher risk category than offshore wind on this factor.

The medium-high risk category also includes **biomass** and **gas-fired generation** enabled with **CCUS** capabilities. These projects are likely to have a higher degree of development and construction risk relative to an unabated project, considering the more limited experience with capture facilities and their integration with the power plant.[50] The assumed BECCs and Power CCUS business models provide mitigations against cross-chain construction risks, related to the development of the CO_2 transport and storage (T&S) network. However, as the business models allocate construction cost and delay risk associated with the power CCUS / BECCS plant itself to the project developer, we have placed projects with this capability one risk level above their unabated counterparts.

The upper bound risk rating for **H2P (emerging)** assumes a larger turbine size and higher proportion of hydrogen blending. This assumption positions the technology in the medium-high risk band, for similar reasons to gas generation with CCUS. That is, while many elements of the construction process are similar, there is limited deployment of H2P, especially at higher levels of hydrogen blending and for larger turbines.[51] A 2023 review noted that requirements for converting unabated gas plants to hydrogen are considered technically complex.[52] We understand that, like the arrangements for CCUS, the H2P business model is not currently expected to provide mitigation of construction cost and delay risk, other than associated with the production, transport and storage of hydrogen.

Our research also indicates that **hydrogen electrolysis** is assessed to have a similar TRL to the storage technologies included in the novel LDES category but is less mature than PHES and lithium batteries. As for the renewable CfD regime, under the hydrogen production business model, hydrogen producers remain exposed to

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[48] UK Parliament POST (2022), *Geothermal Energy,* April, p. 45.

[49] Department for Energy Security & Net Zero (2023), *The case for deep geothermal energy – unlocking investment at scale in the UK,* May, pg. 22.

[50] For example, this is demonstrated by the wide disparities in reported costs across different CCUS facilities. See AECOM (2022a), *Decarbonisation Readiness – Technical Studies – Carbon Capture Readiness*, 30 June 2022, p.35. Available at: https://assets.publishing.service.gov.uk/media/640ae525e90e076cd4b67f57/carbon_capture_readiness_report.pdf.

[51] For example, recent studies conducted for the UK Government place a similar uncertainty range around capital costs for H2P and power CCUS. See AECOM (2022a) and AECOM (2022b), *Decarbonisation Readiness – Technical Studies – Hydrogen Readiness*, 30 June 2022. Available at: https://assets.publishing.service.gov.uk/media/640ae525e90e076cd4b67f57/carbon_capture_readiness_report.pdf.

[52] DESNZ (2024b), p.33.

construction cost and delay risk. For this reason, it sits above the assessed risk level of novel LDES (which has a different revenue model). If this changes, the risk assessment may also change.

High risk technologies

Floating offshore wind, tidal stream, tidal range, wave, new compound batteries

These are all emerging technologies.

Floating offshore wind reflects a similar construction period, challenging construction environment, and supply chain constraints as for offshore wind, plus additional risk associated with a less mature technology and being located further offshore. The construction process is more weather dependent as the assembled assets are towed into place, rather than being assembled offshore. Weather and sea conditions in particular can impact towing speed.[53] One of the key issues facing floating offshore wind is supply chain and infrastructure constraints, including a need for substantial investment in ports.[54] This investment is currently being supported by grant funding through the Floating Offshore Wind Manufacturing Investment Scheme (FLOWMIS).[55]

Tidal stream, **tidal range** and **wave** are nascent technologies with immature supply chains that have not reached commercial scale deployment in the UK. While tidal stream has a longer construction period (4 years compared to 2 years for wave), there is less recent experience with deploying wave technology at scale. Planning has been identified as a significant risk by tidal and wave developers (~4 years). [56,57,58]

New compound batteries are significantly less mature than the other storage technologies considered in this report. Unlike novel LDES, their assumed revenue model (a CM contract) does not provide any mitigation with respect to development and construction risk.

3.2.2. Volume and operating cost risk

For both risk factors, higher risk is considered to be associated with greater uncertainty around:

- Operational performance. For example, uncertainty may result from a lower degree of maturity / operating experience, or more challenging site conditions that could delay the rectification of faults.
- Availability of fuel / resources. This may be due to differences in fuel supply chains, or difficulties in forecasting the availability of renewable resources.[59]

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[53] S. Hong et al., 'Floating offshore wind farm installation, challenges and opportunities: A comprehensive survey', *Ocean Engineering,* 304 (2024), pg. 6.

[54] Baringa (2024), *Floating Offshore Wind: The quest for scale,* February, pg. 6-8.

[55] DESNZ (2025), *Government unlocks floating offshore wind with major investment for Scottish port*, 5 March 2025. Available at: https://www.gov.uk/government/news/government-unlocks-floating-offshore-wind-with-major-investment-for-scottish-port

[56] Crown Estate Scotland (2024), *Market engagement of industry on current and future leasing opportunities for wave and tidal energy*, April, pg. 5.

[57] ORE Catapult (2024), *Tidal Stream Technology Roadmap,* March, p.19. Available at: https://ore.catapult.org.uk/wp-content/uploads/2024/03/ORE-Catapult-Tidal-stream-roadmap-report-2024.pdf.

[58] Offshore Energy (2024), *UK Marine Energy Council sets five key asks for upcoming UK government,* accessed 18 June 2024. Available at: https://www.offshore-energy.biz/uk-marine-energy-council-sets-five-key-asks-for-upcoming-uk-government/#:~:text=1.,additional%2013%20MW%20of%20capacity

[59] S&P also distinguish between plants with varying levels of renewable resource / fuel certainty. For example, in their framework for power projects: assets that have consistently available contracted feedstocks are considered low risk; renewable assets for which the renewable resource can be estimated with a high degree of confidence are considered medium risk; and run-of-river hydro is considered high risk. Moody's, another credit rating agency, also consider the availability of fuel and renewable resource risk as part of their assessment.

- Operational costs, where uncertainty will also be driven by the level of maturity and operating experience. In addition, fuel cost risk impacts the thermal generation technologies, driven by uncertainty around the future availability and price of the necessary fuels and feedstocks. In addition, some technologies may face uncertainty regarding the future application of the Emissions Trading Scheme (ETS). This impacts some of the biofuel technologies[60] and unabated gas.

An additional dimension of operating cost risk relates to discount rates. Movements in interest rates and market returns impact discount rates. If discount rates rise, asset values generally fall. However, regulated assets may be shielded from this effect, depending on the regulatory framework. For example, under the nuclear RAB model, Ofgem's determinations may reflect movements in interest rates and market returns via the allowed rate of return for the nuclear licensee – reducing the sensitivity of its value to changes in discount rates, relative to the broader stock market. This indicates lower exposure for nuclear projects under the RAB model, compared to other business models that do not have this feature. This factor is accounted for in the discussion below, where we consider the extent to which the revenue models for some technologies reflect this dynamic.

Our overall ranking of the technologies is set out in the table below, both before and after overlaying the effect of the assumed revenue model. The assessment has considered the varying levels of assumed volume / operating cost risk mitigations provided by the nuclear RAB regime (large scale nuclear, SMRs, AMRs), the cap & floor regime (interconnectors, pumped hydro, novel LDES), the hydrogen production business model (hydrogen electrolysers), and the Power CCUS business model (gas generation with CCUS). Consistent with our assumptions in Appendix B, we assume that the RAB regime has a more significant impact on operating cost and volume risk compared to the other support mechanisms, due to the frequency of price reviews.

Table 3.4: Summary of volume and operating cost risk

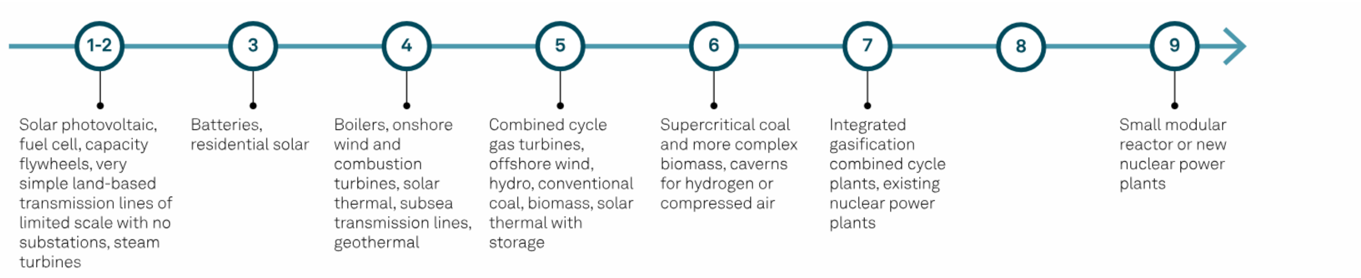
Rating	Technology – Before revenue model risk mitigations	Technology – After revenue model risk mitigations
Low	Solar PV.	Solar PV, **interconnectors**.
Low-medium	Onshore wind, AD/sewage gas, lithium batteries, demand response aggregators, **interconnectors**.	Onshore wind, AD/sewage gas, lithium batteries, demand response aggregators, **pumped hydro energy storage, large-scale nuclear**, **SMRs**, **AMRs.**
Medium	Offshore wind, remote island wind, geothermal, hydro, landfill gas, biomass (unabated), EfW, gas (unabated), H2P (mature), **pumped hydro energy storage**.	Offshore wind, remote island wind, geothermal, hydro, landfill gas, biomass (unabated), EfW, gas (unabated), H2P (mature), biomass (CCUS), gas (CCUS), **novel LDES**.
Medium-high	ACT, biomass (CCUS), gas (CCUS), hydrogen electrolysers, H2P (emerging), **novel LDES, large-scale nuclear**, **SMRs**, **AMRs**.	ACT, H2P (emerging), hydrogen electrolysers.
High risk	Floating offshore wind, tidal stream, tidal range, wave, new compound batteries.	Floating offshore wind, tidal stream, tidal range, wave, new compound batteries.

Source: CEPA analysis.

[60] The regulated activities intended for inclusion in the UK ETS in this sector are the incineration and combustion of waste, and other energy recovery from waste. UK Government, Scottish Government, Welsh Government and the Department of Agriculture, Environment and Rural Affairs for Northern Ireland (2024), *UK Emissions Trading Scheme Scope Expansion: Waste*, 2 August 2024 ,p. 9. Available at: https://assets.publishing.service.gov.uk/media/6669a60c9d27ae501186db79/ukets-scope-expansion-consultation-waste.pdf.

Among other evidence, our assessment has considered S&P Global's assessment of operational stability for different technologies (Figure 3.4). As for construction risk, we have taken into account that the types of assets represented in their framework do not include some of the emerging technologies considered in this report.

Figure 3.4: S&P Global - Typical asset class operational stability



Source: S&P Global, Sector-Specific Project Finance Rating Methodology – Section 1: Power Projects.

Low risk technologies

Solar PV, interconnectors.

Solar PV is considered to have a lower risk of component failure compared to the other technologies. As an established technology with a substantial operating history, operating costs can be estimated with a higher degree of certainty than less mature technologies. It does not face risks relate to fuel costs. There is some risk around forecasting the output of this intermittent renewable technology, but this is considered to be low.

As indicated in Figure 3.4, sub-sea transmission lines sit above solar PV in S&P Global's assessment of operational stability (i.e., the lower-middle end of their spectrum). However, the cap and floor regime provides an opportunity for the controllable operating costs of **interconnectors** to be reviewed after an initial 10-year period, and pass-through arrangements for non-controllable operating costs. To access revenue support via the cap and floor scheme, the asset must meet availability targets. As interconnectors are a mature technology, we expect that investors would be able to forecast future availability with a reasonable degree of precision – i.e., pointing to similar volume risk than for solar PV.

Low-medium risk technologies

Onshore wind, AD, sewage gas, lithium batteries, demand response aggregators, pumped hydro energy storage, large-scale nuclear, SMRs, AMRs.

Onshore wind is considered to have a lower risk of component failure than offshore wind, as components are under less stress closer to shore.[61] As for solar PV, it does not face risk related to fuel cost, but does face volume risks related to forecasts of the wind resource.

The S&P Global operational stability assessment places batteries between solar PV and onshore wind. We have placed **lithium BESS** in the low-medium category (the same as offshore wind) for this factor, to reflect uncertainties around how the operation of battery storage systems can affect their risk profile. For example, Fitch has commented that arbitrage revenue models may mean that batteries could face more rapid degradation and higher volatility in capital expenditure requirements, relative to renewable generators and thermal peaking plants.[62] Fitch suggested that battery systems that operate in this way may need to achieve stronger financial metrics to achieve a given credit rating, relative to other technologies (pointing to a potentially higher cost of debt, all else equal). Similarly, Moody's has commented on elevated cash flow risk for battery storage assets that combine contracted

[61] Swiss Re (2013), *Profiling the risks in solar and wind*, p.9. Available at: https://www.swissre.com/dam/jcr:3260a7b2-960d-48c4-9e4c-3ada7922aec0/Profiling-the-risks-in-solar-and-wind.pdf.

[62] Fitch (2023), *Battery Storage Using Arbitrage May Face Rapid Asset Degradation*, 13 July 2023.

and merchant revenues, due to the risk of more rapid asset degradation.[63] As our base case assumption for lithium BESS is a largely merchant revenue model (save for a CM contract), a "low-medium risk" (or potentially even "medium risk") rating seems appropriate.

Broadly, **demand response aggregators** may operate in the wholesale market in a similar way to a largely merchant battery project. However, an aggregator will not face the same operational challenges as a battery, given the absence of physical assets that require maintenance (as highlighted above, the impact of cycling on the degradation of a battery is considered relevant to their risk rating). Nonetheless, aggregators face other complexities related to the management of the flexible demand resources that they contract with, and the development and implementation of their trading strategy. This may require advanced demand and supply forecasting models, platforms to optimise scheduling of response resources, acquiring and maintaining contracts with flexible demand resources, and management of systems of communication between the aggregator and contracted assets.[64] Although it is challenging to equate these challenges to those faced by physical assets, the level of complexity suggests that it may be reasonable to place aggregators in the same risk category as lithium BESS on this dimension.

PHES is considered a mature technology, that is less subject to unexpected outages that impact operational performance and cost. It faces relatively low fuel and volume risk, as it stores energy drawn from the grid (which creates exposure to market price risk – see Section 3.2.3) and offers long-duration storage potential. This differs from conventional hydropower, which can be more exposed to risks associated with droughts.[65] Further, if the cap and floor regime for PHES operates in a similar way to the framework for interconnectors, there is a degree of cost risk mitigation related to a mid-period review of operating costs and pass-through mechanisms for non-controllable costs. Accordingly, we have positioned PHES:

- One risk level below hydropower, which we have placed in the "medium risk" category, consistent with the S&P Global scale set out above. This reflects that the CfD regime, that is assumed to apply to hydropower projects, does not provide any operating cost risk mitigation.
- One risk level above interconnectors, which we have paced in the "low risk" category. This reflects that the S&P Global scale considers PHES to have less operational stability than sub-sea transmission cables, and that the scope for operating cost adjustments under the cap and floor regime is limited.

New **nuclear plants** and small modular reactors appear at the top end of the S&P Global assessment of operational stability (although as noted above, the spectrum does not include some of the very nascent technologies that we are considering, such as wave and tidal). In terms of fuel risk, nuclear energy is predominantly dependent on the production, conversion, enrichment and fabrication of uranium as a fuel source.[66] However, this does not appear to

[63] Reported in Utility Dive (2018), *Project finance getting more viable for energy storage, Moody's says*, 21 March 2018.

[64] IRENA (2019), *Aggregators Innovation Landscape Brief*. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Innovation_Aggregators_2019.PDF.

[65] Depending on the design of the scheme PHES may be more resilient to drought conditions, because the water used for generation is recycled between the upper and lower reservoirs. See: National Hydro Association (2017), *Challenges and Opportunities For New Pumped Storage Development*, p. 17, available at: https://www.hydro.org/wp-content/uploads/2017/08/NHA_PumpedStorage_071212b1.pdf and Nikolaos, P. C. et al (2023), *A Review of Pumped Hydro Storage Systems*, Energies 2023, 16(11), 4516, section 2.2.2, available at: https://www.mdpi.com/1996-1073/16/11/4516#:~:text=Integrating%20pumped%20hydro%20storage%20systems%20with%20variable,overall%20stability%20of%20the%20power%20grid%20[31].&text=For%20example%2C%20during%20a%20drought%2C%20conventional%20hydropower,still%20function%20as%20a%20pumped%20storage%20facility.

[66] Euratom Supply Agency Advisory Committee (2020), *Analysis of Nuclear Fuel Availability at EU Level from a Security of Supply Perspective*, March 2020, p.15. Available at: https://euratom-supply.ec.europa.eu/system/files/2021-06/2020_Security_report_2.pdf.

be a significant risk for UK-based projects, considering domestic capabilities in completing the nuclear fuel cycle[67] and a large strategic inventory of uranium.[68]

We have considered the impact of the nuclear RAB regime on this risk factor, which provides for five-yearly reviews of the operating expenditure components of regulated revenues. While there are incentives for availability and operating phase costs, there is also scope for the regulator Ofgem to calibrate these over the licence period. Provisions within the RAB framework limit the overall impact of the incentive mechanisms on investors. Further, as explained at the beginning of this section, the nuclear RAB regime provides mitigation against movements in inflation, the cost of debt and (to some extent) movements in total market returns – via the allowed return on capital for the nuclear licensee. On this basis, we have positioned **large-scale nuclear**, **SMRs** and **AMRs** in the low-medium risk category. As noted for construction risk above, there may be arguments for placing SMRs and AMRs in a higher risk category. The way that the RAB regime is applied in future may reveal more information around what degree of technology-specific operating cost and volume risk is borne by investors – for example, whether it is lower than rather than comparable to the other technologies in this category after taking into account the regulatory framework.[69]

AD/sewage gas projects have more operational experience compared to advanced ACT (medium-high risk) and less fuel availability risk compared to some of the other biofuel technologies that sit in the medium risk category. AD operation appears to be well understood, noting some operational complexities in the biogas process.[70] Feedstock availability and regulatory complexities around gas grid injection have been noted as challenges for the deployment of AD technologies. However, the Biomass Strategy published by DESNZ in 2023 indicates relatively stable future availability of sewage gas – setting it apart from landfill gas and energy from waste.[71] This suggests that fuel cost exposure is lower than other waste technologies, as supply is linked to more predictable factors (population and process improvements).

Medium risk technologies

Offshore wind, remote island wind, geothermal, hydro, landfill gas, biomass (unabated), EfW, gas (unabated), novel LDES, H2P (mature), biomass (CCUS), gas (CCUS).

Offshore wind is considered to have more risk around operating performance compared to onshore wind, due to more challenging marine environment. For example, offshore wind has a higher risk of component failure, compounded by difficulties in accessing the site for repairs.[72] Offshore assets may also face higher risk due to the more challenging and unpredictable marine environment. For example, anchor drags or movements in the seabed can result in outages which would not occur onshore. Whilst offshore transmission assets tend to have very good availability (98%+), when a major failure event arises, it can last for a while because the assets are on the seabed.

[67] House of Commons Science, Innovation and Technology Committee (2023), *Delivering nuclear power*, 19 July 2023, p.33. https://committees.parliament.uk/publications/41092/documents/200324/default/.

[68] CoRWM (2023), *UK uranium inventory, management and disposal options: CoRWM position paper,* 1 August 2023. Available at: https://www.gov.uk/government/publications/uk-uranium-inventory-management-and-disposal-options-corwm-position-paper.

[69] In Appendix D.1.1, Table D.4, we discuss asset beta evidence from regulated integrated utilities. These may be more comparable to nuclear RAB projects on the operating cost and volume risk factor, compared to the 'core' contracted generation comparator sample that we have used to set the asset beta range for all technologies included in this report. We note that the alternative comparator evidence could support an asset beta range for nuclear RAB projects that is more in line with the "low" risk rating, although as outlined in the appendix the comparisons involve difficult judgements.

[70] Anaerobic Digestion Community (2023), *5 Anaerobic Digestion Problems to Avoid at Commercial Biogas Facilities*, 4 November 2023. Available at: https://anaerobic-digestion.com/5-anaerobic-digestion-problems/

[71] DESNZ (2023), *Biomass Strategy*, pp.74-75. Available at: https://assets.publishing.service.gov.uk/media/64dc8d3960d123000d32c602/biomass-strategy-2023.pdf.

[72] Swiss Re (2013), p. 9-10.

Remote island wind experiences the same extreme weather events as offshore wind, and it may be reasonable to assume it has a similar operating performance and cost risk profile.[73] On the other hand, both offshore wind and remote island wind may benefit from a more reliable wind resource compared to onshore wind projects – which could potentially point to an overall similar risk rating on this factor.

Geothermal is assessed by S&P Global to have a similar degree of operational stability as onshore wind. Once operational, geothermal is considered a constant and reliable energy source.[74] [75] It also faces low fuel availability risk, and no exposure to fuel cost risk. However, there has been relatively limited operating experience of this technology in the UK to date. For this reason, we have positioned it one level above onshore wind.

Hydro is considered to have similar operational complexity to offshore wind in S&P Global's assessment (see Figure 3.4 above). While this is a mature technology with substantial operating experience in the UK, depending on the size of the reservoir it may face volume risks related to extended periods of low rainfall – although modelling suggests that hydropower generation will increase as a result of climate change in GB by 2080.[76] This technology has no fuel price exposure.

Several biofuel technologies are included in the medium risk category: **landfill gas**, **biomass – unabated**, and **EfW**. Like AD/sewage gas, these have more operational experience compared to advanced ACT and therefore can be considered to have relatively higher certainty regarding non-fuel operating costs. However, they face greater volume and/or cost risk in other areas:

- EfW and landfill gas – The drive by DEFRA to achieve the near elimination of biodegradable waste disposal in landfills from 2028[77] will increase the fuel available for EfW and landfill gas plants in the short-term. However, the Government set an environmental target in 2021 to half residual waste kgs per person by 2042[78], which creates risk related to the long-term supply of fuel.
- Biomass – unabated: Similar risks to ACT in terms of uncertainty around the future cost of sustainable fuel feedstocks. There is also a potential future ETS liability for unabated biomass.

As a mature technology, **unabated gas** is less subject to unexpected outages impacting operational performance and costs than some of the more novel technologies. However, it may be considered more technically complex to operate than solar PV or onshore wind (see Figure 3.4). Prices (and therefore cost risk) will be affected by the availability of natural gas, with the Russia-Ukraine conflict providing an example of the influence of geopolitical

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[73] BEIS (unknown), *Remote island wind impact assessment*. Available at: https://assets.publishing.service.gov.uk/media/5b16baa340f0b634c61412fd/F_-_RIW_Impact_Assessment.pdf.

[74] McClean, A. and Pedersen, O. W. (2023), *The role of regulation in geothermal energy in the UK*, Energy Policy

Volume 173, February 2023, 113378. Available at: https://www.sciencedirect.com/science/article/pii/S0301421522005973.

[75] GEL, University of St Andrews and ARUP (2016), *Deep Geothermal Single Well (DGSW) - Feasibility Report for the Low Carbon Infrastructure Transition Programme (LCITP)*, February 2016, Figure 1. Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/research-and-analysis/2016/03/feasibility-report-deep-geothermal-single-well-aberdeen-exhibition-conference-centre/documents/00497878-pdf/00497878-pdf/govscot%3Adocument/00497878.pdf.

[76] Dallison, R. and Patil, S. (2023), *Impact of climate change on hydropower potential in the UK and Ireland*, Renewable Energy Volume 207, May 2023, Pages 611-628. Available at: https://www.sciencedirect.com/science/article/pii/S0960148123003075.

[77] DEFRA (2023a), *Call for evidence to support the near elimination of biodegradable waste disposal in landfill from 2028*, May 2023. Available at: https://consult.defra.gov.uk/waste-and-recycling/cfe-near-elimination-bio-waste-to-landfill/supporting_documents/23.05.25_Near_Elim_Biodegradable_Waste_to_Landfill_CfE.pdf.

[78] DEFRA (2023b), *The waste prevention programme for England: Maximising Resources, Minimising Waste*, 10 August 2023. Available at: https://www.gov.uk/government/publications/waste-prevention-programme-for-england-maximising-resources-minimising-waste/the-waste-prevention-programme-for-england-maximising-resources-minimising-waste#:~:text=To%20drive%20down%20the%20amount,person%20by%20the%20year%202042.

considerations on prices.[79] Unabated gas also faces ongoing cost exposure related to the parameters of the ETS. This points to a medium level of risk for unabated gas, which is similar to many of the biofuel technologies.

The **Novel LDES** technologies have considerably less operating experience than PHES. However, like PHES, they face lower fuel and volume risk than both the thermal and renewable generation technologies, and benefit from a degree of operating cost risk mitigation under the cap and floor regime. For this reason, we have positioned novel LDES one risk level about PHES, and two levels below new compound batteries (which are both less mature, and do not have any operating cost risk mitigation under their assumed revenue model).

As noted in Section 3.2.1 in relation to development and construction risk, we distinguish between mature and emerging **H2P** technologies. H2P (mature) projects are assumed to deploy smaller turbines that fire at lower higher blending levels and are, therefore, assumed to reflect a similar degree of volume and operating cost risk to unabated gas. We have, therefore, retained H2P (mature) in the medium risk category on this element, but note that further development of the proposed support mechanism could potentially support a different conclusion.

Gas with CCUS capability is exposed to the same risks as unabated gas in relation to natural gas availability and cost – although not in relation to potential future ETS liabilities. CCUS is considered to add an additional layer of operational volume and cost risk, due to its relative novelty. However, we have assumed that the Power CCUS DPA model largely mitigates this difference. For example, the DPA contains a variable payment that is intended to reduce the short-run marginal cost of gas CCUS plants, if that is required to ensure that they are more competitive in the merit order than a conventional unabated gas generator. Accordingly, we have positioned gas with CCUS at the same level as unabated gas on this factor. The rationale for placing **biomass with CCUS** in the medium risk category is similar to gas with CCUS. That is, the incorporation of CCUS capabilities increases operating volume and cost risk while this technology is still maturing. However, we have assumed that the BECCS business model largely mitigates these additional operating cost and volume risks to a similar level as for unabated biomass. For example, while the proposed BECCS business model contains measures to mitigate cross-chain infrastructure risk related to T&S network outages and costs, operating risks related to the biomass plant itself sit with the project.

As the business models for power CCUS are further developed and/or negotiated, more information may become available to inform the risk assessment.

Medium-high risk technologies

ACT, hydrogen electrolysers, H2P (emerging).

Compared to the other biofuel technologies, advanced **ACT** has less certainty over operational performance and costs due to very limited operating experience in the UK. The future cost of sustainable fuel feedstocks is also uncertain and subject to policy change, and ACT faces risks related to potential future ETS liability. We can infer volume risk is relatively high, due to risks related to fuel and availability and as advanced gasification technology (AGT) is thought to have high technical/ performance risk.[80]

H2P (emerging) is positioned in the medium-high risk category for similar reasons to gas and biomass generation with CCUS. That is, while many elements of operating risk are similar to conventional gas generation, there is limited deployment of H2P, especially at higher levels of hydrogen blending.[81] This reflects the distinction made

[79] Digest of UK Energy Statistics (DUKES) (2024), *Chapter 4: Natural Gas*, p.1. Available at: https://assets.publishing.service.gov.uk/media/66a7aeb0fc8e12ac3edb0646/DUKES_2024_Chapter_4.pdf.

[80] AGT refers to a thermal conversion technology (gasification or pyrolysis) used to convert biomass or waste into hydrogen or hydrocarbon products. AGTs do not include technologies used to produce electricity. The term Advanced Conversion Technology (ACT) is used to describe gasification or pyrolysis technologies used to produce electricity. ACT plants may, or may not, include equipment for cleaning or upgrading of syngas prior to use for the generation of electricity. BEIS (2021), *Advanced Gasification Technologies – Review and Benchmarking*, October, p. 19.

[81] For example, recent studies conducted for the UK Government place a similar uncertainty range around capital costs for H2P and power CCUS. See AECOM (2022a) and AECOM (2022b).

between H2P (mature) and H2P (emerging) in relation to development and construction cost risk (see Section 3.2.1).

As noted in Section 3.2.1, **hydrogen electrolysis** is at a similar stage of maturity to the storage technologies included in the novel LDES category. However, our understanding is that similar to the CfD regime for renewable technologies, the hydrogen production business model does not provide mitigation for operating cost and performance risks, as the strike price is set upfront and revenues depend on actual volumes produced. For this reason, it sits one risk level above novel LDES.

High risk technologies

Floating offshore wind, tidal stream, tidal range, wave, new compound batteries.

These are all emerging technologies with limited operating experience. However, none face the fuel price / ETS risks noted for some of the thermal generation technologies.

Floating offshore wind is expected to face similar operating performance and cost challenges to offshore wind, but with additional uncertainty due to the unproven nature of this technology. Floating offshore wind may however face less volume risk compared to fixed bottom, as it is deployed further out at sea where wind speeds are stronger and more consistent. [82]

Tidal stream and **tidal range** face relatively higher performance risk as an emerging technology in a marine environment. Information on the energy/ power performance of operational projects is scarce, with historical projects running under testing conditions.[83] Repairs may be complicated by a lack of spare parts, which may improve as the technology develops. However, this may be partly offset by a more predictable energy output relative to intermittent renewable technologies. Further, this technology does not face fuel availability or fuel price risk.

Wave is considered to face higher operating performance and cost risk compared to tidal, as the technology is less advanced. Wave energy is in early stages, with operational projects acting as research projects. A key issue is winter storms survivability. As for tidal, relative to intermittent renewable and thermal generation projects, exposure to resource and fuel availability / cost risk is lower.

New compound batteries are significantly less mature than the other storage technologies considered in this report, with correspondingly higher operating cost and performance risk exposure. Unlike novel LDES, their assumed revenue model (a CM contract) does not provide any mitigation with respect to operational cost risk.

3.2.3. Price risk

The assessment of this element considers operational phase risks related to wholesale market prices and revenues. As outlined in Section 2.2, a range of different revenue models apply to the technologies. We have considered the relative price risk exposure of each technology in terms of:

- The extent to which its assumed revenue model reduces exposure to market prices – which we consider to be the most significant factor.
- The length of the merchant tail period post expiry of each support mechanism, with a longer tail period pointing to great price risk exposure.

[82] House of Commons Business, Energy and Industrial Strategy Committee (2023), *Decarbonisation of the power sector*, 25 April 2023, p.31. Available at: https://committees.parliament.uk/publications/39325/documents/193081/default/.

[83] TIGER (Tidal Stream Industry Energiser) (2022), *Cost reduction pathway of tidal stream energy in the UK and France,* October 2022. Available at: https://ore.catapult.org.uk/wp-content/uploads/2022/10/Tidal-stream-cost-reduction-report-T3.4.1-v1.0-for-ICOE.pdf.

- The flexibility of each technology to capture higher market prices in the merchant period, with assumed higher risk for less flexible technologies and/or technologies that are likely to generate at times of zero or negative market prices.

Table 3.5 overleaf outlines the key features that we have assumed for each technology and its associated revenue model, that are relevant to this assessment. The table also sets out the proposed risk rating, both before and after the mitigations the revenue model is assumed to provide. Further explanation of the ratings is provided below the table.

As noted in Section 2.2, some of the revenue models are not fully developed, or fully information may not be in the public domain. Accordingly, the assessment reflects the assumptions stated in this report, which could in practice be different from how a given revenue model is ultimately implemented.

Table 3.5: Price risk ratings and assumptions

Technology	Generation characteristics	Operating life	Revenue model (RM)	RM duration	% operating life covered by RM	Risk rating (pre-RM)	Risk rating (post-RM)
Solar PV	Renewable (variable)	38 years	CfD	15 years	<50%	High	Low-medium
Onshore wind	Renewable (variable)	25 years	CfD	15 years	50-75%	High	Low-medium
Offshore wind	Renewable (variable)	35 years	CfD	15 years	<50%	High	Low-medium
Remote island wind	Renewable (variable)	25 years	CfD	15 years	50-75%	High	Low-medium
Floating offshore wind	Renewable (variable)	26 years	CfD	15 years	50-75%	High	Low-medium
Hydropower	Dispatchable (Assuming a small reservoir)	40+ years	CfD	15 years	<50%	Medium-high	Low-medium
Advanced conversion technologies	Dispatchable	27 years	CfD	15 years	50-75%	Medium-high	Low-medium
Anaerobic digestion	Dispatchable	20 years	CfD	15 years	>75%	Medium-high	Low-medium
Sewage gas	Dispatchable	20 years	CfD	15 years	>75%	Medium-high	Low-medium
Landfill gas	Baseload	28 years	CfD	15 years	50-75%	Medium-high	Low-medium
Energy from waste	Dispatchable	27 years	CfD	15 years	50-75%	Medium-high	Low-medium
Biomass – unabated	Dispatchable	24 years	CfD	15 years	50-75%	Medium-high	Low-medium
Deep geothermal	Dispatchable	25 years	CfD	15 years	50-75%	Medium-high	Low-medium
Tidal stream	Renewable (predictable)	25 years	CfD	15 years	50-75%	Medium-high	Low-medium
Tidal range	Renewable (predictable)	25 years	None	15 years	50-75%	Medium-high	Medium-high
Wave	Renewable (uncorrelated)	20 years	CfD	15 years	>75%	Medium-high	Low-medium

Technology	Generation characteristics	Operating life	Revenue model (RM)	RM duration	% operating life covered by RM	Risk rating (pre-RM)	Risk rating (post-RM)
Biomass – with CCUS – mature and maturing	Dispatchable	24 years	BECCS BM	10-15 years	50-75%	Medium-high	Low-medium
Large-scale nuclear	Baseload	60 years	Nuclear RAB	Whole life	100%	Medium-high	Low
Small modular nuclear reactors	Baseload	60 years	Nuclear RAB	Whole life	100%	Medium-high	Low
Advanced modular nuclear reactors	Baseload	60 years	Nuclear RAB	Whole life	100%	Medium-high	Low
Pumped hydro energy storage	Dispatchable	40+ years	LDES cap and floor	25 years / first refurbishment	100% up to first refurbishment	Medium-high	Low-medium
Novel long-duration energy storage	Dispatchable	Up to 30 years	LDES cap and floor	25 years / first refurbishment	100% up to first refurbishment	Medium-high	Low-medium
Lithium-based battery storage	Dispatchable	15 years	CM contract[84]	Up to 15 years	>75%	Medium-high	Medium-high
New compound battery storage	Dispatchable	Up to 10 years	CM contract	Up to 15 years	100%	Medium-high	Medium-high
Gas generation – unabated	Dispatchable	25 years	CM contract	Up to 15 years	50-75%	Medium-high	Medium-high
Gas generation – with CCUS – mature and maturing	Dispatchable	25 years	Power CCUS BM	10-15 years	50-75%	Medium-high	Low-medium
H2P – mature and emerging	Dispatchable	25 years	H2P BM	10-15 years	50-75%	Medium-high	Low-medium

[84] As noted in Section 2.2, some lithium BESS projects may also be eligible for the LDES cap and floor scheme.

Technology	Generation characteristics	Operating life	Revenue model (RM)	RM duration	% operating life covered by RM	Risk rating (pre-RM)	Risk rating (post-RM)
Hydrogen electrolyser	Other	15-30 years	HPBM	15 years	50-100%	High	Low-medium
Interconnectors	Other	30 years	Cap and floor / CM contract	25 years	>75%	Medium-high	Low-medium
Demand response aggregators	Other	n/a	CM contract	1 year (for DR)	n/a	Medium-high	Medium-high

Source: CEPA analysis.

The risk ratings assigned for this factor reflect that "low-medium risk" technologies are positioned around the median of the comparator sample used to set the asset beta and credit rating. Based on the composition of the sample, we consider that the median reflects an intermittent renewable generator (wind or solar PV) with a relatively large proportion of its revenues under contract. There is relatively little information available on the nature of the contracts that apply to each of the comparators. The risk rating assumes that it is a CfD or similar contract type, as this is a relatively common form.

In this context, the risk ratings for each technology **before considering the revenue model** are all in the "medium-high" to "high" risk range – reflecting that we would expect a merchant project to face considerably higher price risk than the median of the sample. A "high" risk rating is assigned to those technologies that are not dispatchable, reflecting their potential exposure to low or negative price periods – i.e., those classified as renewable (variable), renewable (predictable), renewable (uncorrelated) and baseload. Within this group, we might expect those technologies whose output is more correlated to low price periods – i.e., renewable (variable) to have greater price risk exposure than the others. A "medium-high" risk rating is assigned to those technologies who are able to more flexibly respond to prices (i.e., those classified as dispatchable).

The risk ratings **after accounting for each revenue model** reflect the combined effect of the degree of price risk mitigation provided by the revenue model, and its duration relative to the technology's assumed operating life.

We propose a **"low" risk rating** for the nuclear technologies that operate under the **RAB regime**. The nuclear RAB model provides the licensee with a regulated revenue allowance from construction through to the end of operation. Due to the operation of a market price incentive, nuclear licensees continue to face basis risk (i.e., related to differences between actual trading income and expected income for a baseload plant) and buy-back risk (i.e., related to the risk that unplanned outages require the company to repurchase forward sales undertaken to manage basis risk). Nonetheless, the RAB regime means that revenues are relatively certain for a significantly greater proportion of the asset's operating life, compared to the other technologies considered in this report.

We propose a **"low-medium" risk rating** for the technologies that operate under the **renewable CfD**, **Power CCUS business model**, **BECCS business model**, **H2P business model**, **interconnector / LDES cap and floor regime**, and **hydrogen production business model**.

There are differences in how these models mitigate exposure to price risk:

- Interconnectors / LDES technologies are fully exposed to price risk within the cap and floor, but not outside these thresholds. Price risk is also fundamentally different for interconnectors (and to some extent storage technologies) compared to generation technologies – because their revenues are earned from temporal and/or locational price differences, rather than the absolute value of wholesale market prices.
- The renewable CfD regime / BECCS business model / HPBM all share a broadly similar CfD structure that removes price risk for volumes produced but leaves an exposure to basis risk. Even within this, there may be varying levels of basis risk exposure. For example, under the HPBM the reference price is the producer's achieved sales price, so long as that is equal to or greater than the natural gas price. Accordingly, basis risk for hydrogen electrolysers under the HPBM could be lower than the other CfD models.
- The dispatchable power agreements (DPA) under the Power CCUS business model has a two-part availability and variable payment structure. The availability payment is intended to provide a stable revenue stream that recovers capital costs and a return on investment. While we understand that the availability payment will be determined in advance with regard to expected wholesale market revenues, once set the payment itself will not fluctuate with wholesale market prices. The variable payment (a top up to wholesale market revenues) will only be made if the short-run marginal cost (SRMC) of the CCUS plant exceeds a reference H-class CCGT – meaning that there is still exposure to wholesale market prices on output.
- The H2P business model (H2PBM) will be based on elements of the Power CCUS DPA but adapted to suit the needs of H2P.

On the other hand, the cap and floor regime provides support over a considerably longer time frame than the 15-year CfD regime, with the DPA potentially in place for the shortest period (10-15 years). In practice, the relative degree of price risk mitigation provided by these models will also depend on how they are calibrated – for example, how narrowly the cap and floor for LDES is set, and whether a 'soft cap' applies. Overall, we suggest that a "low-medium" rating is reasonable for technologies operating under these revenue models, which should result in price risk exposure that is similar to, or potentially less than, that reflected in the comparator sample. While there are differences in risk within this grouping, it appears reasonable to assume a smaller degree of price risk mitigation compared to the nuclear RAB framework (for which the duration far exceeds even the cap and floor regime).

It is possible that distinctions could also be made for the technologies covered by these revenue models. For example, a 15-year CfD covers a smaller proportion of the operating life for a hydropower project compared to a sewage gas project. This suggests that a "medium" risk rating could potentially be appropriate for the longer-lived technologies, such as hydropower.[85]

The price risk rating for technologies with a CM contract, compared to other revenue models, relies on some assumptions regarding future capacity market prices. In particular:

- In principle, a CM contract offers the same structure as the DPA for Power CCUS – that is, a fixed availability or capacity payment, but exposure to wholesale market prices on the plant's output.
- We understand that part of the rationale for the DPA is to address cross-chain infrastructure risks which are not present for unabated gas generation that is eligible for the CM.
- Accordingly, the difference in risk terms will ultimately depend on the relative magnitude of the DPA availability payment and capacity payments (i.e., the proportion of the project's total required return that these payments recover). If CM prices are sufficiently high, they may cover a similar proportion of the total project return, pointing to a similar degree of price risk.

However, the 2022 evaluation of the Capacity Market found that a CM contract would not typically be the most material part of an asset's revenues:[86]

> *"The value of Capacity Market revenues to investors is purely in their availability, and Capacity Market revenues do not typically form the bulk of an asset's revenue stream. However, the value of a Capacity Market revenue stream was found to differ by technology type. More flexible assets (i.e. revenue stackers) valued Capacity Market revenues higher in the investment case than other technologies (such as CCGTs). Capacity Market revenues are rarely a deciding factor on whether to invest in an asset, as investors typically base investment cases on fully merchant financing in the wholesale market, using Power Purchase Agreements (PPAs) or (in the case of interconnectors) arbitrage."*

This is consistent with the assumptions that respondents to the investor survey reported for short duration storage and gas generation. For example, some respondents considered that lithium batteries effectively operated under a merchant revenue model, because CM revenues make up only a small fraction of total revenues.

This would suggest retaining a **"medium-high" risk rating** for the technologies that are assumed to have a CM contract, but no other long-term revenue stabilisation mechanism. However, it could also be appropriate to adopt a "medium" or even "low-medium" risk rating for CM technologies, if DESNZ expects that future CM prices will in practice deliver similar risk mitigation to the DPA.

[85] Given the ratings assigned for development / construction and operating cost / volume risks, giving hydropower a "medium risk" rating on this element would not change its overall risk score (which is medium).

[86] DESNZ (2022), *Evaluation of the Capacity Market Scheme - Final Evaluation Report*, December 2022, p.7. Available at: https://assets.publishing.service.gov.uk/media/6528f9342548ca000dddf234/capacity-market-evaluation-final-report-technopolis.pdf.

3.2.4. FOAK risk

As noted in Section 3.1.3, we propose a separate upwards adjustment to the overall risk rating for technologies that are at a very early stage of development. We have applied this to the technologies classified as either **maturing** or **emerging**, for which few, if any, examples of commercial scale projects have been implemented.

As explained in Section 3.1.3, this is not intended to be duplicative of the consideration given to technology maturity in the assessment of development and construction risk, and volume and operating cost risk. Rather, this adjustment aims to reflect that the novelty of some of the technologies we are considering may not be fully captured by the three weighted risk categories.

We also consider that there is scope for DESNZ to apply judgement for those technologies classed as maturing. For example, for CCUS in particular, our discussions with DESNZ indicate that there may be examples of UK-based projects where a FOAK adjustment would not be appropriate, because the way the project is structured has transferred FOAK-related risk away from investors (see Section 3.1.4). Accordingly, for this technology we have presented hurdle rates both with and without the adjustment (i.e., for 'mature' and 'maturing' projects respectively).

Table 3.6: Application of FOAK adjustment

Classification	Definition	Technologies
Mature	Technology has been widely deployed at commercial scale.	Solar PV, onshore wind, offshore wind, remote island wind, hydropower, AD, sewage gas, landfill gas, EfW, biomass (unabated), large-scale nuclear, PHES, lithium batteries, gas (unabated), H2P (mature), interconnectors, demand response aggregators.
Maturing	Some examples of commercial-scale developments exist or are under construction.	ACT, deep geothermal, biomass (CCUS), gas (CCUS), novel LDES, hydrogen electrolysers, SMRs.
Emerging	Has not been deployed at commercial scale.	Floating offshore wind, tidal stream, tidal range, wave, AMRs, new compound batteries, H2P (emerging).

Source: CEPA analysis.

3.2.5. Initial risk ratings

The table overleaf summarises our assessment against the elements outlined above and the overall rating. In summary:

- **Solar PV receives a "low" risk rating.** It is an established, mature and relatively simple technology, with substantial construction and operating experience in the UK and internationally.
- **Onshore wind, AD, sewage gas, landfill gas, large-scale nuclear, PHES, and interconnectors receive a "low-medium" rating.** This reflects the following key considerations:
  - **Onshore wind:** While maturity is similar to solar PV, there is a difference in the construction and operational complexity of the assets (as reflected in credit rating agency methodologies), higher development phase risk related to uncertainty over when and to what extent the historic planning restrictions will be resolved, and the effect of current supply chain pressures.
  - **AD / sewage gas / landfill gas:** While maturity is broadly similar to solar PV, there are future uncertainties around the availability and cost of fuel (judged more difficult to assess than solar PV output, with which there is now substantial experience) and a more complex operating profile.

- Large-scale nuclear: While a mature technology, nuclear developments have a particularly challenging construction phase and are more complex to operate than the other technologies included in this category. The rating is materially influenced by the assumed level of mitigation that the nuclear RAB model provides in relation to construction risk, operating cost and volume risk, and price risk. This will depend on how the RAB model is implemented in practice, which we did not have visibility of when developing this report.[87]
- **PHES and interconnectors:** While the level of construction and operational period complexity is considered higher than onshore wind, there are features of the cap and floor regime that mitigate this.

- **Offshore wind, remote island wind, hydropower, EfW, biomass (unabated), biomass (CCUS, mature), SMRs, AMRs, gas generation (unabated), gas generation (CCUS, mature), H2P (mature), lithium batteries, and demand response aggregators receive a medium rating.** The difference relative to the low-medium technologies reflects:
  - **Offshore and remote island wind:** Relative to onshore wind there is a more challenging construction and operating environment, more substantial supply chain pressures, and (for offshore wind) more complex construction.
  - **Hydropower:** While maturity is similar to solar PV, there is greater complexity in the planning, construction and operation phases. There is also a significantly longer merchant tail period post CfD-expiry, although this is not currently reflected in the price risk rating. While construction and operation phase risks may be similar for hydropower and PHES (depending on the project design), the cap and floor regime for PHES is assumed to offer mitigating features that are not present in the CfD regime.
  - **Biomass (unabated), ACT and EfW:** There is a higher degree of uncertainty around future fuel supply and costs for these biofuel technologies, relative to AD/sewage gas.
  - **SMRs and AMRs:** These technologies are less advanced than large-scale reactors (particularly AMRs), and the degree of construction and operating cost / volume risk can initially be expected to be significantly higher until the technology matures. In practice, we capture this difference by applying a FOAK adjustment to SMRs and AMRs, but not to large-scale reactors.
  - **Gas (unabated):** A mature technology that is considered to have comparable construction and operational complexity to offshore wind. Unabated gas receives an elevated risk rating in relation to price risk, reflecting differences in the revenue model – although given the weightings applied, this does not result in a higher overall rating.
  - **Gas (CCUS, mature) and biomass (CCUS, mature):** As discussed in Section 3.2.4, there may be circumstances where it is not appropriate to apply at FOAK adjustment to technologies with CCUS capability (e.g., where there is evidence that the revenue support model and/or project structuring arrangements have fully offset the higher risk that results from these technologies being less mature than their unabated counterparts). This scenario captures such cases, leading to the same risk rating as for unabated gas and biomass respectively.
  - **H2P (mature):** This is a nascent but rapidly developing technology, with uncertainty around the final policy position on retrofit plant versus new plant, hydrogen blending, and the form of the revenue support mechanism. Accordingly, for this report we have positioned H2P between the medium and medium-high risk levels. Given the similarity of basic turbine technology and likely range of revenue support mechanisms, we have adopted the same risk rating as unabated gas at

[87] As discussed in Section 5.1.12, evidence from the July 2025 announcement of a final investment decision in Sizewell C was not available when the risk analysis presented in this report was undertaken.

the lower bound and aligned with gas CCUS at the upper bound. In practice, the upper bound may be slightly higher than gas CCUS, considering that the H2P business model is not yet fully defined and large 100% hydrogen burning turbines are still in development. We also note that DESNZ intends to re-assess the risk rating (and associated hurdle rate) for H2P as the H2P business model is further developed. Accordingly, the risk ratings and hurdle rates presented in this report are subject to change.

  - **Lithium batteries and demand response aggregators:** While these technologies have relatively simple / less capital intensive construction requirements, there are operational complexities – in particular given the assumed revenue model that relies on a diverse stack of short-term revenue sources in addition to a capacity market contract.

- **Deep geothermal, novel LDES, ACT, biomass (CCUS, maturing), gas generation (CCUS, maturing), H2P (emerging) and hydrogen electrolysers receive a medium-high rating.** This reflects:
  - **Deep geothermal:** There are materially higher development and construction risks relative to the lower risk technologies, concerns regarding a lack of supply chain maturity, and less experience with this technology in the UK.[88]
  - **ACT:** Compared to the other biofuel technologies included in the medium-risk category, there is more limited experience with ACT in the UK, implying higher risks across all project phases.
  - **Novel LDES:** Relative to PHES, the technologies included in this category are at a much earlier stage of development, pointing to higher construction, operating cost, and volume risk. The rating assumes that the LDES cap and floor regime does not entirely remove these underlying risk differences.
  - **Hydrogen electrolysers:** Electrolysers are considered to have a broadly similar TRL to the novel LDES technologies, which have also been assigned a medium-high rating. The cap and floor revenue model for novel LDES is assumed to provide greater mitigation of construction and operating cost risks, relative to the hydrogen production business model (see Table 2.2). However, this does not lead to a higher rating overall for hydrogen electrolysers given the weighting of the risk factors.
  - **Biomass (CCUS, maturing), gas (CCUS. maturing) and H2P (emerging)**: Compared to their unabated counterparts, the addition of CCUS technology for biomass and gas is considered to increase the level of construction and operating cost / volume risk. This scenario (where a FOAK adjustment applies) assumes that this risk is not fully mitigated by the BECCS and Power CCUS business models, nor by other project structuring arrangements (e.g., OEM warranties). H2P (emerging) is positioned in the medium-high risk category for similar reasons. That is, while many elements of operating risk are similar to conventional gas generation, there is limited deployment of H2P at higher levels of hydrogen blending and with larger turbines.

- **Floating offshore wind, tidal stream, tidal range, wave and new compound batteries all receive a high rating.**
  - Relative to the other technologies, this reflects that these are immature technologies that have not yet been deployed at scale. FLOW, tidal and wave will also be deployed in a challenging marine environment. While FLOW could be considered ahead of the other technologies in a maturity sense, it is currently subject to material supply chain pressures.

[88] For this report, deep geothermal was assessed for facilities that produce electricity, rather than heat. Based on our discussions with DESNZ, we understand that compared to deep geothermal power, in the UK deep geothermal heat would be likely to face a lower degree of development of construction risk, but a higher degree of price risk due to the absence of a CfD. If this assessment is correct, it would point to a broadly similar risk rating for both power and heat projects.

- The technologies listed in this category have been positioned at the highest risk level. However, this partly reflects the inclusion of a FOAK adjustment. Without this adjustment, FLOW, tidal stream and wave would all sit in the medium-high risk category – reflecting the impact of the CfD regime on price risk. This suggests that in practice, the hurdle rate for tidal range and new compound batteries – which are assumed not to have a revenue model that substantially insulates them from price risk – should potentially be higher than the other technologies included in this category. We consider this further in Section 4.6.

As discussed in Section 3.1.2, we have applied the proposed risk ratings to inform our estimates of the cost of debt (via the credit rating) and cost of equity (via the asset beta). In Section 4.1, we present and sense check the quantitative assumptions that result from the risk ratings for these parameters.

CEPA economics matters

Table 3.7: Overall risk ratings (with assumed revenue model)

Technology	Development and construction risk	Operating cost and volume risk	Price risk	FOAK adjustment	Overall risk rating
	30%	30%	40%	Y/N	
Solar PV	L	L	L-M	No	L
Onshore wind	L-M	L-M	L-M	No	L-M
Offshore wind	M	M	L-M	No	M
Remote island wind	M	M	L-M	No	M
Floating offshore wind	H	H	L-M	Yes	H
Hydropower	M	M	L-M	No	M
ACT	M	M-H	L-M	Yes	M-H
AD	L	L-M	L-M	No	L-M
Sewage gas	L	L-M	L-M	No	L-M
Landfill gas	L	M	L-M	No	L-M
Energy from waste	M	M	L-M	No	M
Biomass – unabated	M	M	L-M	No	M
Deep geothermal	M-H	M	L-M	Yes	M-H
Tidal stream	H	H	L-M	Yes	H
Tidal range	H	H	M-H	Yes	H
Wave	H	H	L-M	Yes	H
Biomass – with CCUS (mature)	M-H	M	L-M	No	M
Biomass – with CCUS (maturing)	M-H	M	L-M	Yes	M-H
Large-scale nuclear	M	L-M	L	No	L-M
SMRs	M	L-M	L	Yes	M
AMRs	M	L-M	L	Yes	M
PHES	L-M	L-M	L-M	No	L-M
Novel LDES	M	M	L-M	Yes	M-H
Lithium batteries	L-M	L-M	M-H	No	M
New compound batteries	H	H	M-H	Yes	H
Demand response aggregators	L-M	L-M	M-H	No	M
Gas generation – unabated	M	M	M-H	No	M
Gas – with CCUS (mature)	M-H	M	L-M	No	M
Gas – with CCUS (maturing)	M-H	M	L-M	Yes	M-H
Hydrogen CCHT / OCHT (mature)	M	M	L-M	No	M
Hydrogen CCHT / OCHT (emerging)	M-H	M-H	L-M	Yes	M-H
Hydrogen electrolyser	M-H	M-H	L-M	Yes	M-H
Interconnectors	L-M	L	L-M	No	L-M

Source: CEPA analysis.

3.2.6. Investor survey results

The investor survey asked respondents to rank technologies they are actively involved in using the same five-level scale applied above. A summary of the survey results is provided in the table below and compared to the ratings we proposed in Section 3.2.5 above.

The following technologies received no responses for this question: ACT, AD, sewage gas, landfill gas, biomass (unabated or with CCUS), tidal range, demand response aggregators, OCGT with CCUS, reciprocating gas engines with CCUS.

Table 3.8: Technology risk rankings – Investor survey

Technology	CEPA Initial Rating	Median Respondent Rating	Survey relative to CEPA	No. responses
Solar PV	L	L-M	↑	11
Onshore wind	L-M	L-M	↔	8
PHES	L-M	M-H	↑	3
Hydropower	M	M	↔	8
Remote island wind	M	M	↔	3
Offshore wind	M	M	↔	8
Lithium batteries	M	M	↔	6
Gas (CCGT - unabated)	M	M	↔	6
Gas (OCGT - unabated)	M	M	↔	4
Gas (CCGT - CCUS) - mature / maturing [1]	M **or** M-H	M-H	↔	3
Deep geothermal (pre-drilling phase)[2]	M-H	M-H	↔	1
Deep geothermal (post-drilling phase)[2]	M-H	L-M	↓	1
Hydrogen (CCHT) - mature / emerging[1]	M **or** M-H	M-H	↔	4
Hydrogen (OCHT) - mature / emerging[1]	M **or** M-H	M-H	↔	3
Hydrogen electrolysers	M-H	M-H	↔	7
Novel LDES	M-H	H	↑	4
Floating offshore wind	H	H	↔	4
Large-scale nuclear reactors	L-M	Response not separately identified to preserve anonymity. Technologies in this category were ranked the same (2 technologies), lower (6 technologies), or higher (1 technology) than CEPA's proposed risk ranking. Where the survey results differed from our assessment, the difference was one risk level (lower or higher, depending on the technology).		
Interconnectors	L-M			
Energy from waste	M			
Gas (reciprocating engine - unabated)	M			
New compound battery storage	H			
Tidal stream	H			
Wave	H			
Small modular nuclear reactors	M			
Advanced modular nuclear reactors	M			

Source: CEPA analysis of investor survey results. Note: (1) Although CEPA's final risk assessment considers mature / maturing variants for gas generation with CCUS and mature / emerging variants for H2P, these variants were not presented to survey respondents. (2) CEPA's risk assessment for deep geothermal relates to a 'whole of life' average risk level. However, survey respondents were invited to comment on the pre- and post-drilling phases separately.

Overall, the survey results are quite consistent with the relative ratings that we have proposed. The main differences relate to solar PV, novel LDES, and (most materially) PHES. Respondents were invited to comment on why they agreed or disagreed with the initial risk ranking provided by CEPA.[89] For solar PV and novel LDES, the reasons provided included that:

- Financiers consider the impact of FOAK risk for nascent technologies, placing novel LDES into the highest category (rather than medium-high in CEPA's risk assessment).
- The impact of grid connection, planning and supply chain delays increases risk for solar PV projects, indicating that a low-medium rating may be more appropriate than low.

In relation to geothermal, our proposed risk rating aims to reflect a blended view of risk across the pre- and post-drilling phases. Accordingly, we consider that the survey results are broadly consistent with our proposed rating.

We note that for gas with CCUS, the risk rating from the survey responses is more consistent with the 'maturing' variant for that technology. Similarly, the survey risk rating for H2P is more consistent with the 'emerging' variant considered in CEPA's assessment.

In relation to the technologies with few responses (for which we have not reported the survey risk rating), we note that in all bar one case, the risk rating selected by respondents was the same or lower than the one we have proposed.

In Section 4.6, we consider whether the qualitative and quantitative survey results, in combination with other evidence, indicate that an adjustment is required.

[89] The initial risk rating provided in the survey differed in some cases from that presented in Section 3.2.5 of this report (as in some cases new evidence became available to inform our assessment).

4. CAPM-BASED ESTIMATES

This section summarises our methodology for developing the CAPM-based hurdle rates, the estimates for each parameter, and the overall hurdle rates derived. The estimates are presented as of 31 December 2024.

While we consider that the methodology set out here is a reasonable approach to deriving hurdle rate estimates in the context that DESNZ will be using them, we recognise that there are other alternative approaches that could also be considered reasonable. We discuss alternative methodologies – and their potential implications – in Appendix D.

4.1. Hurdle rate parameters

DESNZ require hurdle rates expressed in both pre-/post-tax and real/nominal terms:

- A pre-tax hurdle rate reflects the returns that an investor would require before accounting for tax payments.
- A real hurdle rate reflects the returns that an investor would require before accounting for the impact of inflation.

When hurdle rates are being applied to evaluate an investment opportunity, the hurdle rate selected should match the projected cash flows that are being analysed. That is, a pre-tax real hurdle rate should be applied to analyse pre-tax real cash flows, and vice versa. Below we briefly describe the parameters used to calculate these different types of hurdle rates under a CAPM-based methodology, before moving to a detailed discussion of how we have estimated each parameter.

A CAPM-based **hurdle rate** for a project can be calculated as the weighted average of the required **return on debt** (K_d) and required **return on equity** (K_e), where the weighting is determined by the relative proportions of debt and equity within the project's overall capital structure (**gearing**):

$$Hurdle\ Rate = gearing \times K_d + (1 - gearing) \times K_e$$

Under the CAPM, the **post-tax return on equity** ($Ke_{\text{post-tax}}$) is calculated as the **risk-free rate** (R_f), plus the **equity risk premium** (ERP) multiplied by the **equity beta** (β_e):

$$K_{e\ (post\text{-}tax)} = R_f + ERP \times \beta_e$$

Within this framework, the risk-free rate represents the required return on a risk-free asset, conventionally proxied by long-term government bonds. The equity risk premium reflects the additional compensation an investor would require above the risk-free rate, to account for the risk of holding a diversified portfolio of investments, rather than a risk-free asset. The equity risk premium is multiplied by the equity beta. The beta term captures investors' exposure to risk which cannot be eliminated through diversification (systematic risk). This is measured as the covariance of returns in a diversified investment portfolio and returns on the investment the hurdle rate is being derived for.

To derive the equity beta for an unlisted investment, it is common practice to collect market data on the 'raw' equity betas of listed comparators with a similar risk profile to the target investment. The raw equity betas are then de-levered using the gearing and (if used) **debt beta** of the comparators to derive an **asset beta**. Finally, the chosen asset beta is re-levered to derive an estimate of the equity beta for the target investment, using its assumed gearing and (if used) debt beta.

The asset beta (β_a) is the equity beta removing the effect of gearing. This represents the asset's exposure to systematic risk, comprising both the systematic risk to equity returns (equity beta, β_e) and the systematic risk to debt (debt beta, β_d):

$$\beta_a = \beta_e \times (1 - \frac{D}{D+E}) + \beta_d \times \frac{D}{D+E}$$

Equity market data is typically collected in post-tax terms. The post-tax return on equity can be converted to a **pre-tax return on equity** ($Ke_{\text{pre-tax}}$) via the assumed **tax rate** (t):

$$Ke_{(Pre\text{-}Tax)} = Ke_{(Post\text{-}Tax)} / (1 - t)$$

The **return on debt** is typically estimated with reference to observed market yields on corporate bonds at a nominated **credit rating**. The return on debt will also typically include an allowance for **debt raising costs**, the transaction costs involved in obtaining debt finance. This data is typically collected in pre-tax terms. In the UK, interest costs are tax deductible, so no adjustment is required to derive a post-tax cost of debt.

This approach to estimating the return on debt differs from the CAPM framework, which would express the required return on debt as the product of the risk-free rate, ERP and **debt beta** (β_d):

$$K_d = R_f + ERP \times \beta_d$$

One consequence of using corporate bond benchmarks to estimate the return on debt, rather than the CAPM, is that the gearing assumption may affect hurdle rates. This is discussed in more detail in Appendix D.2.5.

Finally, **expected inflation** is required to convert estimates between real and nominal terms using the Fisher equation. The formula to convert real estimates to normal terms is:

$$Nominal\ Hurdle\ Rate = (1 + Real\ Hurdle\ Rate) \times (1 + Expected\ Inflation) - 1$$

4.2. Approach

The parameters outlined above can be divided into "technology neutral" and "technology-specific" categories:

- We assume that the **technology neutral parameters** do not vary across the different technologies we are considering. These parameters are the risk-free rate, total market return, gearing, debt beta, tax rate and expected inflation.
- The **technology-specific parameters** are the asset beta and credit rating (and by extension, the cost of debt). We use these parameters to reflect underlying differences in risk for each technology, as assessed in Section 3. Each risk rating has an associated asset beta and credit rating – for example, a technology rated 'high' risk is assigned a higher asset beta than one rated 'low' risk.

The technology neutral parameters include 'market wide parameters' – the risk-free rate, total market return, and expected inflation – that we would expect to be the same for all electricity sector projects within the UK. We have also assumed that gearing, debt beta and the tax rate do not vary by technology. While there are reasons why these parameters may differ across technologies in practice, we consider that adopting constant assumptions is more appropriate in the context of this advice. We explain this in Section 4.4.5 (gearing), Section 4.4.6 (tax rate) and Section 4.4.8 (debt beta).

It is important to note that by necessity – given the number of technologies and revenue models that need to be captured by the methodology – the approach we have proposed is not designed to address the very specific financing arrangements that might apply to a given project. This means that – as noted in Section 3.1.4 – although the allocation of risk between debt and equity investors may not correspond precisely to that applied to any given project, in the round the overall hurdle rate estimates may still be reasonable.

4.3. Technology-specific parameters

As outlined above, we have developed a technology-specific estimate for asset beta and credit rating, corresponding to the each of the risk ratings outlined in Section 3.

4.3.1. Asset beta

We have developed a distribution of asset beta estimates based on observations from listed comparator firms (i.e., an estimate for each percentile). The distribution informs the asset beta assumption we adopt for each technology.

Estimation approach

We have taken the following quantitative approach to estimating asset beta. This is broadly consistent with UKRN principles and guidance on the cost of capital, but adapted to reflect the specific requirements of this exercise.[90] The six steps of our approach are outlined in the figure below. More detail is provided in Appendix D.1.1.

Figure 4.1: Asset beta estimation approach – Core sample

1. Established a long list of potential comparators. These were listed electricity sector firms with at least 2 years of stock market data and that are listed in a broadly comparable country.
2. Filtered the long list to remove firms: who were not liquid; whose activities where not relevant; and who did not appear to have the majority of revenues secured under long-term contracts.
3. Estimated equity betas for each comparator over 2-, 5- and 10-year horizons, based on daily and weekly return specifications.
4. Used net debt and market capitalisation data to calculate gearing for each comparator.
5. Applied the practitioner's formula to convert the estimated equity betas to asset betas, using the estimated gearing and a zero debt beta assumption.
6. Established a distribution of asset beta estimates, based on this evidence.

Source: CEPA.

Comparators

The process above produced a 'core' sample of 32 listed comparators. In addition to the core sample, we have also considered two separate samples as a cross-check for the following technologies:

- **Nuclear:** We considered a sample comprised of 17 US utilities that are regulated under a rate base framework. The utilities in this sample develop and operate nuclear generation assets, in addition to other generation types and (in many cases) network assets. There are some differences between these comparators and standalone new build nuclear projects. As noted above, the companies include non-nuclear assets; in most cases the proportion of nuclear generation is less than 50%, and in some cases as low as ~10%. Further, the sample includes operating assets – that we would expect to have a lower risk profile than we are seeking for a 'whole life' hurdle rate estimate. Nonetheless, given the nature of the

[90] For example, in other contexts we may recommend conducting a detailed review of how asset beta estimates for individual comparators have evolved over time, partly with a view to understanding the potential drivers of this variation. However, this type of analysis is not practical in this context, where we have developed a broad comparator sample to capture a range of different technologies.

regulatory framework that applies to the comparators, we consider that this provides relevant evidence for projects operating under the nuclear RAB regime. This is consistent with CEPA's 2024 advice to Ofgem on the approach to estimating asset beta for nuclear licensees.

- **Hydrogen electrolysers:** We considered a range of comparators that could potentially better capture the systematic risk of this technology, as it is not well represented in the core sample. We identified two that both pass the liquidity / trading history filters and have a reasonably high proportion of their business linked to hydrogen production or similar activities: Air Liquide and Air Products and Chemicals. Neither is a perfect comparator for a hydrogen electrolyser operating under the hydrogen production business model. A sample of two comparators is also rather limited. Nonetheless, we present this comparison for transparency.

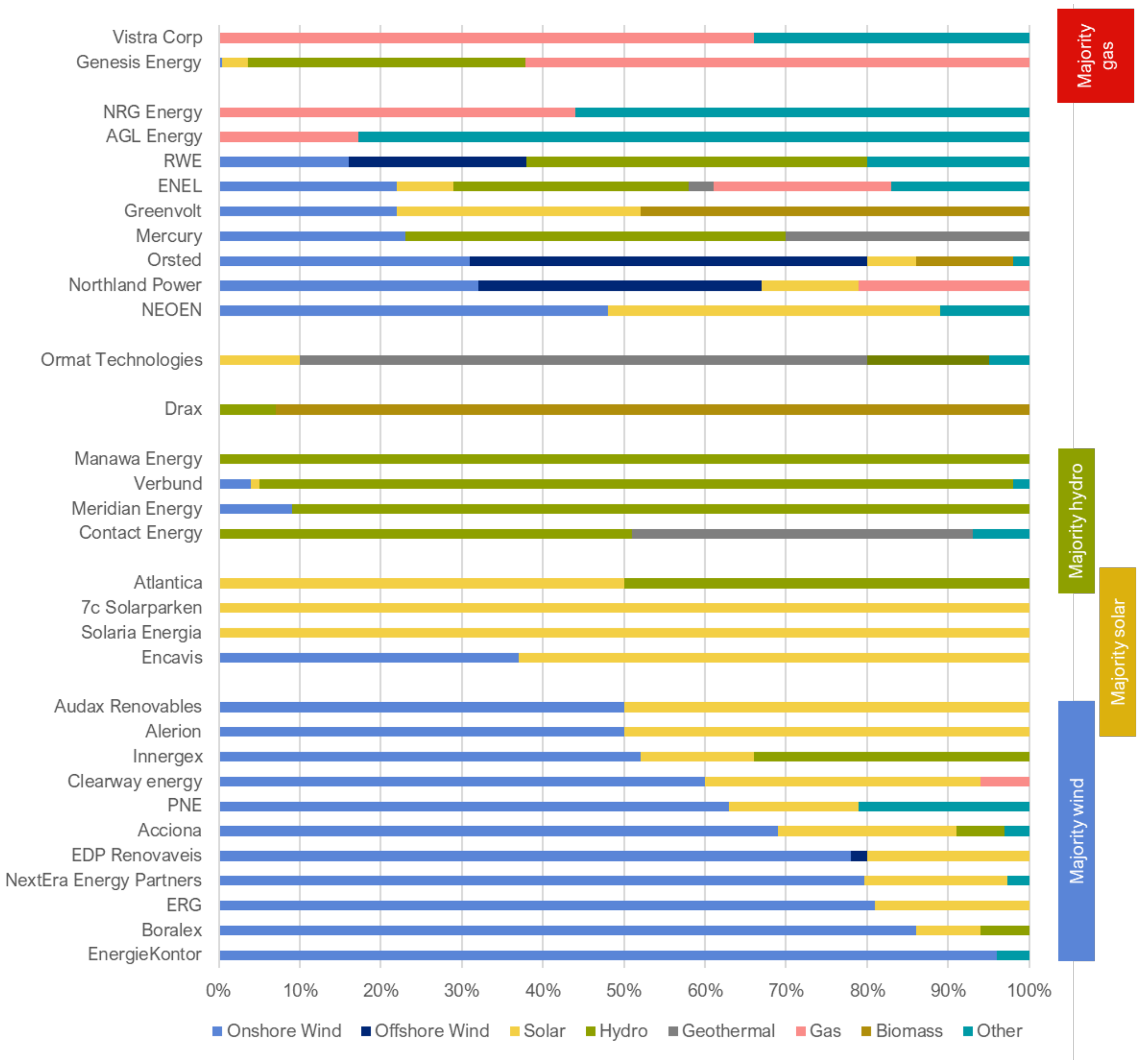
We have used these samples to cross check where nuclear and hydrogen electrolysers are positioned relative to the core sample. We think that in the context of how DESNZ will use this methodology going forwards, it is preferable to use the core sample for these technologies and apply a cross-check, rather than use the individual samples to set the asset beta directly. This is to make sure that the relativity between the hurdle rate estimates is aligned with the risk category they are assigned to.

The comparators included in each of our samples (core, nuclear cross check and hydrogen electrolyser cross check) are listed in Appendix D.1.1.

Figure 4.2 provides an indicative breakdown of the core sample comparators by technology. This indicates that the core sample is primarily comprised of mature generation technologies (primarily onshore wind and solar PV, and to a lesser extent offshore wind, hydropower and natural gas) that have a relatively high proportion of revenues under long-term contracts.

Within the 'core' sample, we have identified where there are comparators that are primarily active in a particular technology (see Figure 4.2). While this has provided some reference points, none of these technology-specific sub-samples are large enough to consider using in isolation.

Figure 4.2: *Indicative breakdown of core sample by generation technology type*



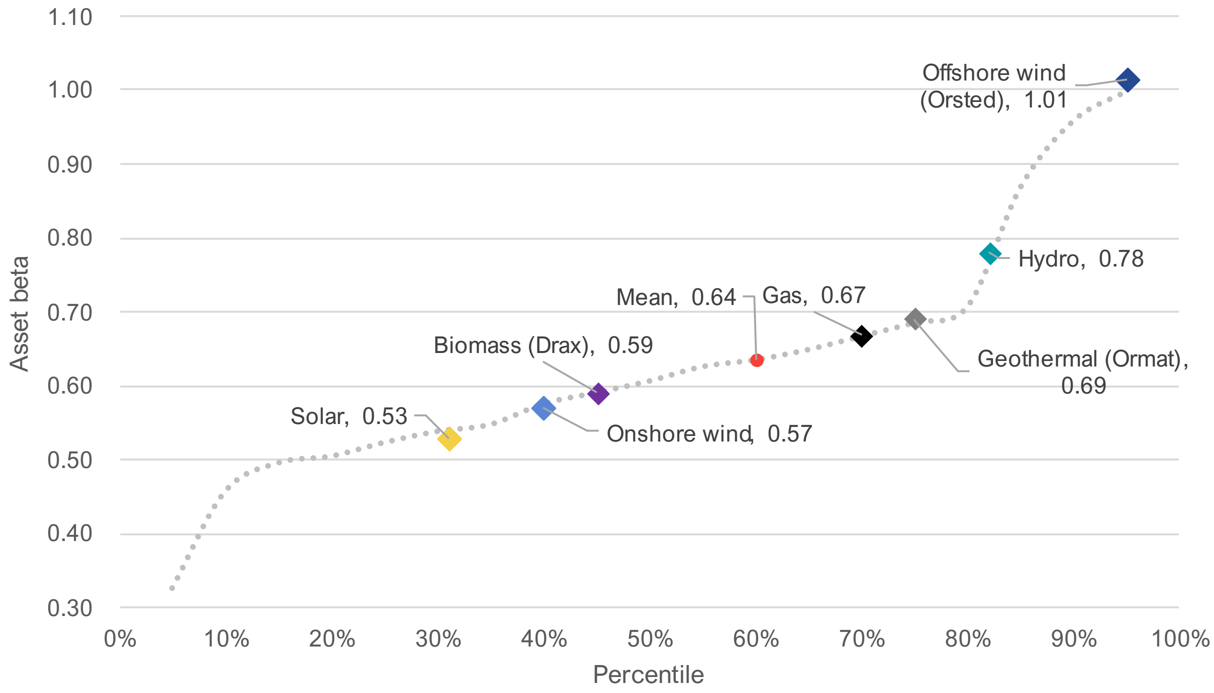
Source: CEPA analysis. Note: The breakdown reflects the contribution of each technology to either EBITDA, revenue or generation – depending on data availability.

The sample also reflects a mix of operating assets, in addition to each comparator's development pipeline. As we discuss in the following sections, this is relevant for where we position each risk category / technology on the spectrum of comparator evidence.

Results

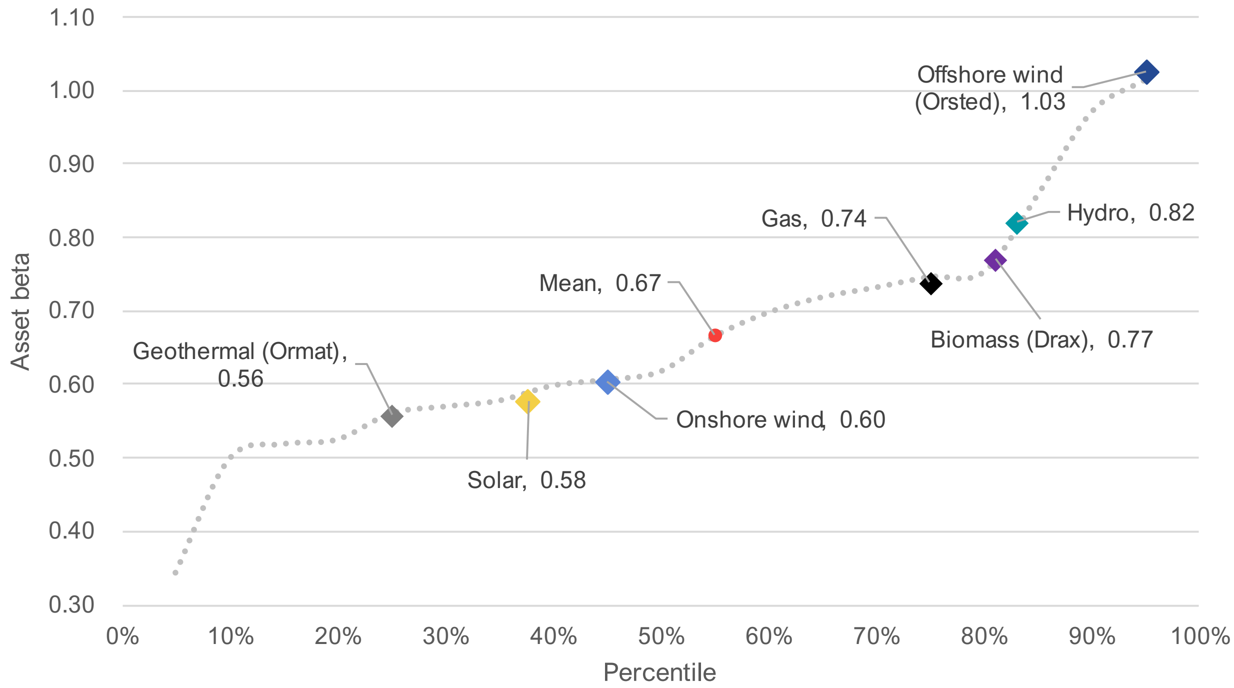
The distribution of asset beta estimates is shown in the figures below for the 5-year daily and weekly beta estimates. The same charts for the 2-year and 10-year estimates are included in Appendix D.1.1.

Figure 4.3: 5-year daily asset beta estimates (core sample, spot, 31 December 2024)



Source: CEPA analysis.

Figure 4.4: 5-year weekly asset beta estimates (core sample, spot, 31 December 2024)



Source: CEPA analysis.

The figures above highlight estimates for sub-samples and individual comparators whose activities are at least 50% comprised of one technology of interest. Caution should be used in interpreting this information. For example, the 'majority gas' sample reflects just two comparators. There is a single comparator each focused on geothermal, offshore wind and biomass. Some technologies have better representation, including onshore wind sample (11 comparators), solar PV (6) and hydro (5).[91]

The full set of estimates (2 / 5 / 10 years and daily / weekly) are summarised in the table below. As discussed in the following section, we have used this information and other sources to select point estimates for each technology risk rating (i.e., low, low-medium, medium, medium-high, high).

[91] Several of the hydro comparators are vertically integrated (i.e., include both generation and retail activities). We have treated these as having long-term contracted revenues for the purpose of establishing the sample. There may be differences in practice (for example, depending on the nature of the customers served, the characteristics of retail prices and contracts, to what extent the vertically integrated company supplies its customers with its own generation, etc). The CMA's 2015 electricity market investigation provides some precedent for this approach, as it considered that the systematic risk faced by a vertically integrated gentailer and standalone generator was similar. However, the CMA did not specify what contracting arrangements were assumed for the standalone generator. CMA (2015), *Energy Market Investigation – Analysis of cost of capital of energy firms*, 25 February 2015, p.21. Removing the vertically integrated comparators from the sample would marginally reduce the asset beta estimates shown above.

Table 4.1: Asset beta estimates (31 December 2024)

Estimate	2-year (spot)		5-year (spot)		10-year (spot)	
	Daily	Weekly	Daily	Weekly	Daily	Weekly
Core sample mean	0.61	0.62	0.64	0.67	0.59	0.62
Minimum	0.24	0.19	0.29	0.33	0.28	0.36
5th percentile	0.33	0.36	0.33	0.34	0.33	0.39
10th percentile	0.37	0.39	0.46	0.50	0.38	0.44
20th percentile	0.38	0.43	0.51	0.53	0.47	0.51
30th percentile	0.43	0.46	0.54	0.57	0.51	0.53
40th percentile	0.54	0.53	0.58	0.60	0.53	0.54
50th percentile (median)	0.58	0.58	0.61	0.62	0.56	0.57
60th percentile	0.65	0.64	0.64	0.70	0.64	0.62
70th percentile	0.71	0.70	0.67	0.73	0.66	0.66
80th percentile	0.74	0.83	0.71	0.75	0.68	0.73
90th percentile	0.93	0.99	0.96	0.97	0.79	0.89
95th percentile	1.04	1.02	1.00	1.01	0.89	0.90
Maximum	1.25	1.15	1.13	1.16	1.09	1.11
Solar average[1]	0.51	0.53	0.53	0.58	0.48	0.53
Onshore wind average[2]	0.61	0.60	0.57	0.60	0.48	0.52
Hydro average	0.68	0.70	0.78	0.82	0.71	0.75
Offshore wind average (Orsted)	1.01	1.04	1.01	1.03	n/a	n/a
Biomass (Drax)	0.65	0.83	0.59	0.77	0.71	0.89
Geothermal (Ormat)	0.69	0.71	0.69	0.56	0.67	0.54
Nuclear cross check	0.22	0.22	0.47	0.47	0.41	0.40
Hydrogen cross check	0.63	0.65	0.75	0.72	0.77	0.74

Source: CEPA analysis. Note: [1] 7C Solarparken in 5-year sample only. [2] Acciona in 2-year sample only.

Calibrating the qualitative-quantitative mapping

This section discusses how we have used the qualitative risk ratings (Section 3.2.4) and the quantitative beta evidence (above) to develop asset assumptions for each technology. While we consider that the approach described is a reasonable way to derive a set of asset beta assumptions across the technologies, in the sections below we discuss some key uncertainties and the potential impact of adopting alternative approaches.

The table overleaf summarises our proposed assumptions and maps these to the comparator sample distribution. We show a point estimate and a lower / upper range. The range is wider for the medium, medium-high and high technologies – reflecting that the evidence is more limited and uncertain.

Table 4.2: Proposed asset beta assumptions relative to the core sample observations

<table>
<tr><th rowspan="2">Percentile</th><th rowspan="2">5-year daily</th><th rowspan="2">5-year weekly</th><th colspan="5">Proposed assumptions</th></tr>
<tr><th>Low</th><th>Low-Med</th><th>Medium</th><th>Med-High</th><th>High</th></tr>
<tr><td>**Minimum**</td><td>0.29</td><td>0.33</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>**5th**</td><td>0.33</td><td>0.34</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>**10th**</td><td>0.46</td><td>0.50</td><td rowspan="3">0.50
(0.45-0.55)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>**20th**</td><td>0.51</td><td>0.53</td><td></td><td></td><td></td><td></td></tr>
<tr><td>**30th**</td><td>0.54</td><td>0.57</td><td rowspan="4">0.60
(0.55 – 0.65)</td><td></td><td></td><td></td></tr>
<tr><td>**40th**</td><td>0.58</td><td>0.60</td><td></td><td></td><td></td><td></td></tr>
<tr><td>**50th**</td><td>0.61</td><td>0.62</td><td></td><td></td><td></td><td></td></tr>
<tr><td>**60th**</td><td>0.64</td><td>0.70</td><td></td><td rowspan="4">0.75
(0.65-0.85)</td><td></td><td></td></tr>
<tr><td>**70th**</td><td>0.67</td><td>0.73</td><td></td><td></td><td></td><td></td></tr>
<tr><td>**80th**</td><td>0.71</td><td>0.75</td><td></td><td></td><td rowspan="3">0.90
(0.80-1.0)</td><td></td></tr>
<tr><td>**90th**</td><td>0.96</td><td>0.97</td><td></td><td></td><td rowspan="3">1.05
(0.95-1.15)</td></tr>
<tr><td>**95th**</td><td>1.00</td><td>1.01</td><td></td><td></td><td></td></tr>
<tr><td>**Maximum**</td><td>1.13</td><td>1.16</td><td></td><td></td><td></td><td></td></tr>
</table>

Source: CEPA analysis

The proposed assumptions have placed most weight on 5-year daily and weekly observations, with a view to striking a balance between more recent evidence (which may better capture expectations regarding the future evolution of the electricity generation sector) and a sufficiently long series of data (which may better smooth out 'noisy' fluctuations in the data). This choice also reflected that some comparators who focus on the technologies of interest do not have sufficient trading data for inclusion in the 10-year estimates.

To select the proposed assumptions, we:

- Constructed a 'first pass' set of assumptions, based on an intuitive alignment of the risk ratings across the spectrum of beta observations. Specifically, we positioned the asset beta for solar PV and onshore wind ("low risk" and "low-medium risk" respectively towards the lower end of the distribution. This reflects that these are the primary technologies represented, and that we would expect the comparator sample to reflect higher risk contracting arrangements compared to a 15-year CfD. We then increased the asset betas for higher risk ratings in a stepwise manner. Positioning the "high-risk" technologies at the very top end of the spectrum may appear extreme. However, we note than the emerging technologies included in that risk category are in many cases not represented at all in the comparator sample (e.g., tidal, wave).
- Cross checked this against the available – albeit limited – evidence. The cross checks included evidence from the technology-specific sub-samples described above (noting that they consist of few comparators) and reference points from other project work.

Cross checks

In Appendix D.1.1, we set out the cross-checks we have considered for these asset beta assumptions, highlighting some key uncertainties.

For some technologies, the cross-checks suggest values that are *lower* than the proposed asset beta estimates. However, as discussed in the appendix, we have not proposed to adjust the asset beta assumptions in response to this. This is because:

- As noted in the appendix, some of the cross-check evidence is itself not strong. For example, there are cases where we have one comparator that primarily invests in a particular technology – which does not in and of itself provide strong evidence that the assumption is right or wrong. While for transparency we have aimed to present all potential cross-checks that we identified, the strength of the cross-check has affected how much weight we have placed on it.
- As discussed in Sections 1.2 and 3.1.2, in this report we are aiming to estimate hurdle rates – rather than a 'pure' CAPM-based WACC. Therefore, although under the CAPM framework the asset beta is intended to only capture systematic risk, the way we have constructed the asset beta estimates (i.e., how we have positioned the risk levels against the comparator sample) reflects both systematic risk and non-CAPM risks.[92] However, in some cases the cross-checks may be more representative of a pure CAPM asset beta assumption.

In light of these factors, we have applied a high bar for making changes to the proposed asset beta assumptions – and in fact have not made any changes based on the cross-check evidence. However, we have considered the directional impact implied by asset beta cross-checks together with the investor survey results, and other evidence, in Section 4.6 where we discuss the overall hurdle rate estimates.

Interpreting the evidence

While we consider that the way we have proposed to use the comparator evidence is a reasonable approach, it is important to highlight some challenges and alternative methodological choices. As we discuss in more detail in Appendix D.1.1:

- **Firstly**, there are multiple differences between the comparator sample firms and the types of projects we are seeking to determine hurdle rate assumptions for. These include differences in relation to: the proportion of revenues that are under a long-term contract; the technology type; the combination of assets that are in the development, construction and operation phases; and differences related to electricity market and/or regulatory arrangements for those comparators with assets outside of the UK. On balance, while it is important to be aware of these factors, we do not think that there is practical way to control for their impact.
- **Secondly**, we have proposed to place most weight on 5-year daily and weekly observations. In other contexts, CEPA emphasises the importance of "looking through" short-term or "noisy" fluctuations in observed betas. In this case we have made a judgement that 5-year evidence may best capture risk expectations, in a context where technology, market, regulatory and policy settings are evolving rapidly. However, placing more weight on either the 2-year or 10-year evidence would have produced lower estimates. There are also alternative specifications of betas that could be considered (e.g., 4-weekly).
- **Thirdly**, we have made choices regarding how the risk levels are mapped across the distribution of observed betas, that have implications for the resulting assumptions. If in future the asset beta estimates are refreshed, it is possible that the shape of the distribution could change, and that this would alter the assumptions for each risk level.
- **Finally**, the asset beta assumptions assigned to each technology reflect the outcome of the qualitative risk assessment. Section 3.1.4 highlighted that this reflects the assumed impact of the revenue models that apply to each technology. These include some UK Government support mechanisms that have not yet

[92] The proposed asset beta for large-scale nuclear generation provides one example of this. Specifically, the risk rating discussion in Section 3.2.1 takes into account construction risk (and some assumptions around how the nuclear RAB regime might mitigate this). While construction risk may have a systematic component, other elements may be more idiosyncratic – i.e., specific to the nuclear project and diversifiable.

been fully developed or widely applied. Over time, experience with these models may indicate that a different assumption would be more appropriate.

While we consider that the methodology we have proposed is a reasonable use and interpretation of the evidence, the factors outlined above indicate that the results are of course sensitive to the approach. This highlights the importance of considering relevant cross-checks to the *overall hurdle rate* estimates, as are set out in Section 4.6.

4.3.2. Credit rating

As outlined in Section 4.4.5, we propose to adopt a common gearing assumption for all technologies.[93] This means that the credit rating assumption is used to reflect technology-specific differences in risk in the cost of debt estimate. Conceptually, we are attempting to establish a reasonable credit rating for each technology, at the assumed level of gearing.

We have reviewed different sources of evidence to establish a spectrum of credit ratings that could potentially apply to the technologies of interest:

- Beta comparator sample evidence – however, only some of the listed comparators have a credit rating.
- A distribution of credit ratings from a much wider range of rated UK and European electricity generators and utilities issuing active bonds. While this includes firms that are less relevant for our purpose, as we outline below the broad distribution provides a helpful point of reference.
- Targeted investigation of non-listed firms, not included in the beta comparator sample, that reflect the technologies of interest. This was based on a review of ratings issued by S&P and Moody's.

This evidence is presented in Appendix D.1.2. In summary, it indicates that:

- In the electricity sector broadly, ratings are concentrated in the BBB- to BBB+ band, although the latter includes a number of companies that undertake regulated network activities, to varying extents. At the lower end of the range, the observed frequency of ratings tails off below BB.
- There is a spread of ratings for entities that are focused on the same technology. This not surprising, as in practice credit ratings for individual projects will depend on a wide variety of factors, that are not all related to technology.
- For the rated comparators in the core sample, we can observe that higher gearing levels are associated with weaker credit ratings. Further, a gearing level of ~50% (in line with our suggested base case assumption – see Section 4.4.5) is broadly consistent with a credit rating in the BB to BBB- range.
- An examination of Moody's credit rating methodology suggests it is reasonable to assume that the technologies of interest would fall within the broad Baa-Ba (BBB-BB) bands.

Based on the evidence we have reviewed, we propose the credit rating assumptions set out in the table overleaf for each risk category. **Here, the "low" and "high" labels refer to the impact of the assumption on the hurdle rate. For example, because a stronger credit rating produces a lower cost of debt, the "low" assumption for solar PV is BBB+, compared to BBB- for the "high" assumption.**

[93] Although as noted in Section 4.4.5, we consider several gearing scenarios.

Table 4.3: Proposed credit rating assumptions

Risk rating	Credit rating assumption		
	Low	**Mid**	**High**
L	BBB+	BBB	BBB-
L-M	BBB	BBB-	BB+
M	BBB-	BB+	BB
M-H	BB+	BB	BB-
H	BB	BB-	B+

Source: CEPA analysis. ***Note: Here, the "low" and "high" labels refer to the impact of the assumption on the hurdle rate. For example, because a stronger credit rating produces a lower cost of debt, the "low" assumption for solar PV is BBB+, compared to BBB- for the "high" assumption.***

These assumptions are applied to each technology based on the qualitative risk assessment set out in Section 3.1.4. Our discussion of the risk assessment emphasised that there is uncertainty around how government support mechanisms for some technologies will be applied in practice. For any given project, the level of business model support may impact both the credit rating and cost of debt that is achievable.

4.3.3. Cost of debt

To translate the credit ratings to a nominal cost of debt, we consider evidence of corporate bond yields at the relevant rating, sourced from Markit iBoxx. The estimates presented below are a 1-month trailing average (i.e., an average over the month preceding 31 December 2024), consistent with the approach to the risk-free rate.

We have based our cost of debt assumptions on the iBoxx index for corporate bonds with a 10+ year term to maturity, as this provides information across the broad BBB, BB and B bands (which we require for the credit rating assumptions noted above). **We consider that this is broadly consistent with an assumed 15-year investment horizon** (see Section 4.4.1 below). However, in some cases this index may include very long-term bonds and there may be a slight overestimate (e.g., for A rated debt the average maturity may be more consistent with 20+ years).[94]

Table 4.4: Markit iBoxx - 1-month trailing average of nominal corporate bond yields (31 December 2024)

Series / rating band	A	BBB	BB	B
10+ years	5.68%	6.11%	7.48%	8.63%

Source: CEPA analysis of Markit iBoxx data. Notes: 'n/a' means no index is provided for the rating band.

The iBoxx indices reflect broad rating bands (i.e. BBB, BB) rather than the specific credit ratings we have assumed for each technology. We have converted the data from the indices to the assumed credit rating using a simple weighted average approach. For example, our assumption for BBB- is calculated by placing 2/3 weight on the BBB index and 1/3 weight on the BB index, BB+ is calculated as 1/3 weight on the BBB index and 2/3 weight on the BB index, and so forth. The resulting nominal cost of debt assumption for each credit rating is shown in the table below. These have been translated to real terms using the inflation assumptions stated in Section 4.4.4 for inclusion in the overall hurdle rate estimate.

[94] Appendix D.1.3 comments on other indices that could have been considered.

Table 4.5: Nominal cost of debt assumptions by credit rating (15-year tenor)

Credit rating	BBB+	BBB	BBB-	BB+	BB	BB-	B+
Nominal	5.97%	6.11%	6.57%	7.03%	7.48%	7.87%	8.25%
Real CPI	3.94%	4.09%	4.53%	4.98%	5.43%	5.80%	6.18%
Real GDP deflator	3.76%	3.90%	4.35%	4.80%	5.24%	5.62%	5.99%

Source: CEPA analysis of Markit iBoxx data

4.4. Technology neutral parameters

This section discusses the technology neutral parameters, that we assume do not vary across the different technologies.

4.4.1. Term of the cost of capital

The term of the cost of capital refers to the time horizon over which returns are estimated. For example, the choice of horizon impacts the estimation of the risk-free rate (i.e., through the chosen tenor of government bonds used as a proxy for the risk-free rate), the cost of debt (i.e., through the chosen tenor of corporate bonds used to determine the debt premium), and inflation (i.e., whether inflation expectations are estimated over a 5-year, 10-year or other horizon). We have applied a common term of 15-years for estimating hurdle rates, across all technology types.

A term of 15 years aligns with the duration of the revenue models available to many of technologies, which may also mean that it is a relevant point of reference for investors when considering hurdle rates for projects under these models. However, it is possible that the revenue models with longer durations – in particular the cap and floor and nuclear RAB regimes – could potentially imply a longer term.

Appendix D.2.1 provides more discussion on this assumption.

4.4.2. Risk-free rate

Within the CAPM, the risk-free rate represents the required return on a riskless asset. Although this is a theoretical construct, a common approach is to use rates on government-issued debt as a proxy.[95]

To derive a real estimate of the risk-free rate, we have adopted a one-month trailing average of UK indexed-linked gilt (ILG) yields. This means averaging observations of ILG yields over the one-month period prior to the estimation date (31 December 2024). Appendix D.2.2 provides more discussion on this approach.

ILGs are referenced to the Retail Price Index (RPI) and therefore produce a 'real RPI' risk-free rate estimate. As we require hurdle rates that are expressed in nominal, real CPI and real GDP deflator terms, we have therefore converted the ILG yields to this basis using the inflation assumptions set out in Section 4.4.4.

Consistent with the 15-year term of the cost of capital we have taken an average of the 10-year and 20-year estimates, which are shown in the table below. This is consistent with the proposed return on debt estimates in Section 4.3.3.[96]

[95] UKRN (2023), p.12.

[96] We have based our cost of debt assumptions on the iBoxx index for corporate bonds with a 10+ year term to maturity, which we consider to be broadly consistent with an assumed 15-year investment horizon.

Table 4.6: Risk-free rate estimates (31 December 2024)

Term	10-year	20-year	Average (15-year)
Real RPI	0.93%	1.65%	1.29%
Nominal	3.30%	3.86%	3.58%
Real CPI	1.35%	1.86%	1.61%
Real GDP deflator	1.22%	1.65%	1.44%

Note: the RPI, CPI and GDP deflator estimates are discussed below.

4.4.3. Total market return and equity risk premium

The Total Market Return (TMR) reflects the return expected by an investor holding a diversified portfolio (i.e., matching the composition of the overall market). The TMR can be thought of as the risk-free rate plus an equity risk premium (ERP), where the ERP reflects the additional compensation that investors require to invest in the market compared to a risk-free asset.[97]

As outlined in Appendix D.2.3, there are a range of methodologies that can be used to estimate these parameters, in terms of both the overall approach and detailed estimation choices.

We suggest that estimating this parameter directly is not the best approach for DESNZ to adopt in this context. Doing so would require DESNZ, in future updates, to refresh a large number of TMR estimates and exercise judgement in interpreting these. We suggest that a more practical (but still reasonable) approach is to derive real TMR estimates from UK regulatory precedent, which is relatively tightly grouped on estimates of the real TMR. DESNZ would be able to replicate this approach in future by referring to new relevant precedent.

At this point in time, Ofwat's PR24 final determination provides a suitable benchmark.[98] For PR24, Ofwat considered both 'ex-post' and 'ex-ante' estimates of the TMR. Ex-post approaches assume that investors expect returns that are similar to those realised in the past. Ex-ante approaches attempt to adjust for features in the historic data that are considered unlikely to apply in future.[99]

Ofwat's upper and lower-bound estimates for TMR (on a real CPIH basis) are shown in the table below. Consistent with the final determination, we propose to adopt the mid-point. We consider that this is a suitable value to adopt, due to the recency of the decision. As outlined in Appendix D.2.3, this estimate is also consistent with Ofgem's sector specific methodology under the RIIO-3 price review process for energy networks proposes, and with other UK regulatory precedent as reported by UKRN.

Table 4.7: Real CPIH TMR estimates

Term	Lower	Upper	Mid-point
Estimates	6.68%	6.98%	6.83%

Source: Ofwat (2024), p. 37, Table 8.

The table below sets out the real CPI TMR and ERP assumptions that we propose. As outlined above, ERP is calculated as the (long-term historic average) TMR less the (spot) risk-free rate.

[97] The ERP is sometimes also referred to as the market risk premium (MRP).

[98] See Ofwat (2024), *PR24 final determinations: Aligning risk and return – allowed return appendix*, 19 December 2024, p.37. Available here: https://www.ofwat.gov.uk/publication/pr24-final-determinations-aligning-risk-and-return-allowed-return-appendix/. CEPA supported Ofwat in the PR24 process.

[99] Ofwat (2024, p.23-24 provides a summary of their approach to TMR.

Table 4.8: Real CPI TMR and ERP assumptions

	TMR	Risk-free rate (15 year)	ERP
Real CPI	6.83%	1.61%	5.22%

Source: Ofwat (2024), p. 37, Table 8.

4.4.4. Inflation

DESNZ requires real hurdle rate values that are consistent with the GDP deflator, rather than CPI, CPIH or RPI – reflecting Green Book guidance. DESNZ requires GDP deflator real estimates for a variety of other purposes, but at times may also need to use nominal estimates or CPI real estimates. Accordingly, the methodology needs to allow DESNZ to make these adjustments.

If, as proposed, we adopt a real TMR estimate directly from regulatory determinations, we do not require historic estimates of inflation to implement the CAPM-based hurdle rate methodology (see Appendix D.2.4 for discussion).

However, we do require forward looking-inflation expectations. As noted in Section 4.4.2, because we derive a real RPI risk-free rate from ILG yields, we need forecast values for RPI (to convert to a nominal risk-free rate) in addition to forecasts of CPI and GDP deflator.

Deriving a forward-looking estimate of expected inflation requires two decisions:

- **A decision on the relevant term / investment horizon.** We have considered a 15-year investment horizon (Section 4.4.1). This means we require forecast inflation for 15 years.
- **A way of estimating inflation expectations for that term.** Appendix D.2.4 explains that there are two broad options: forecasts and market expectations. For the reasons set out in the appendix, we consider that in the context of this methodology and DESNZ's requirements, the best approach is to adopt the Office of Budgetary Responsibility's (OBR) long-term forecasts for RPI, CPI and the GDP deflator.[100] This is because:
    - It provides a consistent long-term series of RPI, CPI and GDP deflator, which meets DESNZ's requirements for the hurdle rate estimates.
    - We understand that the use of OBR forecasts for inflation (and other economic measures) is consistent with DESNZ's general practice elsewhere.
    - It is a simple and practical approach, which will support efficient future updates.

The OBR's forecast average rates of inflation over 10-, 15- and 20-year periods are shown in the table below.

Table 4.9: Estimates of expected inflation

Term	10-year (FY24/25 to FY33/34)	15-year (FY24/25 to FY38/39)	20-year (FY24/25 to FY43/44)
Average RPI	2.34%	2.22%	2.17%
Average CPI	1.92%	1.95%	1.96%
Average GDP deflator	2.05%	2.13%	2.17%

Source: CEPA analysis of OBR data.

[100] OBR (2024), *Supplementary forecast information release: Long-term economic determinants – March 2024*. Available at: https://obr.uk/supplementary-forecast-information-release-long-term-economic-determinants-march-2024/.

4.4.5. Gearing

The weighting of the cost of debt and cost of equity components within the CAPM WACC formula is determined by gearing, the proportion of debt within the overall capital structure. Higher gearing means a higher proportion of debt finance in the capital structure.

To derive an appropriate gearing assumption, we have considered evidence from: the investor survey conducted for this project; the sample of comparator firms used to derive the asset beta; the previous studies conducted for DESNZ by NERA (2015) and Europe Economics (2018); relevant UK regulatory precedent; and surveys undertaken in other markets.

As explained in more detail in Appendix D.2.5, we have proposed to adopt a common gearing assumption of 50% for all technologies. This is because:

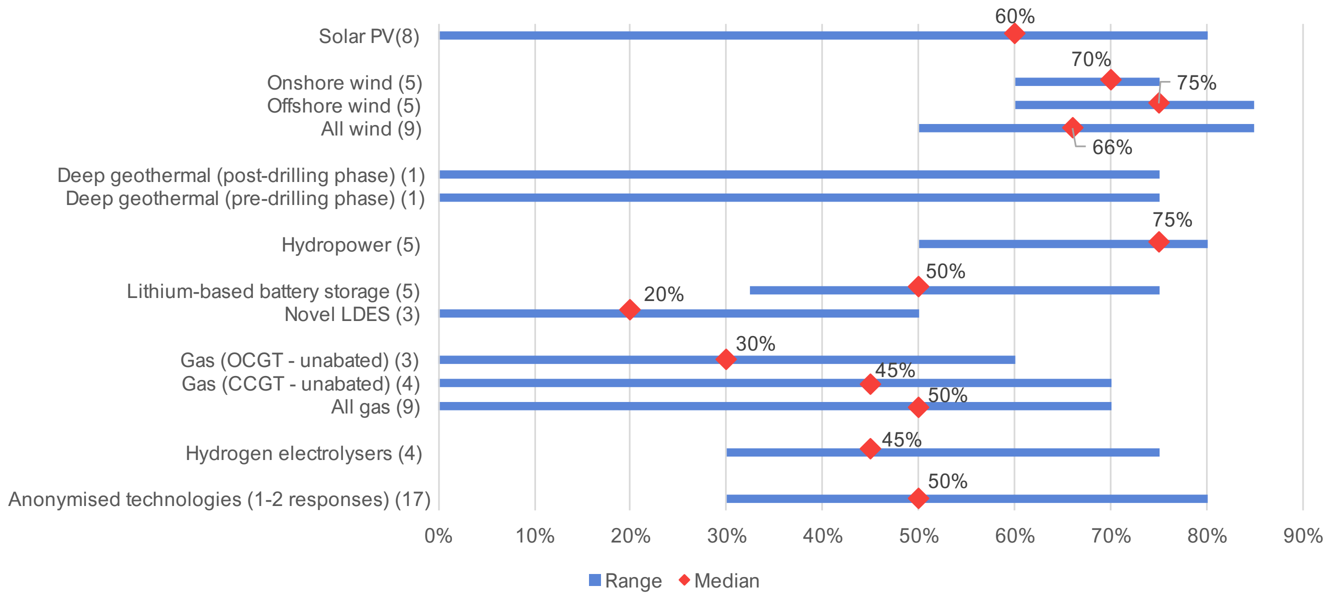
- The evidence does not clearly demonstrate that gearing is mainly a technology-specific issue. This reflects that individual projects of the same technology can have widely varying debt service capacities, for example due factors such as the quality of the renewable resource and specific features of the contracting and implementation arrangements that underpin the project.
- There is a degree of arbitrariness in making technology-specific assumptions, due to the lack of clear and robust evidence on which to base these.
- A common gearing assumption supports a transparent link between the qualitative risk assessment and the resulting hurdle rates (via technology-specific asset beta and credit rating assumptions). This allows technologies to be compared on a common basis – reflecting that a cost of equity estimated on the basis of 80% gearing is not the same as a cost of equity estimated under a 50% gearing assumption.
- There is a potential concern that other hurdle rate parameters (for example, the return on debt) might not be consistent with a higher gearing assumption. For example, as noted in Section 4.3.2, within the comparator sample, higher gearing levels are associated with weaker credit ratings.

On the other hand, this is not the approach that has been taken in past studies for DESNZ. Further, the investor survey (Figure 4.5 overleaf) indicates that there is some evidence of trends or clustering in a narrower gearing range for certain technologies (e.g., wind, for which reported gearing levels were higher). Accordingly, adopting a common, lower gearing assumption may not be aligned with stakeholder expectations. However:

- An assumption of 50% gearing is within -/+ 10% of the median reported gearing levels for a wide range of technologies, including solar PV, hydropower, gas (aggregated), lithium batteries, hydrogen electrolysers, geothermal and the anonymised technologies (in aggregate).
- While 50% is lower than the median survey result for the wind technologies (66%), the reported results do not suggest that a whole-of-life average gearing assumption of 50% is implausible. Indeed, some individual responses were consistent with this, even though they were not in the majority.
- While 50% is higher than the median survey result for some emerging technologies (e.g., 20% for novel LDES), the individual survey responses also suggested that 50% gearing was a plausible assumption for some projects (even though it was not the median response).
- Some of the higher reported gearing levels for wind projects may reflect the initial financing of a project, but not the capital structure that would apply in later years of merchant operation.

On balance, while recognising these issues, we consider a common gearing assumption of 50% is reasonable. Appendix D.2.5 provides further discussion of issues related to gearing, including sensitivities to four alternative gearing assumptions: 0%, 25%, 50% and 75%. Section 4.5 and Appendix F provide the hurdle rate estimates under these four gearing scenarios, should DESNZ wish to consider these in its future analysis.

Figure 4.5: Reported gearing range and median by technology (number of responses in brackets)



Notes: (1) No median is reported for geothermal, as only one response was provided. (2) "All wind" includes onshore wind, offshore wind, remote island wind and floating offshore wind. (3) "All gas" includes OCGT (unabated), CCGT (unabated), CCGT (with CCUS) and reciprocating gas engines (unabated). (4) "Anonymised technologies" includes tidal stream, wave, energy from waste, biomass (unabated / with CCUS), pumped hydro energy storage, hydrogen (CCHT and OCHT) and interconnectors. Gas and wind technologies that received only 1-2 responses have been included under "All gas" and "All wind" respectively.

4.4.6. Tax rate

We have adopted the corporate tax rate (25%) as a common assumption across the technologies.[101]

This departs from the approach taken in past studies for DESNZ by NERA (2015) and Europe Economics (2018). We appreciate that in practice, the effective tax rates that apply to each technology may differ. However, we consider that there is insufficient evidence as of 2024 to estimate technology-specific tax rates.

These issues are discussed further in Appendix D.2.6.

4.4.7. Transaction costs

We have separately applied an estimate of debt transaction costs to the cost of debt, adopting an assumption of 0.15% (applied as an uplift to the cost of debt). This is based on UK regulatory precedent.

More information is provided in Appendix D.2.7.

4.4.8. Debt beta

We have adopted a zero-debt beta for our analysis alongside the common gearing assumption.

Regulators have adopted different approaches to the debt beta. In the UK context, it is not uncommon for a positive debt beta to be applied.[102] This is consistent with financial economic theory, which would suggest that the debt beta should typically be positive for regulated businesses.[103]

[101] HM Revenue and Customs (2025), *Corporation Tax rates and allowances*. Available at: https://www.gov.uk/government/publications/rates-and-allowances-corporation-tax/rates-and-allowances-corporation-tax.

[102] See CEPA (2019), *Considerations for UK regulators setting the value of debt beta*, Report for the UK Regulators Network, 2 December 2019, p.19. Available at: https://ukrn.org.uk/app/uploads/2019/12/CEPAReport_UKRN_DebtBeta_Final.pdf.

[103] CEPA (2019), p.6.

However, we consider that in the context of this report for DESNZ, the simplicity of a zero-debt beta outweighs the potentially greater precision from using a positive one, given the margin for error that would apply. We expand on this in Appendix D.2.8.

Although on balance we consider this approach to be reasonable in the context, in Appendix D.2.5 we explain that a zero-debt beta assumption has some implications for the gearing sensitivities we consider.

4.5. CAPM-BASED ESTIMATES

The overall pre-tax real (CPI) return on debt, return on equity and overall hurdle rate for each risk level is set out in the tables below, including lower and upper bound estimates. The lower and upper bound estimates reflect the asset beta and credit rating ranges set out in Section 4.3. The estimates are provided for the four gearing scenarios discussed in Section 4.4.5 (i.e., the central case of 50% gearing, and sensitivities at 0%, 25% and 75% gearing).

Pre-tax real GDP deflator estimates, pre-tax nominal estimates, and post-tax nominal estimates – under all gearing, asset beta and credit rating assumptions – are included in Appendix F.

Table 4.10: Pre-tax real hurdle rates (CPI real) – 50% gearing

	Technology risk ranking				
	Low	Low-Medium	Medium	Medium-High	High
Return on debt					
Lower bound	4.09%	4.23%	4.68%	5.13%	5.58%
Mid-point	4.23%	4.68%	5.13%	5.58%	5.95%
Upper-bound	4.68%	5.13%	5.58%	5.95%	6.32%
Return on equity					
Lower bound	8.41%	9.80%	11.20%	13.29%	15.38%
Mid-point	9.11%	10.50%	12.59%	14.68%	16.77%
Upper-bound	9.80%	11.20%	13.98%	16.07%	18.16%
Hurdle rate (rounded)					
Lower bound	6.30%	7.00%	7.90%	9.20%	10.50%
Mid-point	6.70%	7.60%	8.90%	10.10%	11.40%
Upper-bound	7.20%	8.20%	9.80%	11.00%	12.20%

Source: CEPA analysis.

Table 4.11: Pre-tax real hurdle rates (CPI real) – 25% gearing

	Technology risk ranking				
	Low	Low-Medium	Medium	Medium-High	High
Return on debt					
Lower bound	4.09%	4.23%	4.68%	5.13%	5.58%
Mid-point	4.23%	4.68%	5.13%	5.58%	5.95%
Upper-bound	4.68%	5.13%	5.58%	5.95%	6.32%
Return on equity					
Lower bound	6.32%	7.25%	8.18%	9.57%	10.96%
Mid-point	6.78%	7.71%	9.11%	10.50%	11.89%
Upper-bound	7.25%	8.18%	10.04%	11.43%	12.82%
Hurdle rate (rounded)					
Lower bound	5.80%	6.50%	7.30%	8.50%	9.60%
Mid-point	6.10%	7.00%	8.10%	9.30%	10.40%
Upper-bound	6.60%	7.40%	8.90%	10.10%	11.20%

Source: CEPA analysis.

Table 4.12: Pre-tax real hurdle rates (CPI real) – 75% gearing

	Technology risk ranking				
	Low	Low-Medium	Medium	Medium-High	High
Return on debt					
Lower bound	4.09%	4.23%	4.68%	5.13%	5.58%
Mid-point	4.23%	4.68%	5.13%	5.58%	5.95%
Upper-bound	4.68%	5.13%	5.58%	5.95%	6.32%
Return on equity					
Lower bound	14.68%	17.47%	20.25%	24.43%	28.61%
Mid-point	16.07%	18.86%	23.04%	27.22%	31.40%
Upper-bound	17.47%	20.25%	25.83%	30.01%	34.19%
Hurdle rate (rounded)					
Lower bound	6.70%	7.50%	8.60%	10.00%	11.30%
Mid-point	7.20%	8.20%	9.60%	11.00%	12.30%
Upper-bound	7.90%	8.90%	10.60%	12.00%	13.30%

Source: CEPA analysis.

Table 4.13: Pre-tax real hurdle rates (CPI real) – 0% gearing

	Technology risk ranking				
	Low	Low-Medium	Medium	Medium-High	High
Return on debt					
Lower bound	4.09%	4.23%	4.68%	5.13%	5.58%
Mid-point	4.23%	4.68%	5.13%	5.58%	5.95%
Upper-bound	4.68%	5.13%	5.58%	5.95%	6.32%
Return on equity					
Lower bound	5.28%	5.97%	6.67%	7.71%	8.76%
Mid-point	5.62%	6.32%	7.37%	8.41%	9.45%
Upper-bound	5.97%	6.67%	8.06%	9.11%	10.15%
Hurdle rate (rounded)					
Lower bound	5.30%	6.00%	6.70%	7.70%	8.80%
Mid-point	5.60%	6.30%	7.40%	8.40%	9.50%
Upper-bound	6.00%	6.70%	8.10%	9.10%	10.20%

Source: CEPA analysis.

The table overleaf presents a breakdown of the pre-tax real CPI estimate for each of the technologies (under the 50% gearing assumption), showing how each of the parameter estimates discussed in the preceding sections contributes to the overall hurdle rate estimate. For illustration, the table sets out the hurdle rate calculation under the 50% gearing assumption and mid-point asset beta / credit rating assumptions only.

Table 4.14: Pre-tax real (CPI) hurdle rate - 50% gearing - Mid-point estimate

		Risk ranking				
		Low	Low-Medium	Medium	Medium-High	High
Parameters						
Gearing	*Mid*	50%	50%	50%	50%	50%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Tax rate		25%	25%	25%	25%	25%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Credit rating	*Mid-point*	BBB	BBB-	BB+	BB	BB-
Return on debt (pre-transaction costs)	*Nominal*	6.11%	6.57%	7.03%	7.48%	7.87%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Return on debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Market risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta	*Mid-point*	0.50	0.60	0.75	0.90	1.05
Equity beta		1.00	1.20	1.50	1.80	2.10
Hurdle rate estimate						
Pre-tax real cost of debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Pre-tax real cost of equity	*Real CPI*	9.11%	10.50%	12.59%	14.68%	16.77%
Pre-tax real hurdle rate	*Real CPI*	6.67%	7.59%	8.86%	10.13%	11.36%
Rounded	***Real CPI***	**6.70%**	**7.60%**	**8.90%**	**10.10%**	**11.40%**

4.6. Differences between high risk technologies

As noted in Section 3.2.5, although FLOW, tidal stream, tidal range, wave and new compound batteries all sit within the high risk category, there is a question as to whether tidal range and new compound batteries should potentially have a higher hurdle rate than the other technologies. This is because FLOW, tidal stream and wave are only positioned in the high risk category due to the FOAK adjustment. Without this adjustment, these technologies would sit in the medium-high risk category – reflecting the impact of the CfD regime on price risk. While the FOAK adjustment also applied to tidal range and new compound batteries, it had no impact on the rating because these technologies were already positioned as high risk – as they are assumed to have a revenue model that does not substantially insulate them from price risk. This indicates that it may not be reasonable to apply the same hurdle rate assumption for all technologies in this group.

Given this, we propose to apply an additional uplift of 1.5% to the assumed hurdle rate for tidal range and new compound batteries. The uplift reflects the merchant adjustment described in Section 5.3.3. Applying this adjustment aims to maintain a consistent difference between the technologies.

4.7. Initial hurdle rate estimates

Table 4.14 overleaf sets out initial risk ratings and hurdle rate estimates for each technology, before consideration of cross-checks. Section 5 then compares these estimates against other available sources of evidence.

Table 4.15: Initial risk ratings & whole-life hurdle rates (pre-tax real CPI, base revenue model) – 31 December 2024

Technology	Revenue model	Initial risk rating	Lead scenario (mid-point, 50% gearing)
Solar PV	CfD	L	6.70%
Onshore wind		L-M	7.60%
Offshore wind		M	8.90%
Remote island wind		M	8.90%
Floating offshore wind		H	11.40%
Hydropower		M	8.90%
Advanced conversion technologies (ACT)		M-H	10.10%
Anaerobic digestion (AD)		L-M	7.60%
Sewage gas		L-M	7.60%
Landfill gas		L-M	7.60%
Energy from waste		M	8.90%
Biomass – unabated		M	8.90%
Deep geothermal		M-H	10.10%
Wave		H	11.40%
Tidal stream		H	11.40%
Tidal range[1]	None (merchant)	H	12.90%
Biomass – with CCUS – mature[1]	BECCs BM	M	8.90%
Biomass – with CCUS – maturing[2]		M-H	10.10%
Large-scale nuclear	Nuclear RAB	L-M	7.60%
Small modular reactors (SMRs)		M	8.90%
Advanced modular reactors (AMRs)		M	8.90%
Pumped hydro energy storage (PHES)	LDES cap & floor	L-M	7.60%
Novel long duration energy storage (LDES)		M-H	10.10%
Lithium batteries	CM contract	M	8.90%
New compound batteries[2]		H	12.90%
Demand response aggregators		M	8.90%
Gas generation – unabated		M	8.90%
Gas generation – with CCUS – mature[1]	Power CCUS BM	M	8.90%
Gas generation – with CCUS – maturing [1]		M-H	10.10%
Hydrogen CCHT / OCHT – mature[3]	H2P BM	M	8.90%
Hydrogen CCHT / OCHT – emerging[3]		M-H	10.10%
Hydrogen electrolyser	HPBM	M-H	10.10%
Interconnectors	Cap & floor	L-M	7.60%

Source: CEPA analysis. Notes: (1) Refer to Section 3.2.4 for more information on the 'mature' and 'maturing' categories for the CCUS technologies. (2) Reflects an additional 1.50% uplift to capture differences between tidal range / new compound batteries and the other high risk technologies. Refer to Section 4.6 for discussion. (3) Given the uncertainties around this nascent but rapidly developing technology and the revenue model, we have included a wide indicative range that will be refined at a future date. Refer to Section 3.2.5 for discussion.

5. CROSS CHECKS

This section cross-checks the CAPM-based estimates presented in Section 4.7. We consider evidence from the investor survey, in addition to other published sources of evidence where available. Appendix E provides a summary of the other reports and surveys we have considered and is referenced throughout this section.

5.1. INTERPRETING THE CROSS CHECKS

This section sets out a more detailed discussion of the proposed assumptions for each technology and how the these compare to the investor survey results and other available sources of evidence.

The discussion notes where the context of the survey results may be different from our assumptions (e.g., if the survey response provided returns for a project in the development phase, rather than whole-of-life returns, or if the survey response assumed a different revenue model). In particular:

- Our estimates aim to reflect a blended 'whole life' hurdle rate. Accordingly, when interpreting the survey responses we have considered what project phase the returns relate to.
- Even projects of the same technology can have very different hurdle rates in practice, depending on their specific characteristics. We are aiming to capture required returns for a 'typical' project, rather than a project at the very high or very low end of the risk spectrum for a given technology. This means that the upper / lower bounds of the ranges we present are not intended to reflect extreme cases. This is important for how we interpret the survey evidence. For example, if only a single response is provided for a given technology, and that is above our mid-point estimate (or even outside the upper / lower bounds), that does not automatically invalidate the estimate, because the response may not relate to a 'typical' project.
- We have used the technologies with "better" survey information (solar PV, onshore wind) to anchor the less well covered technologies. For example, when considering hurdle rates for the technologies with few responses, we have considered evidence for better represented technologies that are judged to have a similar risk level.

Overall, we have been somewhat cautious in placing significant weight on the survey results because – particularly for some technologies – the sample is not large. There are also challenges in interpreting the survey results, as they may not always reflect the same assumptions as our estimates. For example, the survey requested that respondents provide a *levered* return on equity and hurdle rate – i.e., that reflected the level of gearing that the respondent considered typical for that technology. However, follow-up interviews with survey respondents indicated that in some cases the values provided may not in practice match the reported gearing assumptions.[104]

In reporting the investor survey results, we have been careful to maintain the anonymity / confidentiality of the results in line with the preferences of respondents. This means that the full survey results are not reported, although we have taken all the available survey evidence into account when forming our recommendations.

As discussed below, in response to the cross checks we have adjusted the risk rating set out in Section 3 for solar PV and pumped hydro energy storage (PHES). This has increased the overall hurdle rate that applies to these technologies, to make it more consistent with the cross-check evidence.

5.1.1. Solar PV

The table below sets out our **initial** hurdle rate ranges for solar PV – that is, the estimates we derive before comparison with the investor survey results. The "lower" end of the range captures the lower-bound asset beta and credit rating assumptions, combined with the 25% gearing assumption. The mid-point of the range captures the mid-point asset beta and credit rating assumptions, combined with the 50% gearing assumption. The "upper" end

[104] Where possible, given the information provided by respondents, we have corrected for this in our interpretation of the reported results.

of the range captures the upper-bound asset beta and credit rating assumptions, combined with the 75% gearing assumption.

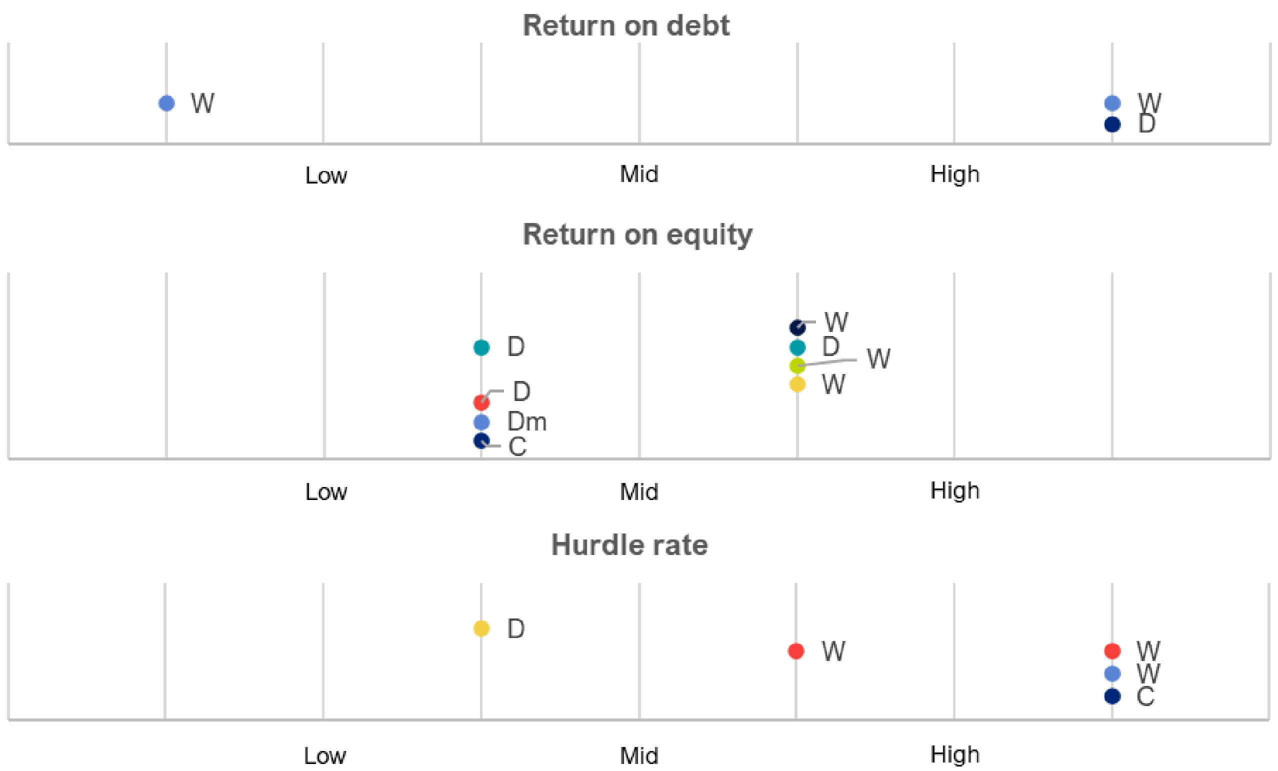
*Table 5.1: Solar PV – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Low	4.1%	**4.2%**	4.7%	6.3%	**9.1%**	17.5%	5.8%	**6.7%**	7.9%

Investor survey – quantitative evidence

The figure below shows where the quantitative survey results sit relative to our initial lower/mid/upper estimates (i.e., results before consideration of the survey responses).[105] The letters indicate the project life cycle stage the response related to – which in many cases was different to the 'whole life' returns that we are attempting to estimate.

Figure 5.1: Solar PV – Quantitative survey responses compared to CEPA initial low-mid-high estimates



Notes: D= Development phase, C = Construction phase, O = Operations phase, W = Whole life. (m) indicates an assumed merchant revenue model. Colours indicate individual responses; where a colour is shown twice this indicates the response provided a range.

Most quantitative survey responses sit above our mid-point estimate for the overall hurdle rate, while responses for the return on debt and return on equity are distributed more evenly above and below the mid-point. However, the responses that sit above the mid-point exceed it by a larger margin than those below. This means that the average survey response sits ~0.5% above the mid-point estimate for the return on debt, ~1% above the mid-point return on equity, and ~1.5% above the mid-point hurdle rate. The median survey response sits ~0.5% and ~1.5% above the mid-point return on debt and hurdle rate respectively, while the median return on equity response is slightly below the mid-point estimate.

The results for the return on equity are dominated by responses for projects in the development and construction phases, which we would expect to be higher than a whole life estimate. On the other hand, the three whole life

[105] Where possible give the information provided, for these comparisons we have aimed to align our assumptions on the return on equity and overall hurdle rate with the respondent's reported gearing level.

estimates all sit above the mid-point (while counter-intuitively, some responses for pre-construction projects are lower).

It is important to bear in mind that the survey responses represent a relatively small sample, particularly for the return on debt and overall hurdle rate. However, the sample is larger for the return on equity and overall hurdle rate, and the reported differentials are quite material. Overall, this indicates that a low-medium hurdle rate assumption – as for onshore wind – may be more consistent with the survey evidence.

The survey respondents that provided quantitative values for both onshore wind and solar PV were equally divided between those who provided the same estimated returns and those who considered that the overall hurdle rate for onshore wind should be higher (+0.5% to +1.0%).

Investor survey – qualitative evidence

The qualitative survey responses also provide a mixed picture on where solar PV should sit relative to other technologies:

- The median survey ranking for solar PV was "low-medium" risk. However, this included some responses that were only active in solar PV and not in any other technologies. In comparison, responses for onshore wind fell between the "low-medium" and "medium" categories.
- Of the respondents who were active in multiple technologies, most ranked solar PV the lowest risk and a significant proportion ranked it equal lowest. For the responses that ranked both solar PV and onshore wind, five considered that solar PV faced lower risk, while three considered that solar PV was either the same or more risky.

Other evidence

As set out in Appendix E:

- A CEPA study conducted in 2023 for Australia concluded – primarily on the basis of survey evidence – that it was reasonable to assume the same hurdle rate for solar PV and onshore wind. A contemporaneous survey conducted by Oxford Economics (also for Australia) placed reported hurdle rates for solar PV slightly above those of onshore wind.
- A 2023 survey by IRENA reported an average WACC of 3.3% for solar PV (for the period 2019-2021) and 3.4% for onshore wind (2019-2021) – on a post-tax nominal basis.
- RWE's 2023 investor day presentation reported onshore wind and solar PV as sitting in the same hurdle rate range. RWE also provide post-tax nominal unlevered IRR targets of 6-10% for onshore wind, solar and battery projects (in Europe and the USA). This compares to our post-tax nominal hurdle rate (at 50% leverage) assumption of 7.6% for solar at the "low risk" level.
- FGEN's 2024 half-year report indicates a discount rate for valuing solar projects that is 1.1% below that of wind (albeit assuming gearing of 15% for solar against 35% for wind).
- The US National Renewable Energy Laboratory's (NREL) 2024 financial assumptions assume a slightly higher post-tax cost of equity for onshore wind compared to solar PV (+0.5%), but the same cost of debt.
- A 2018 survey by Grant Thornton found that hurdle rates for onshore wind were 0.75% higher than for solar PV.

On balance, this evidence lends slightly more support to assuming the same hurdle rate for solar PV and onshore wind.

Conclusion

The quantitative survey results and the other evidence cited above point to increasing the risk rating (and hurdle rate) for solar PV to low-medium, to match that of onshore wind. This would still be consistent with the cross checks considered for asset beta in Section 4.3.1, which noted that the higher end of the "low risk" asset beta range could also be reasonable. Section 4.3.2 indicated that a higher credit rating would also be reasonable for solar PV. On the other hand, the qualitative survey responses gave more support to assigning a lower hurdle rate to solar PV compared to offshore wind. Further, the other evidence discussed above does not unanimously point to these technologies having the same hurdle rate.

Overall, we consider that the evidence narrowly supports moving solar PV to the same low-risk rating as offshore wind. However, this is finely balanced, and it is open to DESNZ to retain the low-risk rating and hurdle rate assumption for solar PV.

*Table 5.2: Solar PV – **Adjusted** risk rating and pre-tax real returns (lower-**mid**-upper)*

Risk rating	Return on debt			Return on equity			Hurdle rate		
Low-medium	4.2%	**4.7%**	5.1%	7.2%	**10.5%**	20.3%	6.5%	**7.6%**	8.9%

5.1.2. Onshore wind

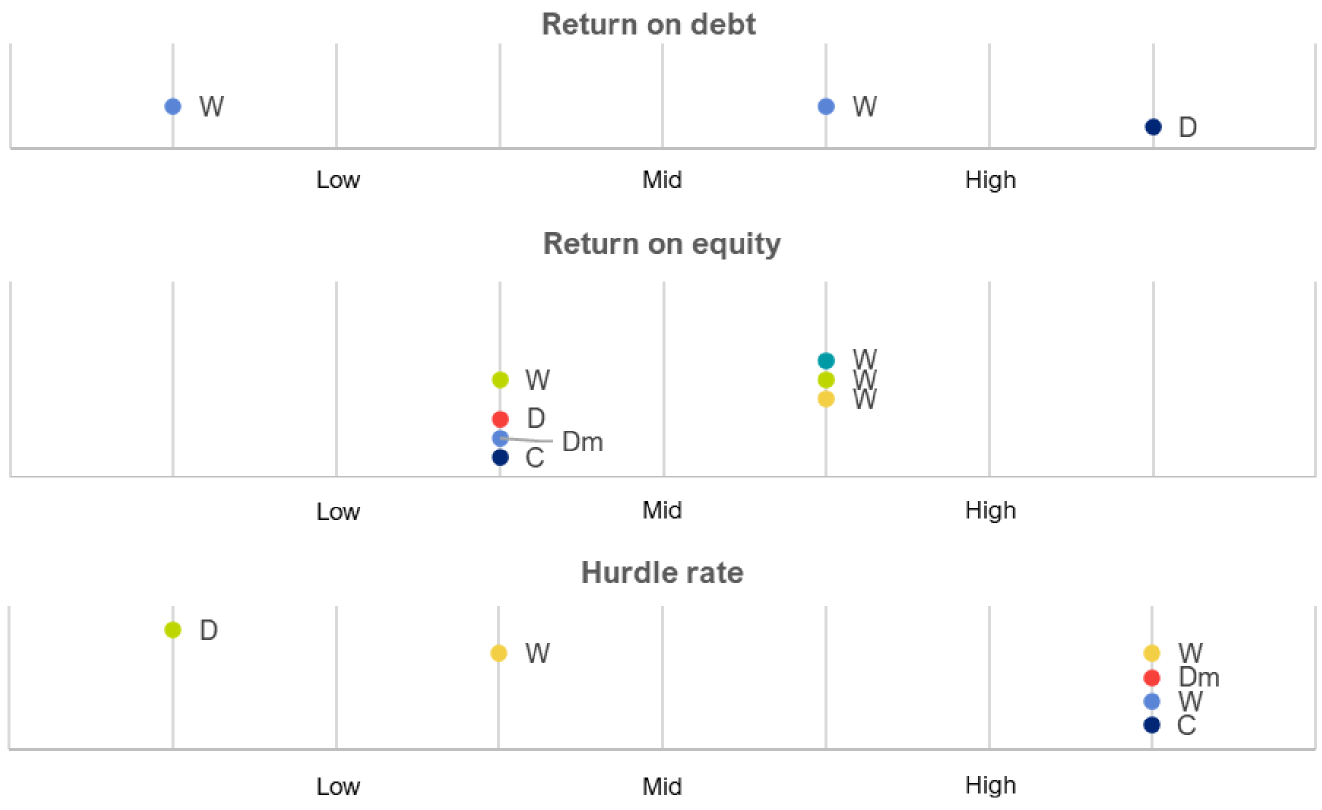
*Table 5.3: Onshore wind – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Low-medium	4.2%	**4.7%**	5.1%	7.2%	**10.5%**	20.3%	6.5%	**7.6%**	8.9%

Investor survey – quantitative evidence

The figure below compares our proposed estimates to the survey results.

Figure 5.2: Onshore wind - Quantitative survey responses compared to CEPA low-mid-high estimates



Notes: D= Development phase, C = Construction phase, O = Operations phase, W = Whole life. (m) indicates an assumed merchant revenue model. Colours indicate individual responses; where a colour is shown twice this indicates the response provided a range.

Our mid-point hurdle rate is towards the lower end of reported results, with reported returns on debt and equity distributed around the mid-point. The average survey response is consistent with the mid-point return on debt and equity, and ~1.5% above the mid-point hurdle rate. The median response is also consistent with the mid-point return on debt, ~0.5% lower than the mid-point return on equity, and ~1.5% above the mid-point hurdle rate. As for solar PV, many responses relate to the development and construction phase (although these are not always the highest values provided). One response assumed a merchant revenue model (excluding this result, the average survey response would be ~1% above our mid-point hurdle rate assumption).

Investor survey – qualitative evidence

The qualitative survey responses indicated that:

- The median survey ranking for onshore wind sat between the “low-medium” and “medium” categories.
- Of the responses that covered multiple technologies, most ranked onshore wind as lowest or second lowest risk. A minority considered onshore wind to be higher risk than unabated gas and hydropower respectively.

Other evidence

See Section 5.1.1 above for comparisons of onshore wind compared to solar PV.

In a 2023 investor presentation, RWE provide post-tax nominal unlevered IRR targets of 6-10% for onshore wind, solar and battery projects (in Europe and the USA). This compares to our post-tax nominal hurdle rate (at 50% leverage) assumption of 8.9% for onshore wind.

Conclusion

On balance, and considering the asset beta cross checks from Section 4.3.1, we consider it is reasonable to maintain the “low-medium” risk ranking for onshore wind and the hurdle rate assumptions set out in Table 5.3. However, DESNZ may wish to explore the sensitivity of its analysis to the upper bound estimate.

5.1.3. Remote island wind

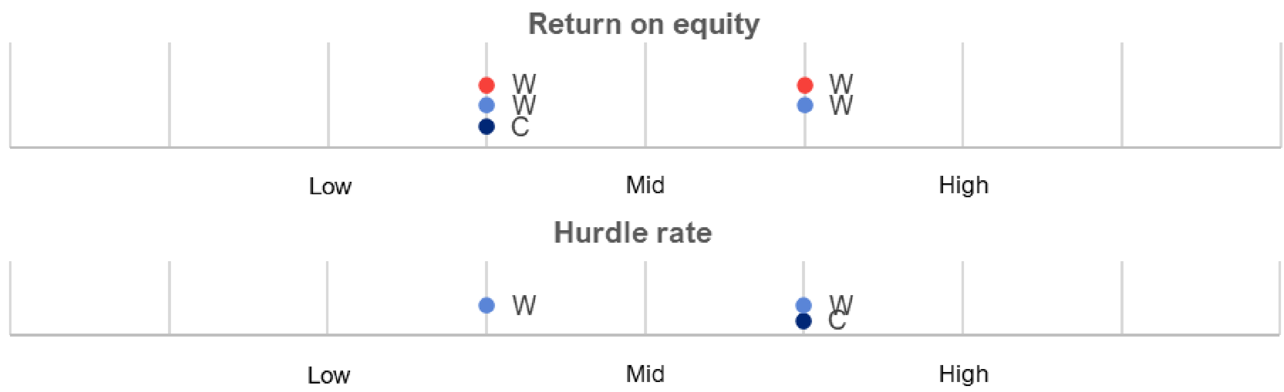
*Table 5.4: Remote island wind – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Medium	4.7%	**5.1%**	5.6%	8.2%	**12.6%**	25.8%	7.3%	**8.9%**	10.6%

Investor survey – quantitative evidence

The figure below compares our proposed estimates to the survey results.

Figure 5.3: RIW - Quantitative survey responses compared to CEPA low-mid-high estimates



Notes: D= Development phase, C = Construction phase, O = Operations phase, W = Whole life. Colours indicate individual responses; where a colour is shown twice this indicates the response provided a range.

Quantitative survey responses were less numerous for remote island wind than for onshore and offshore wind. No survey responses provided quantitative values for the return on debt. The mid-point assumption for both the return on equity and overall hurdle rate falls within the range of survey results. The average and median results are ~1% lower than the mid-point cost of equity, but ~0.5% above the overall hurdle rate.

However, the survey responses that provided quantitative estimates for both remote island wind and onshore wind (low-medium risk) thought that required returns should be the same for both technologies. In a follow-up interview, one respondent explained that this was due to offsetting factors: while remote island wind might face more risk in the construction phase due to more challenging conditions, in the operation phase it enjoyed more certainty in relation to the wind resource. This means that, in effect, the reported ranges for remote island wind are likely higher than offshore wind because they reflect fewer responses, not because survey respondents thought that this should be the outcome.

Investor survey – qualitative evidence

The qualitative survey results either assigned the same risk ranking to onshore wind and remote island wind, or placed remote island wind one risk level above onshore wind.

Conclusion

On balance, we consider it is reasonable to adopt a higher hurdle rate for remote island wind compared to onshore wind, given the risk assessment set out in Section 3. However, it is also open to DESNZ to adopt the same hurdle rate assumption (low-medium) for both technologies.

5.1.4. Offshore wind

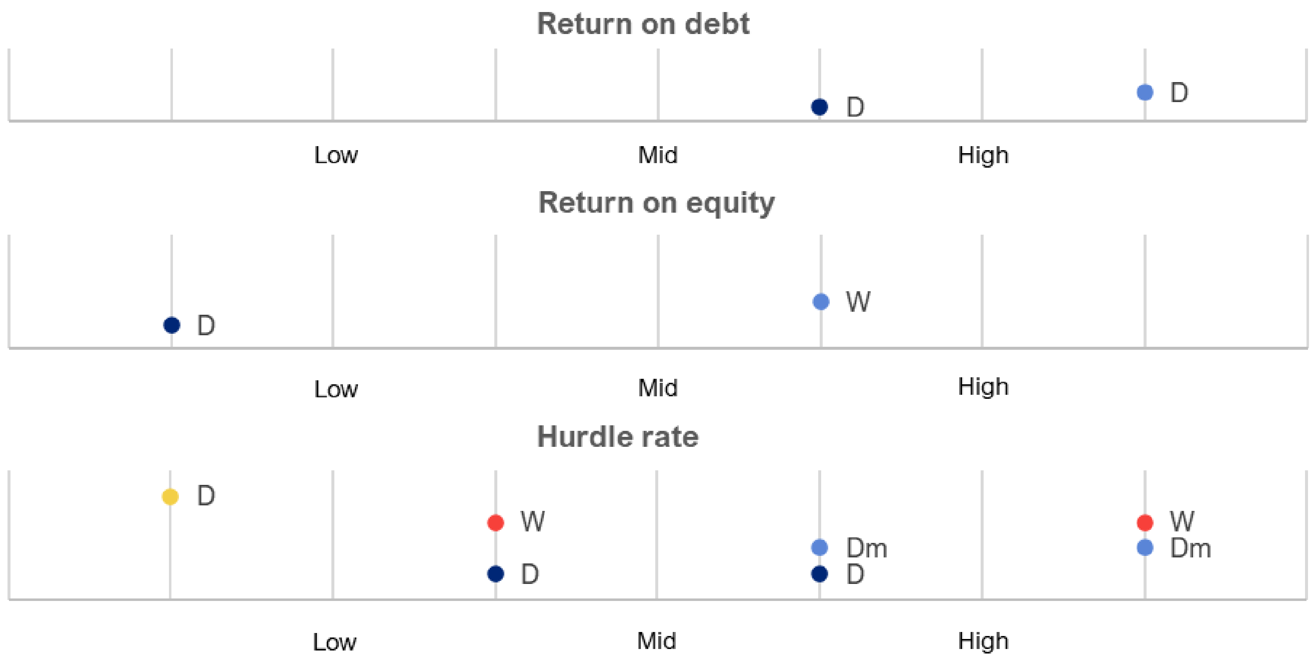
*Table 5.5: Offshore wind – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Medium	4.7%	**5.1%**	5.6%	8.2%	**12.6%**	25.8%	7.3%	**8.9%**	10.6%

Investor survey – quantitative evidence

The figure below compares our proposed estimates to the survey results.

Figure 5.4: Offshore wind - Quantitative survey responses compared to CEPA low-mid-high estimates



Notes: D= Development phase, C = Construction phase, O = Operations phase, W = Whole life. (m) indicates an assumed merchant revenue model. Colours indicate individual responses; where a colour is shown twice this indicates the response provided a range.

The survey results sit above the mid-point estimate for the return on debt, but are distributed around the mid-point for the return on equity and overall hurdle rate. Quantitatively, the average survey response sits ~1.0% above the mid-point estimate for the cost of debt, slightly below the mid-point return on equity, and ~0.5% above the overall hurdle rate. The median response is ~1.0% above the return on debt, and ~0.5% above the return on equity and overall hurdle rate. However, the hurdle rate and cost of debt responses related predominantly to projects in the development phase, which we would expect to be higher than a whole life return for the same project.

Of the quantitative responses that considered both offshore and onshore wind, respondents either considered that the same hurdle rate should apply, or that required returns for offshore wind should be 1-2% higher. This is consistent with the differential we have assumed between the low-medium and medium risk categories.

Investor survey – qualitative evidence

Of the qualitative responses that considered both offshore and onshore wind, most assigned the same risk rating to the two technologies, although some considered that offshore wind sat above onshore wind. Across all respondents that are active in offshore wind (8), the median risk rating was "medium".

Other evidence

As set out in Appendix E:

- A CEPA study conducted in 2023 for Australia concluded – primarily on the basis of survey evidence – that it was reasonable to assume a +1% difference between the pre-tax real hurdle rate for offshore wind compared to onshore wind.
- A 2023 survey by IRENA reported an average WACC of 3.4% for onshore wind and 4% for offshore wind (for 2019-2021) – on a post-tax nominal basis.
- The US National Renewable Energy Laboratory's (NREL) 2024 financial assumptions assume a higher post-tax cost of equity for offshore wind compared to onshore wind (+1.5%). The cost of debt during construction was assumed to be 0.5% higher, but the same in the operation phase.
- A 2018 survey by Grant Thornton found that hurdle rates for offshore wind were 0.75% higher than onshore wind.
- In relation to investor presentations:
    - In a 2024 investor presentation, Equinor reference nominal equity returns of 12-16% (full cycle, excluding farm downs[106]). In comparison, our mid-point nominal return on equity assumptions for a medium-risk project are 11.6% (post-tax) and 15.4% (pre-tax), at 50% gearing. As we do not know what leverage is assumed in Equinor's returns, nor whether these are pre- or post-tax, it is unclear how consistent our assumptions are with this evidence. However, Equinor's presentation also cites real post-tax project returns of 4-8%. This range encompasses our real CPI post-tax hurdle rate assumption of 7.3% for offshore wind.
    - In its 2023 investor presentation, RWE provide post-tax nominal unlevered IRR targets of 7-11% for offshore wind projects (global). This compares to our post-tax nominal hurdle rate (at 50% leverage) of 9.4%. RWE's presentation also reported a target return of for 6-10% for onshore wind. This is consistent with our proposed differential between offshore and onshore wind.
    - In a 2024 investor presentation, SSE refer to post-tax nominal equity returns of at least 11%. This is similar to our post-tax nominal return on equity assumptions for a medium-risk project of 11.6%, at 50% leverage. However, we do not know what leverage assumptions SSE's equity returns are based on.

Generally, this evidence is consistent with our assumed differential between offshore and onshore wind.

Conclusion

On balance, and noting the high representation of development phase projects in the survey results, we consider it is reasonable to maintain the "medium" risk rating and hurdle rate assumptions shown in Table 5.5 above. However, if DESNZ explores a sensitivity with to the upper bound estimate for onshore wind (see Section 5.1.2), it

[106] A 'farm down' refers to the developer selling a share in the project to other investors, to free up its own capital for future projects.

may wish to take the same approach for offshore wind, in order to maintain the relative difference between the two technologies.

5.1.5. Floating offshore wind

*Table 5.6: FLOW – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
High	5.6%	**5.9%**	6.3%	11.0%	**16.8%**	34.2%	9.6%	**11.4%**	13.3%

Investor survey – quantitative evidence

Quantitative survey responses were less numerous for FLOW than the onshore and offshore wind:

- No respondents provided quantitative estimates on required returns on debt.
- One response commented on required equity returns. The value provided was on a whole life basis, and fell around the mid-point estimate.
- Two responses commented on the overall hurdle rate (whole life and development). The responses both provided ranges around the mid-point estimate, with the average sitting ~0.5% above the mid-point estimate.

Investor survey – qualitative evidence

Four respondents commented on the qualitative risk ranking for FLOW, placing FLOW one risk category above offshore wind. In terms of other technologies, FLOW was ranked higher risk than gas (unabated / CCUS), H2P, pumped hydro and hydrogen electrolysers by some responses, but lower than gas (unabated / CCUS), H2P and hydrogen electrolysers by another.

Conclusion

On balance, we consider that it is reasonable to place FLOW in the “high risk” category, and that the mid-point hurdle rate estimate is broadly consistent with the (albeit limited) survey evidence.

5.1.6. Hydropower

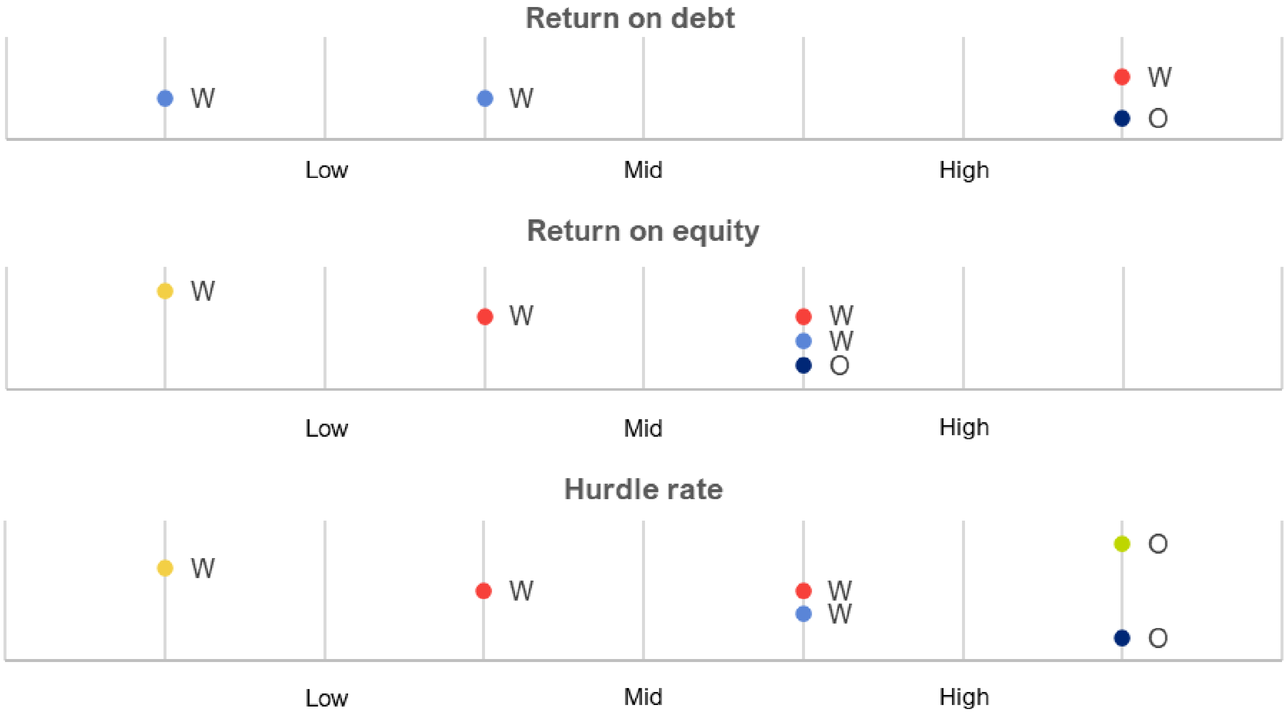
*Table 5.7: Hydropower – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Medium	4.7%	**5.1%**	5.6%	8.2%	**12.6%**	25.8%	7.3%	**8.9%**	10.6%

Investor survey – quantitative evidence

The figure below compares our proposed estimates to the survey results.

Figure 5.5: Hydropower - Quantitative survey responses compared to CEPA low-mid-high estimates



Notes: D= Development phase, C = Construction phase, O = Operations phase, W = Whole life. (m) indicates an assumed merchant revenue model. Colours indicate individual responses; where a colour is shown twice this indicates the response provided a range.

Our mid-point hurdle rate is towards the lower end of reported results. The average survey response is ~1% above the mid-point return on debt, <0.5% above the mid-point return on equity, and ~0.5% above the mid-point hurdle rate. The median response is <0.5% above the mid-point return on debt, ~1.5% above the mid-point return on equity, and ~1% above the mid-point hurdle rate. The survey results include only whole life and operational period estimates, suggesting that the difference to the "medium risk" mid-point estimate is not due to the project stage.

The proposed "medium" risk ranking assumes that the project has a CfD. As noted in Section 2.3, the current pipeline of hydro projects in the UK is not eligible for a CfD, as they are smaller than the 5-50MW size requirement. However, the survey instructed respondents to assume a CfD for all hydropower projects, and no responses indicated that a different assumption had been applied. Nonetheless, some respondents did indicate a view that smaller hydro projects may require higher returns than larger ones – for example, because smaller projects are considered to face greater difficulties in establishing a route to market.[107] Accordingly, it is possible that the reported results are more representative of smaller projects that are not currently eligible for a CfD.

Nonetheless, given current information the quantitative survey results appear to be more consistent with a "medium-high" risk rating.

Investor survey – qualitative evidence

On the other hand, the qualitative survey evidence supports the current "medium risk" assumption:

- The positioning relative to other technologies is consistent with the qualitative survey results, for which the median response reflected a "medium" risk rating.

[107] As explained in Appendix B, to earn the CfD strike price overall, a project needs to secure the reference price. If the project is not able to enter into a contract to secure the reference price, it may face more challenges in achieving the CfD strike price.

- Survey respondents that were active in multiple technologies consistently ranked hydropower above solar PV (4 responses), but it was not always considered higher risk than onshore wind. This too is consistent with placing hydropower in the medium risk category.
- The hydro asset beta sample, although small, was between the mid and upper medium risk asset beta assumption (see Section 4.3.1).

Other evidence

As set out in Appendix E:

- The US National Renewable Energy Laboratory's (NREL) 2024 financial assumptions assume a higher post-tax cost of equity for hydro compared to onshore wind (+0.75%). The cost of debt during construction was assumed to be 0.5% higher, but the same in the operation phase.
- A 2018 survey by Grant Thornton found that levered hurdle rates for hydro were 0.25% lower than for onshore wind and 0.5% higher than for solar PV.
- FGEN's 2024 half-year report indicates a discount rate for valuing hydropower projects that is 0.7% less than for wind (although unclear if offshore or onshore). We have given hydropower projects the same risk rating as offshore wind, which is one level above onshore wind.

Conclusion

On balance, we consider it is reasonable to retain hydropower in the medium risk category.

5.1.7. Deep geothermal

*Table 5.8: Deep geothermal – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Medium-high	5.1%	**5.6%**	5.9%	9.6%	**14.7%**	30.0%	8.5%	**10.1%**	12.0%

Investor survey – quantitative evidence

One survey respondent provided quantitative information on required returns for deep geothermal, across both the pre-drilling and post-drilling phases.[108] As anticipated (and consistent with the cross checks discussed below), returns required in the pre-drilling phase substantially exceed those in the post-drilling phase.

The medium-high ranking is intended to reflect a 'whole life' hurdle rate. Accordingly, we have considered a weighted average of the survey results, with the weighting based on the assumed relative durations of the pre- and post-drilling phases (7 and 25 years respectively).[109] This is shown in the table below. The respondent indicated that gearing would vary between 0% and 75% from pre-development through to end of operations, which we have represented as an average whole-of-life gearing level of ~40%.[110]

[108] The respondent provided consent to publish their survey response.

[109] GeoEnergy Marketing Services (2019), *Phases of a Geothermal Project Pt 1*, 11 March 2019. Available at: https://www.geoenergymarketing.com/energy-blog/phases-of-a-geothermal-project-pt-1/. Iceland GeoSurvey (ISOR) (undated), *Phases of geothermal development*. Available at: https://www.esmap.org/sites/default/files/esmap-files/Flovenz%20Day%201%20-WB-2-phases-final.pdf. Based on these sources, a five-year period is broadly consistent with completing test drilling (including of full-size wells), within a total construction period of ~7 years.

[110] The respondent also provided overall hurdle rate estimates. However, we have placed more weight on the individual return on debt and equity components for this comparison.

Table 5.9: Time-weighted survey responses (pre-tax real CPI)

	Return on debt	Return on equity	Years	Overall hurdle rate			
				40% gearing	**25% gearing**	**50% gearing**	**75% gearing**
Pre-drilling	7.4%	24.2%	5	17.6%	20.0%	15.8%	11.6%
Post-drilling	4.0%	13.8%	27	9.9%	11.3%	8.9%	6.4%
Weighted	4.5%	15.4%	32	11.1%	12.7%	10.0%	7.2%

Note: These values are converted to a pre-tax real basis.

This indicates that the mid-point hurdle rate assumption is similar to the weighted survey response at 50% gearing, although lower than the weighted survey response at the 40% 'whole of life average gearing' reported by the respondent. However, placing high weight on a single survey response is problematic. While other cross-checks for geothermal are relatively limited, we discuss the evidence that is available below.

Other evidence

In its 2015 report, NERA proposed a range of 11-14.9% (pre-tax real) for geothermal, largely based on survey evidence. This compared to, for example, 6.5-9.4% for solar: indicating a delta of 4.5-5.5%. In comparison, the delta between solar and geothermal in our estimates (pre-tax real) is 4% (or 3% if a low-medium risk rating is adopted). At that time, NERA noted that their survey did not include active geothermal developers, and they felt that the high risks of failure in the drilling phase had potentially not been captured.

DESNZ has also provided feedback from another survey it has conducted on geothermal development in the UK.[111] While hurdle rates have not been the focus on this work, the survey posed the following question: *"What is the minimum internal rate of return (hurdle rate) required to ensure the economic viability of a deep geothermal system?"* The answers provided indicate a range of expectations, although they were not entirely clear in terms of whether the value expressed is pre-/post-tax, real/nominal or levered/unlevered. Accordingly, other than the responses being consistent with a material difference in required hurdle rates pre- and post- drilling, they are difficult to interpret given the ambiguity around what they represent.

We have also considered the financial assumptions published by the US National Renewable Energy Laboratory (NREL)[112], which are used as an input to levelised cost of energy estimates. Further discussion of the NREL results is provided in Section E.2. In relation to geothermal specifically:

- There are differences between our estimates and NREL's assumptions in relation to the cost of debt, cost of equity, and gearing. As shown in the table overleaf, our post-tax nominal hurdle rate (a whole of life rate, at 50% gearing) for geothermal is 10.4%. NREL's assumptions produce a post-tax nominal hurdle rate of 15.0% in the pre-drilling construction phase, 7.8% in the post-drilling construction phase, and 7.9% in the operation phase – or 9.0% on a whole of life weighted basis. However, it is difficult to compare these numbers directly (due to possible differences in the underlying risk-free rate, inflation etc).
- The differences between geothermal and other technologies may be more informative. For example, NREL's assumptions point to a broadly similar 'whole life' hurdle rate for geothermal and offshore wind. We have placed the latter in the "medium" risk category.

[111] *UK Geothermal Energy Review and Cost Estimations*, available at: https://www.gov.uk/government/collections/energy-generation-cost-projections.

[112] NREL (2024), *Annual Technology Baseline*, available at: https://atb.nrel.gov/electricity/2024/financial_cases_&_methods.

Table 5.10: NREL (2024) – Cost of capital parameters (nominal)

Technology	Operation		Construction		Leverage	CEPA (50% gearing)	
	Post-tax cost of equity	Cost of debt (term debt)	Post-tax cost of equity	Cost of debt (construction debt)		Post-tax cost of equity	Cost of debt
Offshore wind	10.5%	7.0%	12.5%	7.0%	80%	11.6%	7.2%
Geothermal	10.5%	7.0%	Pre-drilling: 15% Post-drilling: 10%	7.0%	Pre-drilling: 0% Post-drilling: 75%	13.2%	7.6%

Source: NREL (2024).

Conclusion

On balance, the above suggests that the mid-point estimate at the "medium-high" risk level is reasonable. However, DESNZ may wish to consider sensitivities at the upper end of the range.

5.1.8. Biofuels

We discuss the survey results for the biofuel technologies together. This group includes ACT, AD, sewage gas, landfill gas, biomass and energy from waste. We separately consider the evidence for hurdle rate differences between biomass with and without CCUS.

*Table 5.11: Biofuels – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Low-medium (AD, sewage gas, landfill gas)	4.2%	**4.7%**	5.1%	7.2%	**10.5%**	20.3%	6.5%	**7.6%**	8.9%
Medium (biomass – unabated, biomass – CCUS – mature, EfW)	4.7%	**5.1%**	5.6%	8.2%	**12.6%**	25.8%	7.3%	**8.9%**	10.6%
Medium-high (ACT, biomass – CCUS – maturing)	5.1%	**5.6%**	5.9%	9.6%	**14.7%**	30.0%	8.5%	**10.1%**	12.0%

Investor survey – quantitative evidence

Few quantitative survey responses were provided for these technologies:

- In relation to the return on debt:
  - A single response was provided for biomass with and without CCUS (development phase), which sat above the upper estimate for the "medium-high risk" range (i.e., above the level for the 'maturing' variant for this technology). However, the estimate was the same for both technologies – which is consistent with CCUS and unabated projects having a consistent hurdle rate.
  - Similarly, a single EfW (development phase) response provided a cost of debt estimate above the upper estimate for the "medium risk" range.
- In relation to the return on equity:

- Two responses were provided for EfW (development / whole life), positioned above and below the mid-point assumption. On average, the responses were below the mid-point.
- One response provided estimates for biomass with CCUS and unabated (development). Both sat materially below the mid-point for the medium-high and medium risk levels. The estimate for biomass with CCUS was higher than for unabated – which differs from the return on debt response.

- In relation to the overall hurdle rate:
  - One response was provided for biomass with and without CCUS (development phase). Both sat materially below the mid-point estimate for the medium-high risk level, and somewhat below the medium risk level. The estimate for biomass with CCUS was higher than for without.
  - One response was provided for EfW (development phase), sitting below the low point.

It is also relevant to consider the quantitative survey results in relation to gas with and without CCUS (see Section 5.1.13). Two respondents provided hurdle rate estimates for gas with and without CCUS, with no difference in the ranges provided.

No survey results commented on ACT, sewage gas or landfill gas.

Investor survey – qualitative evidence

We consider that the qualitative survey response (although only one) supports our positioning of EfW relative to the other technologies.

It is also relevant to consider the qualitative survey results in relation to gas with and without CCUS (see Section 5.1.13). These placed CCGT with CCUS in either the same risk category as unabated CCGT, or higher.

Other evidence

As set out in Appendix E:

- FGEN's 2024 half-year report indicates:
  - A discount rate for valuing anaerobic digestion projects that is the same as for wind (albeit assuming gearing of 0% for AD against 35% for wind). This appears to be consistent with placing AD in the same risk category as onshore wind.
  - A discount rate for waste / bioenergy projects that is 1.2% above that of AD. This suggests that placing EfW and unabated biomass one risk level above AD is directionally reasonable (if potentially underestimating the differential).
  - The discount rate for waste / bioenergy projects is close to that of batteries (0.2% lower). We have placed lithium BESS in the low-medium category, below EfW and unabated biomass. This could either indicate that the risk rating for lithium BESS is too low, or that the rating for EfW/biomass is too high.
- In a 2023 investor presentation, RWE provide post-tax nominal unlevered IRR targets of 8-12% for flexible generation and hydrogen projects (in Europe and the USA). We understand that flexible generation could encompass gas generation, biomass generation, and pumped hydro.[113] Biomass projects may include CCUS, noting RWE's target of fully decarbonising its flexible generation portfolio by 2040.[114] This compares to our post-tax nominal hurdle rate (at 50% leverage) assumption of 10.4% for biomass generation with CCUS. It also encompasses our post-tax nominal hurdle rate estimate of 9.40% for unabated biomass projects.

[113] RWE (2023) p. 45 and RWE (2024) pp. 112-115.

[114] RWE (2023) p. 21.

Conclusion

Overall, the limited survey evidence suggests that the estimates for EfW and unabated biomass may be on the high side, in particular considering the responses that related to development phase projects. However, the other evidence we have found (albeit a single investor report) suggests that the relative positioning of the technologies is broadly reasonable (other than in relation to EfW/biomass and batteries).

As no survey results or cross-check evidence was identified for ACT, sewage gas or landfill gas, the level of confidence in the estimates is lower for these technologies.

The survey results are evenly split in terms of whether CCUS (both biomass and gas) increases the hurdle rate. On balance, given the risk assessment set out in Section 3, we consider it is reasonable to consider two variants for biomass with CCUS capability (i.e., the 'mature' and 'maturing' variants).

5.1.9. Tidal stream, tidal range and wave

We discuss survey results for the ocean energy technologies together. All three were ranked "high" in our initial risk assessment. The assumption for tidal range reflects that it does not have a CfD revenue model, as applies to the other technologies.

*Table 5.12: Tidal / wave – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
High	5.6%	**5.9%**	6.3%	11.0%	**16.8%**	34.2%	9.6%	**11.4%**	13.3%
High (tidal range)	7.1%	**7.4%**	7.8%	12.5%	**18.3%**	35.7%	11.1%	**12.9%**	14.8%

Investor survey – quantitative evidence

Few responses were provided for this group, and no responses for tidal range. All estimates related to projects in the development phase. In summary:

- For the return on debt, two responses were provided for tidal stream (development phase) and one for wave (whole life). On average, the responses sit materially above the mid-point estimate and are also above the upper estimate for the "high risk" range.
- One response was provided on required equity returns and the overall hurdle rate for tidal steam (development). Required equity returns sit between the mid-point and high estimates (although this is a very large range). The overall hurdle rate also fell between the mid-point and high estimate.

Investor survey – qualitative evidence

While there is limited quantitative evidence of investor views on required returns for tidal and wave, we can also consider the qualitative survey responses. The qualitative responses for the technologies were consistent with the "high risk" ranking. While no respondents were active in both wave and other technologies, there is some comparative evidence for tidal stream, with one response positioning it below hydrogen electrolysers on the risk spectrum.

Conclusion

Overall, this suggests that the high-risk hurdle rate assumption could be an underestimate for a tidal or wave project in the development phase. It may be more reasonable representation of a 'whole life' return. However, we have not identified any cross-check evidence with which to test this. Accordingly, the level of confidence in this estimate is lower.

5.1.10. Storage

We discuss results for the storage technologies together. These include pumped hydro energy storage (PHES), lithium batteries (lithium BESS), novel long duration energy storage (novel LDES) and new compound batteries.

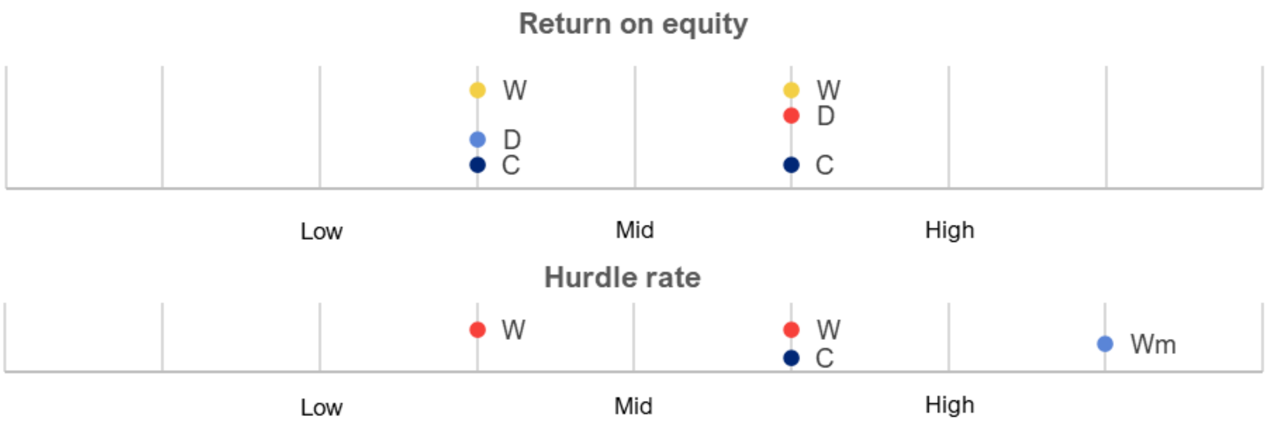
*Table 5.13: Storage – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Low-medium (PHES)	4.2%	**4.7%**	5.1%	7.2%	**10.5%**	20.3%	6.5%	**7.6%**	8.9%
Medium (lithium BESS)	4.7%	**5.1%**	5.6%	8.2%	**12.6%**	25.8%	7.3%	**8.9%**	10.6%
Medium-high (novel LDES)	5.1%	**5.6%**	5.9%	9.6%	**14.7%**	30.0%	8.5%	**10.1%**	12.0%
High (new compound batteries)	7.1%	**7.4%**	7.8%	12.5%	**18.3%**	35.7%	11.1%	**12.9%**	14.8%

Investor survey – quantitative evidence

The figure below compares the survey results to our lithium BESS estimates (no responses were provided for the return on debt).

Figure 5.6: Lithium BESS - Quantitative survey responses compared to CEPA low-mid-high estimates



Notes: D= Development phase, C = Construction phase, O = Operations phase, W = Whole life. Colours indicate individual responses; where a colour is shown twice this indicates the response provided a range.

Most survey responses sit above our "medium risk" mid-point estimate for the return on equity and overall hurdle rate, with some responses also exceeding the upper bound estimate. The average survey result was ~0.5% above the mid-point for the return on equity and ~1.5% above the mid-point overall hurdle rate. The median survey result was consistent with the mid-point return on equity, but ~1% higher than the mid-point hurdle rate. The figure above illustrates that the return on equity responses mainly relate to projects in the development and construction phases. However, this is not the case for the overall hurdle rate responses, of which two out of three reflect whole of life returns.

There were fewer responses that provided quantitative evidence for the other storage technologies:

- One response commented on required debt returns for novel LDES (development phase). The value provided sat above both our mid-point and high estimates.
- Two responses provided return on equity values for PHES (whole life) and novel LDES (development / whole life), which sat between the mid-point and upper estimates.
- One response provided hurdle rate values for PHES and novel LDES (both whole life). These sat between the mid-point and upper estimates.
- No responses provided quantitative information for new compound batteries.

Investor survey – qualitative evidence

Qualitatively, the median survey response (from 6 responses), placed lithium BESS in the "medium risk" category. Of the respondents that were active in both lithium BESS and other technologies:

- Most responses gave lithium BESS the same risk rating as onshore wind and a higher rating than solar PV.
- Responses either placed lithium BESS below PHES and novel LDES, or gave the same rating.

Of the responses that qualitatively compared the other storage technologies:

- PHES was assigned the same ranking as offshore wind, but a higher risk ranking than hydropower. PHES was placed both above and below novel LDES / unabated gas.
- Novel LDES was ranked the same or higher risk than hydrogen electrolysers (which we have assigned as "medium-high").

Other evidence

As set on in Appendix E:

- A CEPA study conducted in 2023 for Australia concluded – primarily on the basis of survey evidence – on an estimated hurdle rate for PHES that was 2.5% higher than solar PV / onshore wind, reflecting an assumed higher level of construction risk (+1.5%) and a different (less contracted) revenue model (+1%). However, that revenue model assumption was very different to the assumed cap and floor model for PHES that we have adopted for this project.
- In a 2023 investor presentation, RWE provide post-tax nominal unlevered IRR targets of 6-10% for onshore wind, solar and battery projects (in Europe and the USA). This compares to our post-tax nominal hurdle rate (at 50% leverage) assumption of 9.4% for lithium BESS. Batteries (type unspecified) sat in the same return range as solar PV and onshore wind (while we have positioned lithium BESS above both technologies).
- RWE's 2023 investor presentation also provided post-tax nominal unlevered IRR targets of 8-12% for flexible generation and hydrogen projects (in Europe and the USA). We understand that flexible generation could encompass gas generation, biomass generation, and pumped hydro.[115] This range encompasses our post-tax nominal hurdle rate (at 50% leverage) assumption of 9.4% for pumped hydro energy storage.
- FGEN's 2024 half-year report indicates a discount rate for valuing battery projects that is 2.4% above that of solar and 1.3% above wind.

Conclusions

Taking the above factors into account, we consider that **lithium BESS** should be no more than one risk level above onshore wind and there is some evidence that the two technologies should have the same assumed hurdle rate. In Section 5.1.2 we explain that we are comfortable with a "low-medium risk" estimate for onshore wind. Given that the survey results do not support a "low-medium" rating, this points to retaining the "medium risk" assumption for lithium BESS.

In relation to **PHES**, the survey responses point to a higher hurdle rate relative to lithium BESS. This is the opposite of our initial assumption, which places PHES in the "low-medium risk" category - reflecting our assessment of how the cap and floor regime may mitigate some risks that might otherwise be higher for PHES relative to lithium BESS. In particular, we have assumed that the cap and floor regime:

- Reduces PHES exposure to construction cost risk, because the final cap and floor values will reflect actual construction costs to the extent that Ofgem considers these efficient. In contrast, while construction is much simpler for lithium BESS, we assume that the developer is fully exposed to overruns. Similarly, we

[115] RWE (2023) p. 45 and RWE (2024) pp. 112-115.

have assumed that the cap and floor regime provides an opportunity to adjust for unforeseen changes in operational costs during the support period.

- Reduces PHES exposure to market price risk. In contrast, the assumed revenue model for lithium BESS is effectively merchant.

Given these factors, we do not consider that the hurdle rate for PHES should sit above that of lithium BESS. However, given the survey evidence it appears reasonable to place PHES and lithium BESS in the same "medium risk" category.

Maintaining **novel LDES** at least one risk level above PHES (i.e., "medium-high risk") is consistent with the limited survey evidence. We do not consider that it would be reasonable to place novel LDES in the "high risk category" (i.e., the same as FLOW), because of the assumed impact of the cap and floor regime on construction risk.

The survey provided almost no evidence on **new compound batteries**. Accordingly, we maintain the "high risk" assumption, while noting that there is less confidence in this estimate compared to some of the other technologies.

*Table 5.14: Storage – **Adjusted** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Medium (lithium BESS, PHES)	4.7%	**5.1%**	5.6%	8.2%	**12.6%**	25.8%	7.3%	**8.9%**	10.6%
Medium-high (novel LDES)	5.1%	**5.6%**	5.9%	9.6%	**14.7%**	30.0%	8.5%	**10.1%**	12.0%
High (new compound batteries)	7.1%	**7.4%**	7.8%	12.5%	**18.3%**	35.7%	11.1%	**12.9%**	14.8%

5.1.11. Interconnectors

*Table 5.15: Interconnectors – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Low-medium	4.2%	**4.7%**	5.1%	7.2%	**10.5%**	20.3%	6.5%	**7.6%**	8.9%

The survey provided very limited evidence in relation to interconnectors. A single respondent provided estimates of the required return on equity and overall hurdle rate. While the response sat above our mid-point assumption for the return on equity, we consider that the response supports our proposed overall hurdle rate.

5.1.12. Nuclear

We discuss the three nuclear technologies – large-scale nuclear, SMRs and AMRs – together. The estimates below assume that all are developed under the nuclear RAB framework.

*Table 5.16: Nuclear – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Low-medium (large-scale nuclear)	4.2%	**4.7%**	5.1%	7.2%	**10.5%**	20.3%	6.5%	**7.6%**	8.9%
Medium (SMRs, AMRs)	4.7%	**5.1%**	5.6%	8.2%	**12.6%**	25.8%	7.3%	**8.9%**	10.6%

Investor survey – qualitative and quantitative evidence

The survey provided very limited evidence in relation to nuclear:

- The survey provided no information on the return on debt or overall hurdle rate.
- One respondent commented on the required return on equity for large-scale nuclear (whole life), providing a range which sits around our mid-point estimate. No information was provided on SMRs and AMRs.

Qualitative responses were also limited, and provided an inconsistent picture of where large-scale nuclear sits relative to other technologies.

Other evidence

In Appendix D.1.1, we consider an alternative asset beta sample for nuclear technologies, based on regulated US utilities with portfolios of nuclear generation and other electricity sector assets. This sample produces an asset beta estimate that would be more consistent with our assumption for a "low risk" technology. As we explain in that appendix, as further information on the application of the nuclear RAB regime becomes available, this may provide more evidence on the relevance of the alternative sample.

On 22 July 2025, FID was announced for the Sizewell C large-scale nuclear project. The information released with the FID announcement included hurdle rate evidence. For example, Centrica (an equity investor in Sizewell C) disclosed that an allowed pre-tax real CPIH WACC of 6.7% will apply over the project's construction period and initial operations period.[116] Several factors may mean that this WACC is not directly comparable to our pre-tax real CPI hurdle rate estimates.[117] However, it is within – albeit at the very lower end of – our range for a low-medium risk technology (6.5%-8.9%). The International Public Partnerships (INPP) consortium (another equity investor in Sizewell C) also commented on the project, drawing comparisons between the project and other regulated infrastructure.[118, 119] This is also relevant for considering the impact of the nuclear RAB framework on hurdle rates.

As the Sizewell C FID evidence became available after the 31 December 2024 cut-off date for our analysis, we have not considered it in detail as part of this report. However, this information could be considered by DESNZ as part of any future update of the hurdle rate estimates.

Conclusions

Given the evidence that was available at the time our analysis was completed, we have retained the assumptions proposed in Table 5.16 above – noting that the lower end of the range encompasses the WACC published as part of the Sizewell FID announcement.

5.1.13. Gas-fired generation

We discuss all three gas-fired technologies – CCGT, OCGT, reciprocating engines – together in this section. We also consider whether a different hurdle rate should apply for each of the technologies, and for unabated projects compared to those with CCUS.

*Table 5.17: Gas generation – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Medium (unabated gas, gas generation with CCUS – mature)	4.7%	**5.1%**	5.6%	8.2%	**12.6%**	25.8%	7.3%	**8.9%**	10.6%
Medium-high (gas generation with CCUS – maturing)	5.1%	**5.6%**	5.9%	9.6%	**14.7%**	30.0%	8.5%	**10.1%**	12.0%

[116] Centrica (2025), *Market Announcement*, p.1, 22 July 2025. Available at: https://www.centrica.com/media/tfnbsmm5/centrica-2025-sizewell-c-rns-announcement-final-220725.pdf. The 6.7% pre-tax real CPIH WACC combines a 10.8% cost of equity and 4.5% cost of debt at 65% gearing.

[117] See Section 1.6.

[118] INPP (2025a), *Press Release – INPP selected as preferred bidder on Sizewell C*, 22 July 2025. Available at: https://www.internationalpublicpartnerships.com/media/press-releases/inpp-selected-as-preferred-bidder-on-sizewell-c/.

[119] INPP (2025b), p.6.

Investor survey – quantitative evidence

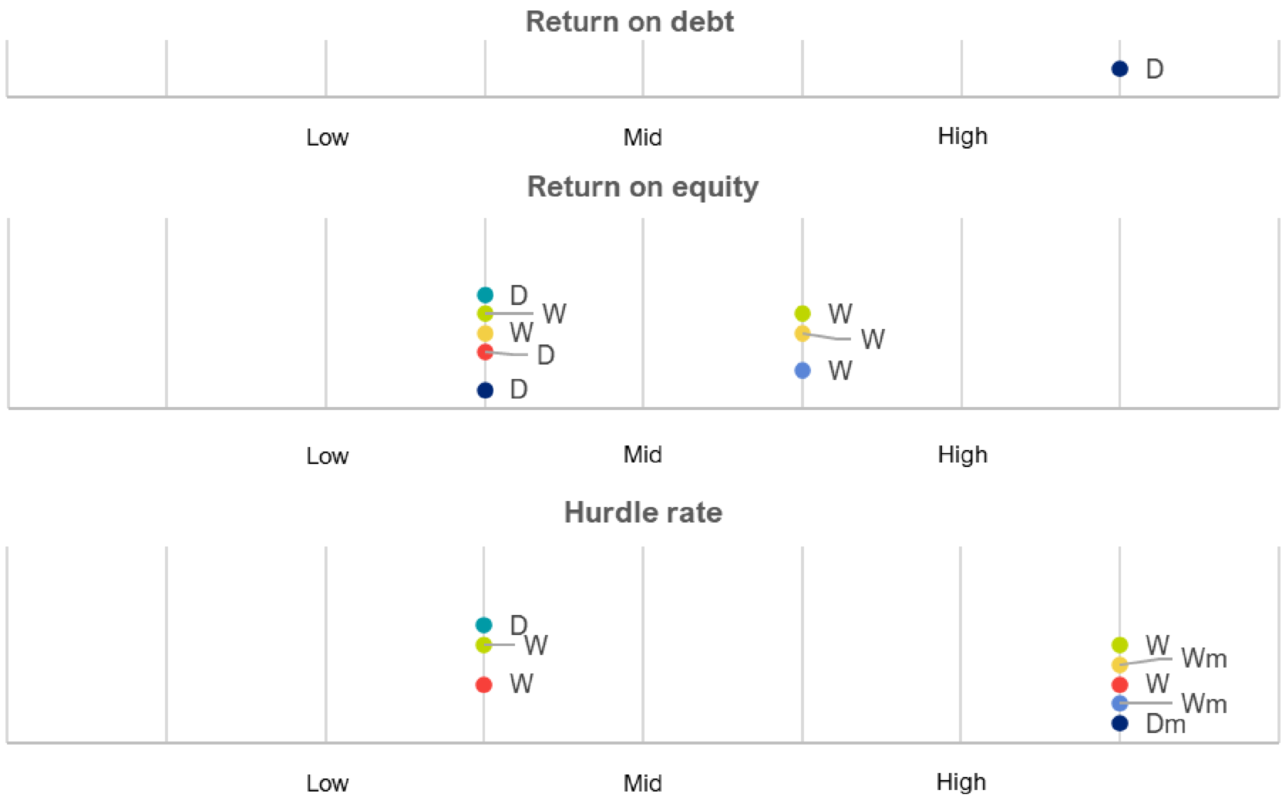
The figure below compares the survey results for **unabated gas** to our estimates. The figure reflects aggregated responses for all unabated gas technologies, which included CCGT, OCGT and reciprocating engines. In total, five different respondents provided quantitative estimates. Where the same respondent provided estimates for different technologies (e.g., CCGT and OCGT), these are shown as individual data points in the figure.

The survey results are distributed around the mid-point for the return on equity, which the average and median responses falling ~1% / ~0.5% below the mid-point respectively. However, three results for the overall hurdle rate extend beyond our upper estimate. The average result sits ~2.5% above the mid-point hurdle rate estimate and ~1% above the upper estimate.

While both the return on equity and overall hurdle rate responses include whole life and development phase projects, it is the former that set the higher end of the range.

There was a single return on debt response, which is materially higher than the upper estimate. However, it is for a development phase project. One respondent also considered debt financing of unabated gas projects to be infeasible, given risks related to carbon emissions reduction policies. It is difficult to evaluate how widespread or material this perception may be, given the number of survey results received. However, DESNZ may wish to explore this issue further in future.

Figure 5.7: Unabated gas generation - Quantitative survey responses compared to CEPA low-mid-high estimates



Notes: D= Development phase, C = Construction phase, O = Operations phase, W = Whole life. "m" indicates a merchant project. Colours indicate individual responses for different unabated gas technologies; where a colour is shown twice this indicates the response provided a range.

Fewer responses were provided for gas generation with CCUS. A single response commented on required equity returns, which were broadly consistent with our mid-point estimate for the medium-high risk level (i.e., for the 'maturing variant'). Two responses commented on the overall hurdle rate. One sat materially above the upper end of the range for medium-high risk, while the other sat between the lower- and upper-bound estimates for medium-high risk. The CCUS survey estimates all related to whole life returns. Two respondents provided estimates for gas with and without CCUS, with no difference in the ranges provided.

The survey instructed respondents to assume that gas-fired generation held a capacity market contract, in addition to the respondent's view of 'typical' wholesale and balancing market revenues. The survey responses indicate that the estimates provided (for both unabated and CCUS) are consistent with a project that, aside from the capacity market contract, is merchant. However, as described in Section 2.2 in practice gas with CCUS may be eligible for a dispatchable power agreement under the Power CCUS business model. This is one reason why some of the survey responses for gas with CCUS may be higher than the "medium-high risk" estimates we have proposed for a 'maturing' gas CCUS project.

Investor survey – qualitative evidence

In terms of the **qualitative** survey responses:

- Overall, unabated gas was ranked in the "low-medium" to "medium" risk range.
    - Most responses considered that unabated gas should sit 1-2 risk levels higher than onshore wind and solar PV.
    - The responses (although limited) supported assigning the same risk rating to CCGT, OCGT and gas reciprocating engines.
- Responses placed CCGT with CCUS in either the same risk category as unabated CCGT, or higher. As noted above, this likely reflected the same assumed revenue model for unabated / CCUS projects (i.e., did not reflect the impact of the Power CCUS business model).

Other evidence

As noted in Appendix E:

- SSE's 2024 reporting to investors indicated a spread to the corporate WACC of 100-400 basis points for onshore wind and 300-500 basis points for future CCS / hydrogen. This is broadly consistent with our proposed assumptions for onshore wind and gas (unabated / with CCUS).
- In a 2023 investor presentation, RWE provide post-tax nominal unlevered IRR targets of 8-12% for flexible generation and hydrogen projects (in Europe and the USA). We understand that flexible generation could encompass gas generation, biomass generation, and pumped hydro.[120] Gas generation projects may include CCUS, noting RWE's target of fully decarbonising its flexible generation portfolio by 2040.[121] This compares to our post-tax nominal hurdle rate (at 50% leverage) assumption of 10.4% for gas generation with CCUS. It also encompasses our post-tax nominal hurdle rate estimate of 9.40% for unabated projects.
- CEPA's 2023 advice to AEMO Services Limited on hurdle rates for Australian generation assets considered OCGT. Informed by the Australian investor survey and a qualitative review of risks in the Australian context at that time, we determined that – assuming a long-term contracted asset in both cases – hurdle rates would be broadly the same for solar PV, onshore wind, and OCGT. However, a merchant OCGT project would have a pre-tax real hurdle rate around 1% higher. This is consistent with our proposed differential between onshore wind ("low-medium") and unabated gas ("medium").
- The US National Renewable Energy Laboratory's (NREL) 2024 financial assumptions assume the same operation phase post-tax cost of equity for offshore wind (with a PPA) and natural gas generation (quasi-merchant), and with the cost of debt for gas sitting 1% higher. This is broadly consistent with grouping offshore wind and unabated gas together in the "medium" risk category.

Conclusions

Overall, the survey results suggest that:

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[120] RWE (2023) p. 45 and RWE (2024) pp. 112-115.

[121] RWE (2023) p. 21.

- There is evidence to support assigning the same assumption to gas generation with and without CCUS. As for biomass, we consider it is reasonable to consider two variants for gas generation with CCUS capability (i.e., the 'mature' and 'maturing' variants).
- The "medium risk" estimate is lower than the survey results provided for unabated gas. On the one hand, we have 'whole of life' responses that sit above the upper end of the range. However, the responses provided for development phase projects (which we would expect to require a higher return than a 'whole life' estimate) sit below the mid-point. On balance, we have proposed to retain the "medium risk" estimate, which maintains consistency with the survey responses on the qualitative ranking of unabated gas relative to other technologies.

In relation to the question of whether different hurdle rates should apply to different gas generation technologies (i.e., CCGT, OCGT, reciprocating engines), it is also relevant to consider the past hurdle rate studies conducted for DESNZ. NERA's 2015 hurdle rate study adopted the same assumptions for the gas generation technologies. However, Europe Economics' 2018 study proposed different assumptions for CCGT and OCGT. This reflected an assumption that CCGT would tend to be deployed as part of a portfolio of generation technologies, rather than as a standalone asset under a project finance structure.

In particular, in the 2018 report, Europe Economics considered that: "[p]*ortfolio players have balancing market risk from their intermittent assets and supply obligations which is negatively correlated with the economics of dispatch of CCGTs. Thus, addition of CCGTs to such a portfolio can bring added benefits in terms of risk management and enable portfolio players to better extract the value of the real option."* CEPA's 2018 review of the Europe Economics report expressed reservations about making strong assumptions in relation to the assumed portfolio characteristics and financing approach for CCGT.[122]

Accordingly, in light of the survey results, we have not sought to differentiate between the CCGT and OCGT on that basis in this report. However, we note that the overall hurdle rates determined by Europe Economics for these technologies were not, ultimately, far apart. The difference of 0.4% is well within the lower-upper bands that we propose in Section 4.5.

5.1.14. Hydrogen to power

We have proposed the same hurdle rate assumptions for both hydrogen CCHT and OCHT, distinguishing between 'mature' and 'emerging' specifications for this technology.

*Table 5.18: H2P – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Medium (mature)	4.7%	**5.1%**	5.6%	8.2%	**12.6%**	25.8%	7.3%	**8.9%**	10.6%
Medium-high (emerging)	5.1%	**5.6%**	5.9%	9.6%	**14.7%**	30.0%	8.5%	**10.1%**	12.0%

Investor survey – quantitative evidence

The survey provided quite limited quantitative evidence in relation to hydrogen to power (H2P):

- One respondent commented on required debt returns for a development phase project. This sat materially above the upper end of our whole life estimate for a "medium-high risk" project.
- Two responses provided values (whole life / development phase) for the required return on equity. These sat between the lower and upper assumptions, with average / median response sitting below our mid-point assumption for a "medium-high risk" project.

[122] CEPA (2018), *CEPA Peer Review: Cost of capital update for electricity generation, storage and demand side response technologies*, 28 September 2018, p.3.

- Two responses provided whole life values for the overall hurdle rate. One sat materially above the upper end of our range for the "medium-high risk" category. However, the respondent had assumed a merchant revenue model, rather than the H2P business model described in Section 2.2. The other response provided a range between our lower and upper estimates for medium-high risk.

Two responses provided estimates for H2P CCHT and OCHT, with the same ranges provided for both technologies. It was not clear from the survey responses what assumptions had been made in relation to the turbine size or hydrogen blending.

Investor survey – qualitative evidence

In terms of the qualitative survey results, the median response placed H2P in the "medium-high" risk category. Respondents who were active in multiple technologies, including H2P, considered that it was higher risk than unabated gas (which we have maintained as "medium risk") and the same risk as hydrogen electrolysers (which we have ranked as "medium-high" risk).

Conclusion

The relatively low survey response rate combined with nascent but rapidly developing technology, as well as uncertainty over the final policy on retrofit plant versus new plant, blending and the form of the revenue support mechanism we have included a wide indicative range that will be refined at a future date.

Given the similarity of basic turbine technology and likely range of revenue support mechanisms we have selected a hurdle rate range that is equivalent to unabated gas at the lower bound and gas CCUS at the upper bound. We consider that the available evidence is supportive of this range.

It is expected that small turbines, firing less than 100% hydrogen, combined with revenue support covering a significant proportion of capital and operating expenditure would attract a hurdle rate at the lower bound.

5.1.15. Hydrogen electrolysers

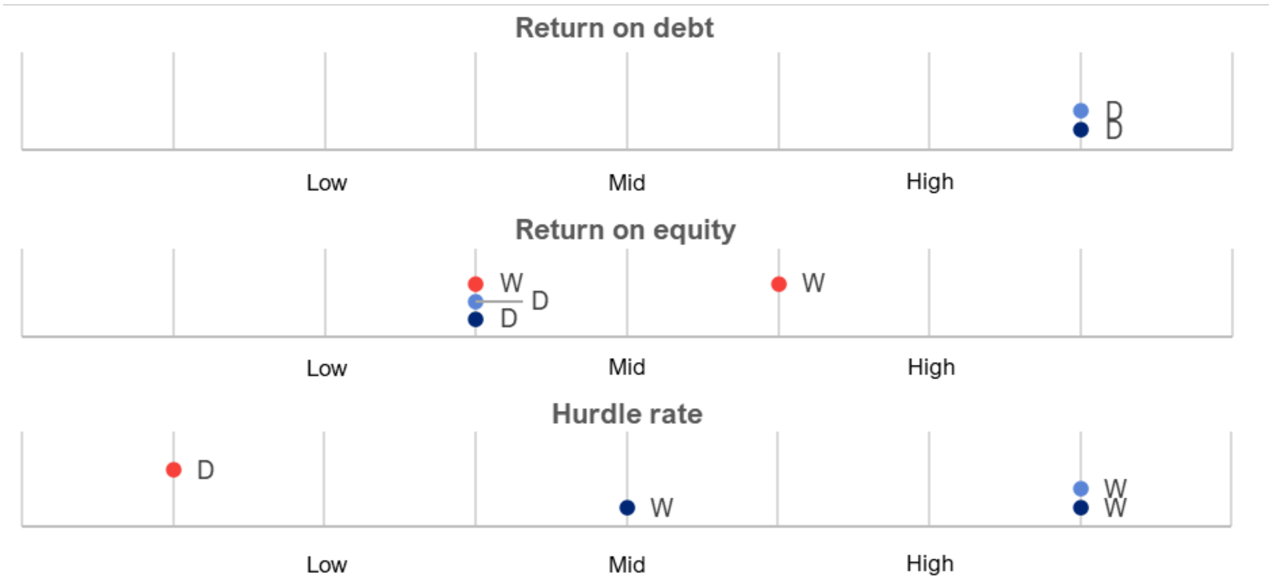
*Table 5.19: Hydrogen electrolysers – **Initial** risk rating and pre-tax real returns (lower-**mid**-upper)*

Initial risk rating	Return on debt			Return on equity			Hurdle rate		
Medium-high	5.1%	**5.6%**	5.9%	9.6%	**14.7%**	30.0%	8.5%	**10.1%**	12.0%

Investor survey – quantitative evidence

The figure below compares our whole life estimates to the survey responses.

Figure 5.8: Hydrogen electrolysers - Quantitative survey responses compared to CEPA low-mid-high estimates



Notes: D= Development phase, C = Construction phase, O = Operations phase, W = Whole life. Colours indicate individual responses for different unabated gas technologies; where a colour is shown twice this indicates the response provided a range.

The survey provided fairly limited evidence in relation to hydrogen electrolysers:

- Two respondents provided return on debt information for development phase projects. Both sat materially above the upper end of our whole life range.
- Three respondents commented on required equity returns (whole life / development). The average / median result sat ~1% below our mid-point estimate.
- Three respondents commented on the overall hurdle rate (whole life / development). As the figure above indicates, there was a wide spread of reported results around our range. The average / median result sat ~0.5% above / ~0.5% below our mid-point estimate, respectively.

Investor survey – qualitative evidence

In terms of qualitative responses, the median survey response placed hydrogen electrolysers in the "medium-high" risk category. Of those respondents that are active in multiple technologies, two responses considered that hydrogen electrolysers have the same risk level as H2P and three responses ranked hydrogen electrolysers above unabated gas.

Other evidence

As noted in Appendix E:

- SSE's 2024 reporting to investors indicated a spread to the corporate WACC of 100-400 basis points for onshore wind and 300-500 basis points for future CCS / hydrogen. This is broadly consistent with our proposed assumptions for onshore wind and hydrogen electrolysers.
- In a 2023 investor presentation, RWE provide post-tax nominal unlevered IRR targets of 8-12% for flexible generation and hydrogen projects (in Europe and the USA). We understand that the hydrogen projects refer predominantly to electrolysers.[123] This compares to our post-tax nominal hurdle rate (at 50% leverage) assumption of 10.4% for hydrogen electrolysers.

Conclusion

We consider that the available evidence supports the risk rating and estimates set out above.

5.1.16. Demand response aggregation

No survey responses (qualitative or quantitative) were provided for demand response aggregation. This means that there is less confidence in our proposed estimates compared to other technologies.

5.2. Final risk ratings and hurdle rate estimates

The table overleaf summarises the final proposed risk ratings and hurdle rates for each technology under the base case revenue assumption, taking into account the cross-checks discussed above.

[123] RWE (2023), p.22 and RWE (2024), pp.110-125.

Table 5.20: Final risk ratings & whole-life hurdle rates (pre-tax real CPI, base revenue model) – 31 December 2024

Technology	Revenue model	Initial risk rating	Final risk rating	Lead scenario (mid-point, 50% gearing)
Solar PV	CfD	L	L-M	7.60%
Onshore wind		L-M	L-M	7.60%
Offshore wind		M	M	8.90%
Remote island wind		M	M	8.90%
Floating offshore wind		H	H	11.40%
Hydropower		M	M	8.90%
Advanced conversion technologies (ACT)		M-H	M-H	10.10%
Anaerobic digestion (AD)		L-M	L-M	7.60%
Sewage gas		L-M	L-M	7.60%
Landfill gas		L-M	L-M	7.60%
Energy from waste		M	M	8.90%
Biomass – unabated		M	M	8.90%
Deep geothermal		M-H	M-H	10.10%
Wave		H	H	11.40%
Tidal stream		H	H	11.40%
Tidal range[1]	None	H	H	12.90%
Biomass – with CCUS – mature[1]	BECCs BM	M	M	8.90%
Biomass – with CCUS – maturing[1]		M-H	M-H	10.10%
Large-scale nuclear	Nuclear RAB	L-M	L-M	7.60%
Small modular reactors (SMRs)		M	M	8.90%
Advanced modular reactors (AMRs)		M	M	8.90%
Pumped hydro energy storage (PHES)	LDES cap & floor	L-M	M	8.90%
Novel long duration energy storage (LDES)		M-H	M-H	10.10%
Lithium batteries	CM contract	M	M	8.90%
New compound batteries[2]		H	H	12.90%
Demand response aggregators		M	M	8.90%
Gas generation – unabated		M	M	8.90%
Gas generation – with CCUS – mature[1]	Power CCUS BM	M	M	8.90%
Gas generation – with CCUS – maturing[1]		M-H	M-H	10.10%
Hydrogen CCHT / OCHT – mature[3]	H2P BM	M	M	8.90%
Hydrogen CCHT / OCHT – emerging[3]		M-H	M-H	10.10%
Hydrogen electrolyser	HPBM	M-H	M-H	10.10%
Interconnectors	Cap & floor	L-M	L-M	7.60%

Source: CEPA analysis. Notes: (1) Refer to Section 3.2.4 for more information on the 'mature' and 'maturing' categories for the CCUS technologies. (2) Reflects uplift to capture differences between the other high risk technologies – see Section 4.6. (3) Given the uncertainties around this nascent technology, we have included a wide indicative range. that will be refined at a future date. It is expected that small turbines, firing less than 100% hydrogen, combined with revenue support covering a significant proportion of capital and operating expenditure would attract a hurdle rate at the lower bound – see Section 3.2.5.

5.3. Technology variants

In this section, we consider how the hurdle rates set out in Section 4.5 could change under different assumptions in relation to CHP, repowering and a merchant revenue model.

5.3.1. Impact of repowering

We received responses for the impact of repowered projects across solar PV and all wind technologies:

Table 5.21: Survey responses - impact of repowering

Technology	Summary of responses
Solar PV	Across seven responses, two respondents said there was no impact. The remaining responses considered that the required return would be lower for a repowered project, assuming these projects were eligible for CfDs. The estimated impact on the overall hurdle rate ranged from -0.1% to -2%.
All wind technologies	Across six responses, three respondents said there was no impact. The remaining responses agreed the required return would be lower for a repowered project, assuming these projects were eligible for CfDs. The estimated impact on the overall hurdle rate ranged from -0.2% to -2%.

Source: CEPA analysis of survey responses.

On balance, this suggests it would be broadly reasonable to consider a lower hurdle rate for repowered projects. However, follow up discussions with some survey respondents indicated that impacts may depend substantially on the specifics of the project. For example, possible reasons for a repowered site to have a lower hurdle rate could include:

- Because of lower construction risk related to cross-chain infrastructure delays (e.g., the grid connection, ports, roads etc). Whether the existing supporting infrastructure is suitable will however depend on the nature of the repowered project (e.g., if network upgrades are required).
- Because elements of the existing project infrastructure can be recycled (e.g., foundations). This will not always be possible – for example if a repowered wind development adopts larger and heavier turbines.
- Because there is better information on the renewable resource at the site, due to the longer operating history.

Therefore, DESNZ may wish to consider whether, in the context of DESNZ's analysis, is it reasonable to assume that construction risk, operating cost and volume risk, and price risk can all be considered the same or lower than an equivalent greenfield project.

5.3.2. Impact of CHP

We received four responses for the impact of CHP across geothermal, energy from waste, gas and hydrogen generation. The responses were evenly split between those who considered that CHP would reduce the overall hurdle rate, and those who considered that it would increase. Responses referred to interactions with the quality and price of the offtake contract for heat as being relevant for the outcome.

No quantified impacts were provided.

Our own qualitative research indicated that solid fuel fired renewable CHP systems may be less capable of meeting fluctuating heat and power demand compared to gas or liquid fuel fired systems, preferring relatively consistent demand profiles.[124] This may point to less flexibility, and therefore possibly higher price risk, for certain

[124] DESNZ (2021), *Combined Heat and Power – Technologies, A detailed guide for CHP developers – Part 2*, February 2021, section 4.1-4.2. Available at: https://assets.publishing.service.gov.uk/media/602a7b6bd3bf7f031e1bdcdd/Part_2_CHP_Technologies_BEIS_v03.pdf.

technologies with CHP (e.g., EfW, biomass). However, the impact may not be material in the context of the lower/upper hurdle rate ranges we propose.

On balance, we consider it is reasonable to assume no difference in hurdle rate for projects with and without CHP.

5.3.3. Impact of a merchant project

We have considered how the hurdle rate assumptions proposed in Section 4.5 could change, if instead of the "base case" revenue assumption, the project was assumed to operate under a merchant revenue model.

Broadly speaking, we would expect to see higher hurdle rates for assets that have a higher proportion of merchant revenues. All else equal, contracts that provide long-term revenue certainty reduce risk for the asset, by lowering its exposure to uncertain future wholesale market prices.[125] This is borne out by a range of evidence, outlined in the sections below. We have considered evidence from the investor survey, and other sources.

Investor survey evidence

In terms of quantitative responses:

- Six respondents provided information on how assuming a merchant project would impact required returns on debt.
- Eight respondents provided information on the impact on required equity returns.
- Five respondents provided information on the impact on the overall hurdle rate.

The responses are summarised in the table below. For most technologies, there was only one response – and so we have not disaggregated the responses by technology here (the median refers to all technologies).

Table 5.22: Survey responses - Impact of merchant revenue model

Type of return	Impact (all technologies)	Comments
Return on debt	+1% to +5%, 2% median	One response indicated varying impacts across technologies with the same assumed revenue model.
Return on equity	+1% to +10%, 3% median	As above. Multiple responses were provided for solar PV and onshore wind, with a reported range of 1-3%.
Overall hurdle rate	+1.5% to 3%, 1.5% median	As above.

Source: CEPA analysis of survey responses.

In comments to explain their responses, many survey participants that had not initially assumed a merchant project expressed the view that this would be unlikely to occur in reality. These respondents also noted that their reported capital structure would also change, with lower levels of gearing for a merchant project.

This perspective was confirmed in follow up interviews, in which several respondents indicated that they viewed the merchant projects as hypothetical, rather than based on investments that are actually being considered. The follow up interviews also indicated that differences in the assumed impact of a merchant project depend on:

- The underlying price risk exposure of the technology. For example, the impact of moving to a merchant revenue model may be higher, all else equal, for a project that is more exposed to low or negative market prices.

[125] Europe Economics (2018), *Cost of Capital Update for Electricity Generation, Storage and Demand Side Response Technologies*, November; NERA (2015), *Electricity Generation Costs and Hurdle Rates Lot 1: Hurdle Rates update for Generation Technologies*, July.

- The extent of price risk mitigation that was provided by the base case revenue model. For example, the impact of moving to a merchant revenue model may be lower, all else equal, if the base case assumption provided a relatively lower degree of price risk mitigation.

Other evidence

This section outlines a range of other evidence that we have identified in relation to hurdle rate differences between merchant projects and those with substantially contracted revenues.

Gohdes and Simshauser (2022)

This study of the cost of capital for Australian renewable generation projects found that compared to a fully merchant project:[126]

- For a project with a partial corporate or retail power purchase agreement (PPA), the required equity return was found to be 2.5% lower, the required credit spread 60 basis points lower, and gearing 16% higher.
- For a project with a full corporate or retail PPA, the required equity return was found to be 4.25% lower, the required credit spread 80 basis points lower, and gearing 26.75% higher.

We assume that the cost of equity impacts reported in Gohdes and Simshauser (2022) refer to a post-tax nominal cost of equity.

In this paper, a "partial PPA" covered 50% of the asset's output, while a "full PPA" covered 100% of output. As discussed above, our estimates for several technologies assume a 10-15-year contract, and so a degree of merchant tail risk upon contract expiry. Accordingly, the upper end of the 3.7%-5.4% range is likely to overstate the difference between our base case estimates and a fully merchant project.

Moody's credit rating methodology

The stability of cash flows is an important consideration in determining the credit rating (and therefore cost of debt) of a generation. As discussed in Section 3.1.3, the extent of contracted cash flows is a factor considered in Moody's credit rating methodology for power generation projects. For example, Moody's methodology describes the following contracted revenue characteristics for the broad rating bands[127]:

- A (A+, A, A-): Highly predictable, fully contracted cash flow with off-taker rated Aa3 (AA-) or better. Contracts extend for full term of financing.
- Baa (BBB+, BBB, BBB-): Highly predictable, fully contracted cash flow with off-taker rated Baa3 (BB-) or better. Contracts extend for full term of the financing.
- Ba (BB+, BB, BB-): At least 50% cash flow contracted/hedged over medium term (3-5 years). Unhedged cash flow has low year-to-year volatility.

This indicates that, all else equal, it may be reasonable to drop our credit rating assumption for contracted assets by up to three notches to produce an assumption for a merchant asset.[128] For example, this indicates that the credit rating assumption for a "low-medium" risk project could move from BBB- to BB-, which would increase the real return on debt by ~1.3%.

CEPA survey of Australian investors (2023)

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[126] Gohdes and Simshauser (2022), *Renewable entry costs, project finance and the role of revenue quality in Australia's National Electricity Market*, Centre for Applied Energy Economics & Policy Research Working Paper Series, January 2022, p 8.

[127] An example of a broad rating band is Baa, which encompasses the specific ratings of Baa1, Baa2 and Baa3 (which translate to BBB+, BBB and BBB- in S&P's rating scale). Contracted revenues are just one of many factors that determines the overall credit rating.

[128] As described in Section 4.4.5, our credit rating assumptions assume a constant level of gearing across technologies. Here we assume that the same level of gearing applies for contracted and merchant projects, meaning that the change in risk is reflected in the credit rating (rather than a reduction in gearing).

CEPA conducted a survey of Australian investors in generation and storage assets in 2023. Respondents commented that moving from a (partly) contracted revenue model to a merchant one would increase the cost of capital as follows:

- 1.0-2.0% uplift in the cost of equity (fully/partly contracted vs fully merchant).
- 2.0-2.8% uplift in the cost of debt (fully/partly contracted vs. fully merchant).
- 1.5-3.0% uplift in the overall pre-tax real hurdle rate (partly contracted vs. fully merchant).

There was some uncertainty around what baseline the survey responses were starting from (i.e., whether the point of comparison was a partly or fully contracted project, or precisely what respondents meant by 'partly contracted').

Oxford Economics survey of Australian investors (2023)

A cost of capital survey of Australian investors undertaken by Oxford Economics in 2023 reported a risk premium of c. 2.5% for merchant risk exposure (applied to the overall cost of capital). However, it was not entirely clear what this estimate was relative to (e.g., a fully or partly contracted project).

Grant Thornton survey (2019)

A 2018 survey conducted by Grant Thornton found that across UK solar, wind, hydro and biomass projects: [129]

- 21% of respondents would apply a hurdle rate premium of more than 2.0% for projects that were unsubsidised.
- 11% of respondents would apply no premium for an unsubsidised project.
- Roughly equal proportions of respondents would apply a premium of 0.5% to 2.0%.

Again, the reference point was not stated (i.e., what was assumed for a "subsidised" project).

Generation asset valuations

Some companies that invest in generation assets report the discount rates used to value contracted and uncontracted assets in their financial accounts. We have identified two examples, New Energy Solar and Brookfield Renewable Partners. While the definition of the discount rates is not reported (i.e., if they are pre-tax / post-tax, real / nominal), the differential between the contracted and uncontracted rates is still informative.

New Energy Solar are an Australia-based company, with a portfolio of solar assets in US and Australia. Their 2021 annual report stated that: *"[t]he fair value of NEW's renewable energy asset investments as of 31 December were determined as described above, using a cost of equity range of 5.00% to 5.75% for contracted cash flows, and 5.75% to 6.75% for uncontracted cash flows"*.[130]

The discount rates, and related assumptions, used to value Brookfield Renewable Partners' portfolio in 2023 are summarised in the table below. The reported discount rates are the same for European assets, presumably reflecting that 100% of this portfolio is contracted to some extent. We assume that the discount rate reflects the weighted average cost of debt and equity (rather than just equity returns as for New Energy Solar above).[131]

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[129] Grant Thornton (2019), *Renewable energy discount rate survey results – 2018*, January 2019, p.29.

[130] New Energy Solar (2021), *Annual Report*, 31 December 2021, p.52, available at: https://www.annualreports.com/HostedData/AnnualReportArchive/n/ASX_NEW_2021.pdf.

[131] This is because the discount rates are being used to value the company's property, plant and equipment – which is financed by a mix of debt and equity. In contrast, the New Energy Solar discount rate was being applied to value equity interests in generation asset investments.

Table 5.23: Brookfield Renewable Partners - Generation portfolio discount rate assumptions and contract positions

Geography	North America	Colombia	Brazil	Europe
Discount rate				
Contracted	5.1% - 5.7%	8.7%	8.4%	4.8%
Uncontracted	6.3% - 7.0%	10.0%	9.7%	4.8%
Uncontracted - Contracted	1.2% - 1.3%	1.3%	1.3%	-
Percentage of total generation that is contracted				
1-5 years	75%	61%	81%	100%
6-10 years	57%	29%	70%	76%
>10 years	30%	3%	40%	47%
Average remaining contract duration	15 years	4 years	9 years	13 years

Source: Brookfield Renewable Energy Partners (2023), Annual Report, 31 December 2023, p.25 and pp.126-127. Available at: https://bep.brookfield.com/sites/bep-brookfield-ir/files/Brookfield-BEP-IR-V2/2023/Q4/bep-2023-annual-report-v1.pdf.

In its 2024 half-year report, Foresight Environmental Infrastructure Limited (FGEN) report that *"the discount rate used for energy generating asset cash flows which have received lease extensions beyond the initial investment period of 25 years retains a premium of 1% for subsequent years, reflecting the merchant risk of the expected cash flows beyond the initial 25-year period."* [132]

Europe Economics (2018)

In its 2018 report, Europe Economics provided estimates for low carbon technologies under two assumptions: with a UK Government CfD and on a merchant basis. The table below shows these assumptions for a selection of technologies. Europe Economics developed these assumptions by adopting different asset beta and gearing assumptions for the technologies under both revenue model scenarios. The debt premium did not change, because the gearing adjustment was considered to keep debt risk at the same level. This is the inverse of our proposed approach, where we keep gearing the same but change the credit rating to reflect the change in debt risk.

Table 5.24: Europe Economics (2018) - Pre-tax real hurdle rates for selected technologies

Technology	CfD	Merchant	Merchant – CfD
Solar PV	5.0%	5.8%	+0.8%
Onshore wind	5.2%	6.0%	+0.8%
Offshore wind	6.3%	7.6%	+1.3%
Hydro	5.4%	6.2%	+0.8%
Wave	8.6%	10.4%	+1.8%
Tidal stream	9.4%	11.7%	+2.3%
Geothermal CHP	18.8%	23.8%	+5.0%
Biomass CHP	9.9%	12.0%	+2.1%

Source: Europe Economics (2018), pp.47-48.

[132] FGEN (2024), *Half-year Report 2024*, p.18. Available at: https://media.umbraco.io/foresight/dxll25ld/final_web_fgen_hy24.pdf.

Conclusions

The evidence above suggests that the overall hurdle rate impact reported in the investor survey (1.5% median, in a range of 1.5% - 3%) is broadly consistent with the other evidence we have reviewed. This is equivalent to increasing the assumed risk ranking for a technology between 1-2 risk levels (i.e., from “low-medium” to either “medium” or “medium-high”).

Our qualitative analysis of price risk in Section 3.2.3 suggested that the risk ratings for this factor for each technology **before considering the revenue model** would sit in a range of:

- “Medium-high” – for those technologies classified as renewable (variable), renewable (predictable), renewable (uncorrelated) and baseload.
- “High” – for those technologies classified as dispatchable.

Given the weighting assigned to the other risks, adopting these ratings for price risk would imply a smaller change in the overall risk rating (i.e., this would at most increase the risk rating by 1 level).

On balance, given the other evidence, we consider that adopting an uplift of 1.5% to the pre-tax real hurdle rate, equivalent to moving up 1-2 risk levels, provides a reasonable sensitivity for a merchant project.

However, DESNZ should consider this sensitivity in light of survey respondent comments that adopting a merchant model may not, in practice, be an option that is being actively considered for a large number of projects. This may be particularly for those technologies that are already assumed to be at the higher end of the risk spectrum under the base case revenue model.

This sensitivity does not apply to:

- The technologies that already operated under a largely merchant revenue model in the base case, i.e., unabated gas, lithium BESS, demand response aggregators, and new compound batteries.[133]
- The nuclear technologies, as agreed with DESNZ during the project.

[133] As noted in Section 4.6, the base case hurdle rate for new compound batteries and tidal range includes an uplift of 1.5%, to maintain this differential between these technologies and the other high risk technologies that have revenue models that are assumed to provide a higher degree of price risk mitigation.

6. COMPARISON TO EXISTING ASSUMPTIONS

This section explains how the assumptions that we have proposed differ from those that underpin the hurdle rate estimates that have been applied by DESNZ in the past.

We first set out the headline differences in the assumptions for each technology. We then step through a reconciliation of the AR6 hurdle rate assumption for offshore wind and the mid-point estimate we propose in this report. Finally, we set out the same reconciliation for other technologies and comment on some of the key differences.

6.1.1. Comparison of assumptions

The tables below set out the final pre-tax real CPI return on debt, return on equity, and overall hurdle rate estimates (**mid-point, 50% gearing**) and compares these to the existing assumptions that we are aware of. Table 6.1 presents a comparison for CfD-eligible technologies, to both Europe Economics 2018 study and those adopted by DESNZ for AR6. Table 6.2 reports on non-CfD technologies, comparing to Europe Economics 2018.

The Europe Economics (and DESNZ AR6 estimates derived from them) are based on market conditions (e.g., interest rates, inflation) that applied in 2018. Conditions in 2025 are different. This means that the values are not directly comparable. We provide a reconciliation of these changes in Sections 6.1.2 and 6.1.3 below.

The AR6 ASPs were based on hurdle rates estimated by Europe Economics (EE) in 2018, which in turn referred back to estimates produced by NERA in 2015. The AR6 hurdle rates reflected some adjustments from the Europe Economics estimates. Specifically, the hurdle rates for offshore wind, floating offshore wind, onshore wind and remote island wind included additional risk premia, with 2% added to offshore and floating offshore wind, and 1% added to onshore and remote island wind. The reason for these premiums were:[134]

- DESNZ considered that the Transmission Network Use of Service (TNUoS) charges released in the (then) recently published National Grid ESO 10-year projection for TNUoS charges did not reflect the amount that customers and generators could pay under potential TNUoS reforms and changes to National Grid's charging methodology. This greater uncertainty was thought to impact technologies with more transmission-connected projects in more expensive TNUoS zones, namely wind technologies.
- Offshore wind and floating offshore wind have complex supply chains. DESNZ considered that this uncertainty was compounded by variability across projects, impacting developers differently depending on the outcome of individual negotiations with key suppliers.

The AR6 values shown in the table below **include** these adjustments.

[134] DESNZ (2023), *Methodology used to set Administrative Strike Prices for CfD Allocation Round 6*, p. 22.

Table 6.1: Hurdle rate estimates (pre-tax real CPI) – CfD technologies

		Pre-tax real CPI hurdle rate				Pre-tax real CPI return on debt			Pre-tax real CPI return on equity			Gearing		
Technology	CEPA risk	EE 2018	DESNZ AR6	CEPA 2025	*Difference to DESNZ AR6*	EE 2018	CEPA 2025	*Difference to EE 2018*	EE 2018	CEPA 2025	*Difference to EE 2018*	EE 2018	CEPA 2025	*Difference to EE 2018*
Solar PV	L-M	5.0%	5.0%	7.6%	*2.6%*	2.0%	4.7%	*2.7%*	16.9%	10.5%	*-6.4%*	80.0%	50%	*-30.0%*
Onshore wind	L-M	5.2%	6.2%	7.6%	*1.4%*	2.3%	4.7%	*2.4%*	14.8%	10.5%	*-4.3%*	77.5%	50%	*-27.5%*
AD	L-M	8.3%	8.3%	7.6%	*-0.7%*	2.3%	4.7%	*2.4%*	23.7%	10.5%	*-13.2%*	72.5%	50%	*-22.5%*
Sewage gas	L-M	7.1%	7.1%	7.6%	*0.5%*	2.0%	4.7%	*2.7%*	13.8%	10.5%	*-3.3%*	57.5%	50%	*-7.5%*
Landfill gas	L-M	6.1%	6.1%	7.6%	*1.5%*	2.0%	4.7%	*2.7%*	11.3%	10.5%	*-0.8%*	57.5%	50%	*-7.5%*
Hydropower	M	5.4%	5.4%	8.9%	*3.5%*	2.0%	5.1%	*3.2%*	12.9%	12.6%	*-0.4%*	70.0%	50%	*-20.0%*
Biomass – unabated	M	9.9%	9.9%	8.9%	*-1.0%*	2.5%	5.1%	*2.7%*	15.6%	12.6%	*-3.0%*	45.0%	50%	*5.0%*
Offshore wind	M	6.3%	8.3%	8.9%	*0.6%*	2.3%	5.1%	*2.8%*	19.9%	12.6%	*-7.3%*	77.5%	50%	*-27.5%*
Energy from waste	M	7.6%	7.6%	8.9%	*1.3%*	3.1%	5.1%	*2.1%*	13.6%	12.6%	*-1.0%*	57.5%	50%	*-7.5%*
ACT	M-H	8.1%	8.1%	10.1%	*2.0%*	2.5%	5.6%	*3.1%*	15.0%	14.7%	*-0.4%*	56.0%	50%	*-6.0%*
Deep geothermal	M-H	18.8%	18.8%	10.1%	*-8.7%*	3.7%	5.6%	*1.9%*	58.0%	14.7%	*-43.3%*	72.5%	50%	*-22.5%*
Tidal stream	H	9.4%	9.4%	11.4%	*2.0%*	2.3%	6.0%	*3.7%*	25.5%	16.8%	*-8.8%*	70.0%	50%	*-20.0%*
Wave	H	8.6%	8.6%	11.4%	*2.8%*	2.3%	6.0%	*3.7%*	24.8%	16.8%	*-8.0%*	72.5%	50%	*-22.5%*
Remote island wind	M	-	6.2%	8.9%	*2.7%*	-	-	-	-	-	-	-	-	-
Floating offshore wind	H	-	9.8%	11.4%	*1.6%*	-	-	-	-	-	-	-	-	-

Source: CEPA analysis. Note: Europe Economics (2018) did not provide estimates for floating offshore wind or remote island wind. We understand that for AR6 DESNZ adopted the EE 2018 hurdle rate estimates for offshore wind (plus 1.5% risk premium) and onshore wind, respectively, as proxies for these technologies.

Table 6.2: Hurdle rate estimates (pre-tax real CPI) – Non-CfD technologies

		Pre-tax real CPI hurdle rate			Pre-tax real CPI return on debt			Pre-tax real CPI return on equity			Gearing		
Technology	CEPA risk	EE 2018	CEPA 2025	*Difference to EE 2018*	EE 2018	CEPA 2025	*Difference to EE 2018*	EE 2018	CEPA 2025	*Difference to EE 2018*	EE 2018	CEPA 2025	*Difference to EE 2018*
CCGT	M	7.5%	8.9%	*1.4%*	1.7%	5.1%	*3.4%*	10.2%	12.6%	*2.4%*	35.0%	50.0%	*15.0%*
OCGT	M	7.1%	8.9%	*1.8%*	2.3%	5.1%	*2.8%*	16.9%	12.6%	*-4.3%*	70.0%	50.0%	*-20.0%*
Gas reciprocating engine	M	7.1%	8.9%	*1.8%*	2.3%	5.1%	*2.8%*	16.9%	12.6%	*-4.3%*	70.0%	50.0%	*-20.0%*
CCS Gas FOAK	M-H	9.0%	10.1%	*1.1%*	2.5%	5.6%	*3.1%*	20.6%	14.7%	*-5.9%*	65.0%	50.0%	*-15.0%*
CCS Gas FOAK	M	9.0%	8.9%	*-0.1%*	2.5%	5.1%	*2.6%*	20.6%	12.6%	*-8.0%*	65.0%	50.0%	*-15.0%*
CCS Biomass	M-H	9.1%	10.1%	*1.0%*	2.5%	5.6%	*3.1%*	20.9%	14.7%	*-6.2%*	65.0%	50.0%	*-15.0%*
CCS Biomass	M	9.1%	8.9%	*-0.2%*	2.5%	5.1%	*2.6%*	20.9%	12.6%	*-8.3%*	65.0%	50.0%	*-15.0%*

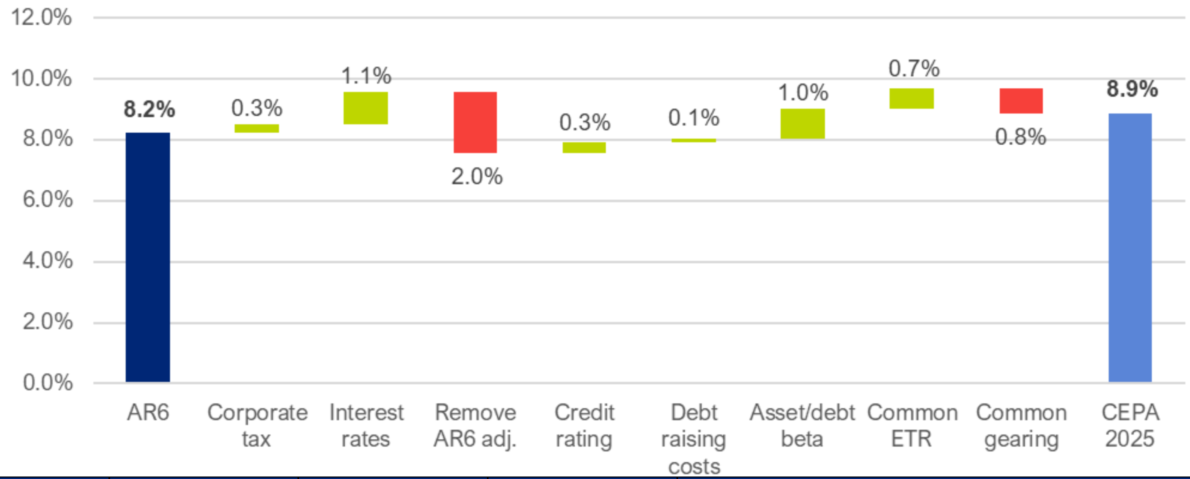
Source: CEPA analysis.

6.1.2. Reconciliation of offshore wind assumptions

The table and figure overleaf show the impact of sequentially updating each hurdle rate parameter (or group of parameters, where appropriate). The reconciliation indicates that:

- The proposed pre-tax real CPI hurdle rate for offshore wind is 0.6% higher than the assumption applied at AR6.
- As expected, there is an increase in the overall hurdle rate from reflecting that current interest rates are higher than in 2018 (impacting both the risk-free rate and return on debt) and that the corporate tax rate has also increased since 2018. Together, these two factors increase the pre-tax real hurdle rate by 1.3%.
- Broadly, the combination of other changes could be taken as representing a different view in relation to:
    - Assessed risk and the associated required returns for this technology, relative to the 2018 study and AR6 adjustments.
    - The characteristics of a representative project, in terms of both gearing and the effective tax rate.
    - Together, these factors reduce the pre-tax real hurdle rate by -0.7%. This does not reflect a view that technology-specific risk has necessarily reduced since AR6 (or 2018). This is because our methodology has sought to estimate hurdle rates afresh based on current evidence, rather than starting from the AR6 assumptions as a base (given that these were based on evidence from 2018, which was in turn based on survey evidence from 2015).

Table 6.3: Offshore wind - AR6 compared to CEPA 2025 – Pre-tax real CPI hurdle rate



Item	Hurdle rate	Return on equity	Return on debt	Description
AR6	**8.3%**	**19.8%**	**2.3%**	The AR6 hurdle rate assumption for offshore wind, which combines the EE 2018 estimate with a 2% uplift to account for TNUoS and supply chain risk.
A. Corporate tax	+0.3%	+1.1%	-	Update EE's 2018 effective tax rate (ETR) assumption from 10.2% to 15.0%, in proportion to the movement in the corporate tax rate between 2018 and 2025 (from 17% to 25%). A higher ETR increases the pre-tax return on equity.
B. Interest rates	+1.1%	-2.9%	+2.2%	Update the risk-free rate and ERP for current economic conditions. Real TMR remains at ~6.8%, but the real risk-free rate is higher (from 0% to 1.6%, reflecting rising interest rates) and the ERP correspondingly lower (from 6.8% to 5.2%). Because EE's assumed equity beta is above 1, this reduces the return on equity. Update the return on debt to reflect increase in corporate bond yields (but keeping EE's 2018 credit rating assumption). When this step is applied, the 2018 EE gearing assumption (77.5% debt) is still in place – meaning that the increase in the return on debt outweighs the reduction in the return on equity.
C. Remove AR6 adj.	-2.0%	-	-	Remove adjustment applied by DESNZ to EE 2018 hurdle rate estimate for AR6.
D. Credit rating	+0.3%	-	+0.4%	Update credit rating assumption to BB+, which is lower than the EE 2018 assumption of BBB-.
E. Debt raising costs	+0.1%	-	+0.2%	Include assumed debt transaction costs, which were not part of the EE 2018 method.
F. Asset / debt beta	+0.9%	+4.2%	-	Update the asset beta and debt beta assumptions. The asset beta changes from 0.77 to 0.75. However, these values are not directly comparable because EE 2018 assumed a debt beta of 0.23 and we assume 0.
G. Common ETR	+0.7%	+3.0%	-	Reflect our assumption that the corporate tax rate (25%) can apply to all technologies, instead of the 15% ETR applied at step A. A higher ETR increases the pre-tax return on equity.
H. Common gearing	-0.8%	-12.8%	-	Reflect our assumption that a common 50% gearing assumption can apply to all technologies, replacing the EE 2018 assumption of 77.5% for offshore wind. As described in Section 4.4.5, while the impact on the pre-tax return on equity is large, the effect on the overall hurdle rate is smaller.
CEPA 2025	**8.9%**	**12.6%**	**5.1%**	The assumption proposed by CEPA in this report. Overall 0.6% higher than EE 2018.

Source: CEPA analysis.

Due to the way that the parameters interact, to some extent the impacts shown reflect the order in which we have changed each parameter. The table below shows the impact of changing the assumptions in a different order. This indicates that the impact of the asset beta / debt beta assumptions, common ETR assumption, and common gearing assumption are particularly sensitive to the order in which the assumption changes are made. This further illustrates the difficulty of attributing a specific hurdle rate impact to a specific parameter change.

Table 6.4: Alternative sequences of parameter adjustments

Sequence 1				Sequence 2			
Item	**Hurdle rate**	**Return on equity**	**Return on debt**	**Item**	**Hurdle rate**	**Return on equity**	**Return on debt**
AR6	**8.3%**	**19.9%**	**2.3%**	**AR6**	**8.3%**	**19.9%**	**2.3%**
A. Corporate tax	+0.3%	+1.1%	-	A. Corporate tax	+0.3%	+1.1%	-
B. Interest rates	+1.1%	-2.9%	+2.2%	B. Interest rates	+1.1%	-2.9%	+2.2%
C. Remove AR6 adj.	-2.0%	-	-	**C. Common ETR**	**+0.5%**	**+2.4%**	**-**
D. Credit rating	+0.3%	-	+0.4%	**D. Common gearing**	**-0.2%**	**-9.3%**	**-**
E. Debt raising costs	+0.1%	-	+0.2%	E. Credit rating	+0.2%	-	+0.4%
F. Asset / debt beta	**+9.0%**	**+4.2%**	**-**	F. Remove AR6 adj.	-2.0%	-	-
G. Common ETR	**+0.7%**	**+3.0%**	**-**	G. Debt raising costs	+0.1%	-	+0.2%
H. Common gearing	**-0.8%**	**-12.8%**	**-**	**H. Asset / debt beta**	**+0.6%**	**+1.3%**	**-**
CEPA 2025	**8.9%**	**12.6%**	**5.1%**	**CEPA 2025**	**8.9%**	**12.6%**	**5.1%**

Source: CEPA analysis.

6.1.3. Reconciliation of other technologies

The table overleaf sets out the same reconciliation as described for offshore wind above (using the first sequence of assumption changes). For simplicity, we present only the impact on the overall hurdle rate (rather than also on the return on equity and return on debt in isolation).

Table 6.5: Impact of updated assumptions on the hurdle rate estimates (pre-tax real CPI)

Technology		A	B	C	D	E	F	G	H		
	AR6 replicated	Update ETR	Update interest rates	Remove AR6 adjustments	Update credit rating	Debt transaction costs	Asset beta / debt beta	Common ETR	Common gearing	Total change	CEPA 2025
Solar PV	**5.0%**	0.2%	1.3%		0.4%	0.1%	0.9%	0.5%	-0.8%	2.6%	**7.6%**
Onshore wind	**6.1%**	0.2%	1.4%	-1.0%	0.0%	0.1%	0.9%	0.6%	-0.7%	1.5%	**7.6%**
AD	**8.2%**	0.4%	0.6%		0.0%	0.1%	-1.6%	0.6%	-0.6%	-0.6%	**7.6%**
Sewage gas	**7.0%**	0.6%	0.7%		0.3%	0.1%	-0.8%	0.0%	-0.2%	0.6%	**7.6%**
Landfill gas	**5.9%**	0.3%	0.9%		0.3%	0.1%	-0.2%	0.6%	-0.2%	1.7%	**7.6%**
Hydropower	**5.3%**	0.4%	1.2%		0.6%	0.1%	1.9%	0.0%	-0.6%	3.6%	**8.9%**
Biomass – unabated	**9.7%**	0.9%	0.2%		0.0%	0.1%	-2.1%	0.0%	0.1%	-0.8%	**8.9%**
Offshore wind	**8.3%**	0.3%	1.1%	-2.0%	0.3%	0.1%	0.9%	0.7%	-0.8%	0.6%	**8.9%**
Energy from waste	**7.5%**	0.3%	0.8%		-0.3%	0.1%	-0.1%	0.7%	-0.2%	1.3%	**8.9%**
ACT	**8.0%**	0.4%	0.7%		0.3%	0.1%	0.1%	0.8%	-0.2%	2.1%	**10.1%**
Deep geothermal	**18.6%**	1.7%	-1.8%		-0.3%	0.1%	-7.4%	0.0%	-0.8%	-8.5%	**10.1%**
Tidal stream	**9.3%**	0.8%	0.3%		0.9%	0.1%	0.7%	0.0%	-0.8%	2.1%	**11.4%**
Wave	**8.5%**	0.4%	0.5%		0.9%	0.1%	0.9%	0.9%	-0.9%	2.9%	**11.4%**
CCGT – unabated	**7.2%**	0.7%	0.5%		0.4%	0.1%	-0.5%	0.0%	0.4%	1.6%	**8.9%**
OCGT – unabated	**6.7%**	0.5%	0.9%		0.3%	0.1%	0.9%	0.0%	-0.6%	2.2%	**8.9%**
Gas reciprocating engine – unabated	**6.7%**	0.5%	0.9%		0.3%	0.1%	0.9%	0.0%	-0.6%	2.2%	**8.9%**
Gas - CCUS - maturing[1]	**8.8%**	0.8%	0.6%		0.3%	0.1%	0.1%	0.0%	-0.5%	1.3%	**10.1%**
Biomass - CCUS -maturing[1]	**8.9%**	0.8%	0.6%		0.3%	0.1%	0.0%	0.0%	-0.5%	1.2%	**10.1%**
Remote island wind[2]	**6.1%**	0.2%	1.4%	-1.0%	0.3%	0.1%	1.8%	0.7%	-0.8%	2.8%	**8.9%**
Floating offshore wind[2]	**9.8%**	0.3%	1.1%	-3.5%	1.0%	0.1%	2.8%	0.9%	-1.0%	1.6%	**11.4%**

Source: CEPA analysis. Notes: (1) We have included only the maturing variants in this comparison. (2) Floating offshore wind and remote island wind are not shown, as these were not included in Europe Economics' 2018 analysis.

The analysis in Table 6.5 indicates that, as described for offshore wind, there are some expected changes associated with updating for current economic conditions (as reflected in the real risk-free rate and corporate bond yields) and the increase in the corporate tax rate. Unlike the other technologies, the combined impact of these factors on deep geothermal is slightly negative (-0.1%). This reflects that in the 2018 Europe Economics study, geothermal was assumed to have a higher equity beta (7.1) than the other technologies. This means that the reduction in the return on equity (due to lower ERP) is larger than for the other technologies and outweighs the increase in the return on debt.

The combined impact of the other assumption changes is, as described for offshore wind, more challenging to interpret because of the interactions between parameters. However, we can draw out some observations:

- The impact of adopting a common (rather than technology-specific) tax rate does not impact all technologies equally, because some were already assumed to pay the full corporate tax rate. The pre-tax real hurdle rate increases for those technologies previously assumed to have a lower effective tax rate. The increase is 0.5-0.9%, depending on the technology.
- The application of a common gearing assumption also impacts some technologies more than others, depending on their starting gearing assumption and interactions with other parameters.
- Our assumptions for geothermal produce a much lower real hurdle rate compared to Europe Economics' 2018 study. We understand that this reflects that the Europe Economics assumption related to the pre-drilling phase, which is different from the blended whole life rate we discuss in Section 5.1.7.
- The risk categorisation of some technologies, as assessed in Section 3 and tested through the investor survey, has had an impact. In particular:
    - Adopting a low-medium risk rating for solar PV and a medium risk rating for hydropower appears to have contributed materially to the increase for these technologies.
    - Our qualitative risk rating concludes that the biofuel technologies (AD, sewage gas, biomass, landfill gas, ACT and EfW) have lower risk than floating offshore wind, tidal and wave – reducing their assumed asset beta and cost of debt. For AD and biomass, this more than offsets the hurdle rate increase resulting from the update of market-wide parameter and tax assumptions.

Relatedly, some aspects of the methodology that we have recommended for DESNZ necessarily brings some technologies closer together compared to AR6 / Europe Economics 2018. In particular, this is the effect of the five-level risk categorisation and common ETR/gearing assumptions, because previously each technology was assumed to have a unique hurdle rate. For example, this can be seen for tidal stream and wind. Whereas previously tidal stream was assessed to have a higher hurdle rate than wave, we have proposed to assign these technologies the same risk rating and hurdle rate. This reflects our view that more granular distinctions between technologies may be spurious, given the level of uncertainty involved.

This latter point does imply that some changes from the AR6 assumptions are driven by differences between the approach taken in our study compared to past studies. In our view, this is outweighed by the benefits of adopting the proposed methodology, in terms of DESNZ's ability to update the estimates and test the assumptions with stakeholders using a simple risk framework.

Finally, as discussed in Section 4.6, the level of confidence in some estimates varies with the amount of supporting evidence that is available. While there are reasonable cross-checks available for the more established technologies, for others there is relatively limited evidence – and the proposed assumptions rely substantially on the assumed risk rating and assessed similarities to other technologies.

7. FUTURE UPDATES

DESNZ has asked CEPA to consider how the estimates set out in this report can be "future proofed" – noting that the underlying parameter of the hurdle rate estimates can evolve over time.

We suggest that a practical approach to future updates is as follows:

- DESNZ can frequently (e.g., annually, or more frequently if desired) update many of the technology-neutral parameters discussed in Section 4.4 to reflect either:
    - Changes in macroeconomic conditions, which impact the risk-free rate, return on debt and inflation.
    - Changes in regulatory precedent, which may impact the TMR, ERP and debt transaction cost assumptions.
    - Change in government tax policy, which impacts the corporate tax rate.
    - The information required to make these updates is readily available, and can be implemented with relatively limited effort. This will flow through to the technology-specific hurdle rates.
- DESNZ can also frequently (e.g., annually) undertake a *partial* update of:
    - The underlying asset beta and credit rating estimates discussed in Section 4.1. A partial update would involve retaining the same comparator sample, but refreshing the empirical beta and credit rating estimates that underpin the percentiles that each risk rating is linked to.
    - The common gearing assumption which, as noted in Section 4.4.5, is informed by a range of evidence, including the average gearing of the asset beta comparator sample.
    - This also relies on readily available information.
- DESNZ can less frequently (e.g., every 2 years) undertake a *full* update of the asset beta and credit rating estimates discussed in Section 4.1. A full update would involve reviewing the comparator sample. This is a far more involved process than the partial update described above, as it requires a level of research into the comparators. We consider it is reasonable to undertake a full update less often, as the underlying comparator sample is less likely to change rapidly.
- DESNZ can also less frequently update the qualitative risk assessment. This would involve adjusting certain risk ratings if new information becomes available – for example, on an ad hoc basis if a new policy decision is made in relation to one of the assumed revenue models, or if it is no longer appropriate to apply the FOAK uplift to a particular technology. This process could be undertaken by DESNZ internally, but requires a level of judgement.
- Finally, DESNZ can also choose to undertake a full refresh of the investor survey evidence. This could involve either re-running the survey designed for this report, or directly surveying stakeholders on whether the set of parameters established through this study and/or the qualitative risk assessment have changed.

Appendix A TECHNOLOGIES

This appendix provides a more detailed description of each technology, and the basis for the classifications set out in Section 2.

Table A.1: Solar PV (>5MW)

Technology	Solar PV (>5MW)
Description	Large-scale solar PV (>5MW) comprises ground-mounted solar systems that generate utility-scale solar electricity.[135]
Development status (UK)	Large-scale solar PV is a mature, established technology in the UK. The Environmental Audit Committee recently found that solar is the cheapest form of power.[136] In 2023, a Solar Taskforce was established to develop the UK's Solar Roadmap.
Generation characteristics	Variable renewable.

Table A.2: Onshore wind (>5MW)

Technology	Onshore wind (>5MW)
Description	Large-scale onshore wind farms (>5MW) consist of multiple wind turbines installed on land to generate electricity from wind energy.[137]
Development status (UK)	Large-scale onshore wind is a mature, established technology. Tight planning restrictions in England have meant that deployment there has historically been more limited.
Generation characteristics	Variable renewable.

Table A.3: Offshore wind (>5MW)

Technology	Offshore wind (>5MW)
Description	Large-scale offshore wind farms (>5MW) have wind turbines constructed in bodies of water, typically in the ocean, to take advantage of stronger and more consistent winds offshore compared to on land.[138]
Development status (UK)	An established, mature technology in the UK. The UK is a world leader in offshore wind, with the largest fleet of turbines outside China. Offshore wind is widely expected to provide the bulk of the UK's electricity in future.
Generation characteristics	Variable renewable.

[135] DESNZ (2024), *Energy Trends June 2024*, Table 6.1. Available at: https://www.gov.uk/government/statistics/energy-trends-section-6-renewables.

[136] Houst of Commons Environmental Audit Committee (2023), *Technological innovations and climate change: onshore solar power*, 4 May 2023, p.4. Available at: https://committees.parliament.uk/publications/39836/documents/193860/default/.

[137] House of Commons Business, Energy and Industrial Strategy Committee (2023), *Decarbonisation of the power sector*, 28 April 2023, p.33-34. Available at: https://committees.parliament.uk/publications/39325/documents/193081/default/.

[138] House of Commons Business, Energy and Industrial Strategy Committee (2023), p.29-31.

Table A.4: Floating offshore wind

Technology	Floating offshore wind
Description	Floating offshore wind can be deployed in deeper waters where wind speeds are more consistent. Floating offshore wind farms comprise wind turbines installed on floating platforms (substructures) anchored to the seabed by means of flexible anchors, chains or steel cables.[139]
Development status (UK)	A relatively new technology that has not yet reached commercial scale deployment in the UK. Scotland, the Celtic Sea and the North Sea are three main regions for floating offshore wind development. Grid connectivity, ports and logistics, supply chain development, and cost relative to fixed bottom offshore wind are key challenges facing the floating offshore wind sector.
Generation characteristics	Variable renewable.

Table A.5: Remote island wind

Technology	Remote island wind
Description	Onshore wind projects situated on the remote islands of Great Britain, particularly in Scotland. [140]
Development status (UK)	This is a mature technology in the UK.
Generation characteristics	Variable renewable.

Table A.6: Deep geothermal

Technology	Geothermal
Description	Energy generated and stored, in the form of heat, in rocks and soils beneath the surface of the solid earth. The focus of this stud is deep geothermal systems, where the heat is of a high enough temperature to be converted into usable electricity.
Development status (UK)	Deep geothermal is not widely established in the UK.[141] The high capital cost and risk during the drilling phase, and lower potential capacity, compared to other renewable sources are seen as barriers to the deployment of geothermal energy.[142] Construction started in early 2024 on the first geothermal power plant in GB, which will generate renewable electricity.[143]
Generation characteristics	Dispatchable (although in practice, we understand that a conventional geothermal plant would tend to run as baseload).

[139] House of Commons Business, Energy and Industrial Strategy Committee (2023), p.31.

[140] BEIS (2017), *Impact assessment - classifying remote island wind as a separate technology in the Contracts for Difference (CfD) scheme*, 2017, p. 3. Available at: https://assets.publishing.service.gov.uk/media/5b16baa340f0b634c61412fd/F_-_RIW_Impact_Assessment.pdf.

[141] Abesser, C. et al (2023), *The case for deep geothermal energy – unlocking investment at scale in the UK*, p.18. Available at: https://evidencehub.northeast-ca.gov.uk/downloads/665/nel1435a-geothermal-white-paper-report-v10.pdf.

[142] House of Lords Library (2023), *Geothermal energy: Potential for heat and power in Great Britain*, 28 June 2023. Available at: https://lordslibrary.parliament.uk/geothermal-energy-potential-for-heat-and-power-in-great-britain/.

[143] Open Access Government (2024), *The UK's first geothermal power plant holds promise for a greener and more sustainable future*, 6 February 2024. Available at: https://www.openaccessgovernment.org/the-uks-first-geothermal-power-plant-holds-promise-for-a-greener-and-more-sustainable-future/173218/.

Table A.7 Hydro (>5MW and <50MW)

Technology	Hydro[144]
Description	Energy derived from flowing water used to drive turbines. The plants are either with or without dams and reservoirs, which determines the scale of generation.
Development status (UK)	An established mature technology that has been employed in the UK for decades. The CfD scheme currently applies to projects of between 5-50MW installed capacity. We understand that there is currently no development pipeline for projects of this size in the UK, although there is a pipeline of smaller projects.
Generation characteristics	Dispatchable, assuming that the hydropower schemes in this category would have a small reservoir.

Table A.8: Advanced conversion technologies (ACT)

Technology	ACT
Description	ACTs generate electricity using a gas or liquid that is formed by the gasification or pyrolysis of biomass or waste.[145]
Development status (UK)	Experience with advanced ACT is relatively limited in the UK. The eligibility criteria in the CfD allocations for ACT has changed over time in an attempt to incentivise more efficient technologies. While ACT projects have been developed to generate electricity in the UK since 2008[146], there are few examples of the 'advanced ACT' currently eligible for CfD contracts.[147]
Generation characteristics	Dispatchable.

Table A.9: Anaerobic digestion (>5MW) and sewage gas

Technology	AD and sewage gas
Description	Anaerobic digestion (AD) is the breakdown of organic material by microorganisms in the absence of air. Biogas produced by AD can be combusted to produce electricity, or purified for injection into the gas network or for use as transport fuel.[148] We have grouped AD and sewage gas together, on the understanding that the latter is a specific type of AD and the risk profile is therefore similar.
Development status (UK)	AD technologies are considered well-proven. They have been used in the UK for decades to treat sewage, with more recent interest in using AD to process a wider range of materials.
Generation characteristics	Dispatchable - once produced, biogas can be combusted when required.

[144] IRENA, *Hydropower*. Available at: https://www.irena.org/Energy-Transition/Technology/Hydropower.

[145] BEIS (2018), *Guidance note for Advanced Conversion Technologies*, December 2018, p.3. Available at: https://assets.publishing.service.gov.uk/media/5f6a5703e90e077ca433503d/ACT_Guidance_-_Compliance_with_the_ACT_Efficiency_Standard_criterion.pdf.

[146] Vismudi (2015), *The Growth of Advanced Conversion Technologies for the Treatment of Waste in the UK*, August 2015, p.4. Available at: https://task36.ieabioenergy.com/wp-content/uploads/sites/34/2016/06/The-Growth-of-ACT-for-treatment-of-waste-in-the-UK.pdf.

[147] NNFCC (2020), *Review of BEIS assumptions underlying estimates of power generation costs for ACT and EfW with CHP*, December, p. 10.

[148] DEFRA (2021), *Official Statistics – Section 3: Anaerobic digestion*, 9 December 2021. Available at: https://www.gov.uk/government/statistics/area-of-crops-grown-for-bioenergy-in-england-and-the-uk-2008-2020/section-3-anaerobic-digestion.

Table A.10: Biomass (dedicated / conversions, with / without CHP, unabated / with CCUS)

Technology	Biomass
Description	Biomass involves the use of solid biomass, such as plant or animal matter, which can be directly combusted to produce hot flue gases and steam. These pass through turbines to produce electricity with the residual heat recovered and used for industrial processes.[149] Combined heat and power (CHP) is a process that utilises the heat that is a byproduct of electricity generation. Carbon capture use and storage (CCUS) captures and stores carbon dioxide emissions.
Development status (UK)	The technologies available for the direct combustion of solid fuels are very mature and reliability is considered high.[150] In 2013, the UK removed financial incentives for energy-only biomass powerplants in favour of more efficient biomass CHP plans.[151] The 2023 Biomass Strategy noted that while biomass electricity and CHP without carbon capture is an important contributor to the electricity system, it did not anticipate government support for deployment of any new, large scale biomass plants without post combustion CCUS
Generation characteristics	Dispatchable, noting that solid fuel fired renewable CHP systems are less capable of meeting fluctuating heat and power demand compared to gas or liquid fuel fired systems, preferring relatively consistent demand profiles.[152]

Table A.11: Landfill gas

Technology	Landfill gas
Description	Gas, produced during the anaerobic decomposition of biodegradable waste sent to landfill, is used to generate electricity.
Development status (UK)	An established, mature technology in the UK. However, the amount of electricity produced from landfill gas has steadily decreased from its peak in 2011. This is due to the reduction in the volume of biodegradable municipal waste sent to landfill[153], along with the load factor (electricity produced as a share of total generating capacity).
Generation characteristics	Baseload but not dispatchable – landfill gas sites have no capacity to store gas, which is burnt as it is collected.

[149] BEIS (2021), *Combined Heat and Power – Technologies*, December 2021, Section 4.1-4.2. Available at : https://assets.publishing.service.gov.uk/media/602a7b6bd3bf7f031e1bdcdd/Part_2_CHP_Technologies_BEIS_v03.pdf.

[150] BEIS (2021), Section 4.1-4.2.

[151] Power Engineering International (2013), *UK government uphold CHP ahead of dedicated biomass*, 19 July 2013. Available at: https://www.powerengineeringint.com/decentralized-energy/uk-government-upholds-chp-ahead-of-dedicated-biomass/.

[152] BEIS (2021), Section 4.1-4.2.

[153] DEFRA (2024), *Official Statistics: UK statistics on waste*, 26 September 2024, Figure 2. Available at: https://www.gov.uk/government/statistics/uk-waste-data/uk-statistics-on-waste#biodegradable-municipal-waste-bmw-sent-to-landfill.

Table A.12: Energy from waste (with / without CHP)

Technology	Energy from waste with CHP
Description	Energy from waste (EfW) involves taking waste, diverted from landfill, and turning it into a useable form of energy. [154] With CHP this results in the production of both heat and electricity. The waste used is that remaining after recycling, or where it is not practicable to reclaim materials.[155]
Development status (UK)	Established, mature technology. The introduction of landfill diversion targets in the 1990s has driven the development of EfW plants in the UK.[156]
Generation characteristics	Dispatchable.

Table A.13: Tidal stream and tidal range

Technology	Tidal stream and tidal range
Description	Tidal stream generates electricity by harvesting kinetic energy from flowing water driven by tidal currents. Tidal range captures the potential energy created by differences in water levels at high and low tide.
Development status (UK)	Whilst tidal stream energy is considered to be in its infancy globally, the UK is at the forefront of development with the largest pipeline of projects globally.[157, 158] However, it has not yet reached commercial scale deployment in the UK. Tidal range is considered less mature than tidal stream.
Generation characteristics	Not dispatchable, but a fully predictable (time and strength) renewable energy source, whose output is uncorrelated with wind and solar.[159]

Table A.14: Wave

Technology	Wave
Description	Energy is generated by converting the energy within ocean waves into electricity.
Development status (UK)	There has been testing of half-scale devices in UK by Wave Energy Scotland (Mocean and AWS). The technology still, however, appears to be in its infancy at present and has not yet reached commercial scale deployment in the UK. We understand from DESNZ that the development of wave energy is considered to be around a decade behind tidal.
Generation characteristics	Variable renewable, uncorrelated with wind and solar.[160]

[154] DEFRA (2014), *Energy from waste – A guide to the debate*, February 2014, p.1.Available at: https://assets.publishing.service.gov.uk/media/5a7c77ade5274a559005a113/pb14130-energy-waste-201402.pdf.

[155] GDF Suez, *Energy from waste*, Available at: https://www.suez.co.uk/en-gb/our-offering/communities-and-individuals/education-tools-and-resources/what-happens-to-waste/general-waste/energy-from-waste.

[156] DEFRA (2014), p.1.

[157] LSE (2023), *What is tidal stream energy?*, 22 June 2023. Available at: https://www.lse.ac.uk/granthaminstitute/explainers/what-is-tidal-stream-energy/.

[158] IEA-OES (2024), *Annual Report: An Overview of Ocean Energy Activities in 2023*, p.196. Available at: https://www.ocean-energy-systems.org/documents/79878-oes-annual-report-2023.pdf/.

[159] Frazer-Nash (2023), *Review of Technical Assumptions and Generation Costs – Levelised Cost of Electricity from Tidal Stream Energy*, May 2023, p.7. Available at: https://assets.publishing.service.gov.uk/media/655372484ac0e1001277d819/tidal-lcoe-report.pdf.

[160] Pacific Northwest National Laboratory (2019), *Understanding the Grid Value Proposition of Marine Energy: A Literature Review*, July 2019, p.21. Available at: https://www.osti.gov/servlets/purl/1643688.

Table A.15: Nuclear technologies

Technology	Nuclear
Description	Nuclear energy is energy produced through nuclear reaction. In the UK context, nuclear can be separated into: • 'Large' GW-scale nuclear developments. • Small modular reactors (SMRs) • Advanced modular reactors (AMRs). SMRs are similar to existing water-cooled nuclear reactors but on a smaller scale, while AMRs use novel cooling systems or fuels but share the same modular build principles as SMRs. All currently operating commercial reactors are considered generation II reactors. Most SMRs and new reactors under development are considered generation III, with enhanced safety and fuel efficiency. AMRs are considered the newest technology, forming generation IV.
Development status (UK)	Large-scale reactors are an established technology in the UK. Two large-scale reactors are currently under development – Hinkley Point C and Sizewell C – with Sizewell C approaching FID.[161] SMRs are still commercially immature, and AMRs are not yet to reach the demonstration stage: • In 2021, the UK Government provided £210 million in grant funding to the Rolls-Royce SMR programme to further develop their design, with a view to deploying one of the world's first FOAK SMRs in the early 2030s.[162, 163] • The AMR R&D programme aims to demonstrate High Temperature Gas Reactor (HTGR) technology by the early 2030s, to support potential commercial AMRs supporting the net zero by 2050 target.[164]
Generation characteristics	Baseload.

[161] DESNZ (2024), *Civil nuclear: Roadmap to 2050*, January 2024, p.6. Available at: https://assets.publishing.service.gov.uk/media/65c0e7cac43191000d1a457d/6.8610_DESNZ_Civil_Nuclear_Roadmap_report_Final_Web.pdf.

[162] UKRI, *Low cost nuclear*. Available at: https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/low-cost-nuclear/.

[163] DESNZ (2024), *Advanced nuclear technologies*, 6 December 2024. Available at: https://www.gov.uk/government/publications/advanced-nuclear-technologies/advanced-nuclear-technologies#small-modular-reactors-smrs.

[164] DESNZ (2024), *Advanced Modular Reactor Research, Development and Demonstration Programme: successful organisations and programme summary*, 30 January 2024. Available at: https://www.gov.uk/government/publications/advanced-modular-reactor-amr-research-development-and-demonstration-programme-successful-organisations.

Table A.16: Pumped hydro energy storage (PHES)

Technology	PHES
Description	PHES uses two water reservoirs at different elevations to store and generate electricity. During periods of low demand, water is pumped to the higher reservoir using excess electricity, and during high demand, water is released to the lower reservoir through turbines to generate power. Storage durations for PHES can range from 8-32 hours. [165]
Development status (UK)	PHES is considered a very mature technology and was rated the highest TRL (9) by developers in a recent survey of storage technologies.[166] It has been close to 40 years since a PHES project has been commissioned in the UK.[167] However, there are several large-scale projects in the development pipeline.
Generation characteristics	Dispatchable.

Table A.17: Lithium-based batteries

Technology	Lithium-based batteries
Description	This battery technology stores electrical energy using lithium electrodes. Lithium-ion batteries have been extensively used in the consumer energy and EV sectors, but can also be scaled to provide grid storage. Storage durations for lithium batteries range from 1-8 hours.[168]
Development status (UK)	Lithium batteries are considered a mature technology and were considered to have the highest TRL (9) by developers in a recent survey.[169] Battery energy storage is expected to form the majority of energy storage in the UK by 2050, with this being dominated by lithium-based technologies.[170]
Generation characteristics	Dispatchable.

[165] LCPDelta and Regen (2024), *Scenario Deployment Analysis for Long-Duration Electricity Storage*, January 2024, p.19. Available at: https://assets.publishing.service.gov.uk/media/659be546c23a1000128d0c51/long-duration-electricity-storage-scenario-deployment-analysis.pdf.

[166] LCPDelta and Regen (2024), p. 34.

[167] BiGGAR Economics (2023), *The Economic Impact of Pumped Storage Hydro*, May 2023, p.3. Available at: https://www.scottishrenewables.com/assets/000/003/039/The_Economic_Impact_of_Pumped_Storage_Hydro_original.pdf?1683649197.

[168] LCPDelta and Regen (2024), p.19.

[169] LCPDelta and Regen (2024), p. 34.

[170] Rho Motion and the Faraday Institution (2023), *Market and Technology Assessment of Grid-Scale Energy Storage required to Deliver Net Zero and the Implications for Battery Research in the UK*, September 2023, pp.31-32. Available at: https://www.faraday.ac.uk/wp-content/uploads/2023/09/20230908_Rho_Motion_Faraday_Institution_UK_BESS_Report_Final.pdf.

Table A.18: Novel long-duration energy storage (LDES) technologies

Technology	Novel LDES
Description	This category captures a range of less established storage technologies including: [171] • **Liquid air energy storage (LAES)** stores electricity by liquefying air into tanks and generates electricity by expanding the liquefied air in a turbine (4-12 hours storage). • **Compressed air energy storage (CAES)** compresses and stores air in underground caverns using surplus or off-peak power. During times of peak power usage, air is heated which drives a turbine to generate power (4-8 hours storage). • **Flow batteries** generate energy through the controlled reaction of redox pairs, two substances which undergo electrochemical reactions in which electrons are transferred between them. The capacity of the battery is based on the size of the tanks, making flow batteries easily scalable (duration range 4-8 hours). • **Gravitational** energy storage stores potential energy, by using electricity to raise large masses to a certain height over the charge cycle (6-10 hour duration).[172]
Development status (UK)	While some technologies in this group are approaching higher TRLs, commercial-scale deployment is not yet well advanced. The battery technologies in this group have TRLs in a range of 6-9 (although can be lower in some cases depending on the specific chemistry employed).[173, 174] Generally, a TRL of 8-9 is required for a technology to commence small-scale commercial trials.[175] At present: • There are a number of flow batteries currently operational in the UK, including **vanadium flow batteries** installed by Invinity.[176] • There are currently no operational **CAES** sites in the UK. • The world's first grid-scale **LAES** plant commenced operation in 2018 in Manchester.[177] The developer, Highview Power, has since secured funding for its first commercial-scale LAES plant in the UK and is progressing other UK-based projects. [178] • Some of the world's first grid-scale **gravitational storage** systems have been deployed in China and the US.[179] In the UK, front-end engineering and design (FEED) studies and small-scale demonstration projects have been developed.[180]
Generation characteristics	Dispatchable.

[171] LCPDelta and Regen (2024), pp.19-20.

[172] LCPDelta and Regen (2024), p.19.

[173] LCPDelta and Regen (2024), pp.19-20.

[174] Marek, B. et al (2023), *Clean Energy Technology Observatory: Battery Technology in the European Union - 2023 Status Report on Technology Development, Trends, Value Chains and Markets*, December 2023, p.4. Available at: https://publications.jrc.ec.europa.eu/repository/handle/JRC135406.

[175] ARENA (2014), *Technology Readiness Levels for Renewable Energy Sectors*, p.2. Available at: https://arena.gov.au/assets/2014/02/Technology-Readiness-Levels.pdf.

[176] Invinity Energy Systems, *Invinity's Utility-Grade Energy Storage Has Been Deployed Across the World.* Available at: https://invinity.com/flow-battery-case-studies/.

[177] University of Brighton, *Future Energy: Liquid Air Energy Storage (LAES) research*. Available at: https://www.brighton.ac.uk/research/research-news/feature/b-liquid-air-energy-storage.aspx.

[178] Highview Power, *UK projects.* Available at: https://highviewpower.com/projects/#uk-projectshttps://highviewpower.com/projects/#uk-projects.

[179] Enel (2024), *Gravity storage becomes reality*, 21 May 2024. Available at: https://www.enelgreenpower.com/media/news/2024/05/gravity-storage-energy-vault.

[180] Gravicity (2023), *Secure £912k LODES grant funding*, 16 November 2023. Available at: https://gravitricity.com/cool_timeline/912000-grant/ and https://gravitricity.com/projects/.

Table A.19: New compound batteries.

Technology	New compound batteries
Description	This group includes other types of battery storage technologies with lower TRLs (i.e., 5 or lower), indicating technologies that are still in the development and early demonstration phase. For example, these include technologies such as iron-air, copper-zinc, sodium-ion and sulphur-bromide batteries.[181, 182]
Development status (UK)	These technologies are still in the relatively early stages of development. We have not identified existing grid-scale / commercial deployments of these 'next generation' technologies in the UK.
Generation characteristics	Dispatchable.

Table A.20: Natural gas generation (OCGT/CCGT/reciprocating engines, with / without CHP, unabated / with CCUS)

Technology	Natural gas generation
Description	Combined cycle gas turbines (**CCGT**) use both gas and steam turbines to generate electricity. CCGT is highly efficient and can adjust output relatively quickly. Open cycle gas turbines (**OCGT**), or single cycle gas turbines, use only gas turbines to generate electricity. They have lower efficiency, but higher ramp rates compared to CCGT. Gas **reciprocating engines** are internal combustion engines that use the reciprocating motion of pistons to convert energy from the combustion of gaseous fuels into mechanical energy, which is then used to generate electricity. Many gas reciprocating engines have faster ramp rates and greater efficiency than OCGT technologies.[183]
Development status (UK)	Gas CCGT, OCGT and reciprocating engines are all very mature technologies that have been extensively in the UK. Despite a long-term transition away from fossil fuels, current policies are signalling that more gas capacity will be required to maintain energy reliability and security. From February 2026 new or substantially refurbishing combustion power plants must now demonstrate decarbonisation readiness (DR) through evidencing the ability to convert to either Carbon Capture Usage and Storage retrofit or hydrogen firing.[184][185]
Generation characteristics	Dispatchable.

[181] LCPDelta and Regen (2024), pp.19-20.

[182] Marek, B. et al (2023), p.4.

[183] NS Energy (2022), *Small gas engines: Will batteries hollow out market for small engines in UK?*, 30 November 2022. Available at: https://www.nsenergybusiness.com/analysis/small-gas-engines-will-batteries-hollow-out-market-for-small-engines-in-uk/?cf-view

[184] DESNZ (2024), *Decarbonisation readiness,* October 2024. Available at: https://assets.publishing.service.gov.uk/media/670d4cdd92bb81fcdbe7b7db/decarbonisation-readiness-consultation-government-response.pdf.

[185] DESNZ (2024), *Energy Secretary takes action to reinforce UK energy supply*, 12 March 2024. Available at: https://www.gov.uk/government/news/energy-secretary-takes-action-to-reinforce-uk-energy-supply

Table A.21: Hydrogen to power (OCHT/CCHT, with / without CHP)

Technology	Hydrogen to power
Description	CCHT / OCHT plants fired with hydrogen or hydrogen-natural gas blends are considered a potential replacement for current natural gas-fired technologies (see above).
Development status (UK)	There are a wide range of specifications that could potentially apply to this technology group, in particular in relation to turbine size and hydrogen blending rates. Small turbines with lower blending rates can be considered relatively mature. However, there are no operating examples of larger turbines firing at 100% hydrogen.
Generation characteristics	Dispatchable.

Table A.22: Hydrogen electrolysers

Technology	Hydrogen electrolysers
Description	Hydrogen electrolysers split water into hydrogen and oxygen through electrolysis. Hydrogen produced can either be stored or used to generate electricity.
Development status (UK)	Hydrogen electrolysis is considered a relatively mature technology and was rated at a TLR of 8 by developers in a recent survey.[186] To date, typical installations in the UK have been under 1 MWe, primarily supplying hydrogen for transport applications.[187] The UK government is strongly supportive of a domestic hydrogen industry. The updated UK Hydrogen Strategy sets out targets to have up to 10GW of low carbon hydrogen production capacity by 2030, with at least half coming from electrolytic 'green' hydrogen.
Generation characteristics	n/a

Table A.23: Interconnectors

Technology	Interconnectors
Description	Electricity interconnectors are high-voltage cables that connect the electricity systems of neighbouring regions. Different types of interconnectors are being developed: • Point-to-point interconnectors connect GB to an electricity market in another jurisdiction. • Multi-purpose interconnectors (MPIs) are projects that both (i) link GB and the connecting jurisdiction and (ii) provide transmission to offshore generation assets (located in GB and/or the connecting jurisdiction). • Non-standard interconnectors (NSIs) link GB and the connecting jurisdiction and provide transmission to offshore generators in the connecting jurisdiction only (and not in GB).
Development status (UK)	There is considerable experience with the development of point-to-point interconnectors in the UK. The other categories have been less widely deployed to date.
Generation characteristics	n/a

[186] LCPDelta and Regen (2024), p. 34.

[187] Environment Agency (2024), *Review of emerging techniques for hydrogen production from electrolysis of water*, March 2024. Available at: https://assets.publishing.service.gov.uk/media/65fb0d06703c42001158f0c9/Review-of-emerging-techniques-for-production-of-hydrogen-by-electrolysis-of-water.pdf.

Table A.24: Demand response aggregators

Technology	Demand response aggregators
Description	Demand response aggregators pool flexible demand resources and trade these via the wholesale and balancing markets. This requires investment in metering, aggregation systems / processes, and customer acquisition.
Development status (UK)	Demand response aggregation business models have been established in the UK.[188]
Generation characteristics	Firmness depends on the underlying flexible demand sources and the strength of contracts / incentives that govern their use by the aggregator.

[188] UK Parliament POST (2024), *Demand side response: A tool for lowering household energy bills*, 20 February 2024. Available at: https://researchbriefings.files.parliament.uk/documents/POST-PN-0715/POST-PN-0715.pdf.

Appendix B REVENUE MODELS

This appendix provides more detail on the revenue models that are assumed to apply for each of the technologies under the support mechanism scenario. As indicated, the UK Government support mechanisms take a variety of forms and imply different risk allocations between the project's investors and UK consumers. This means that differences in hurdle rates will be driven not only by factors related to the technical characteristics of each technology (e.g., maturity, intermittency, etc) but also how the various support mechanisms impact risk.

The revenue support mechanisms listed below also have different durations (which are also somewhat uncertain, for mechanisms that are still being developed). The analysis set out in this report assumes that after the relevant mechanism has expired, the project operates on a merchant basis.[189]

B.1. CONTRACT FOR DIFFERENCE

A UK Government contract for difference (CfD) is assumed to apply to:

- Solar PV
- Floating island wind
- ACT
- Tidal stream
- Onshore wind
- Hydropower
- AD
- Sewage gas
- Wave
- Offshore wind
- Deep geothermal
- Landfill gas
- Remote island wind
- Biomass
- Energy from waste

The CfD scheme is the UK Government's main mechanism for supporting low carbon generation. Key features of the scheme include:

- A guaranteed 'strike price' per unit of electricity generated from renewable sources over a 15-year contract period. The strike price is indexed to the consumer price index (CPI).
- CfDs for intermittent projects (e.g., PV and wind) are referenced to intra-day half-hourly prices. For baseload technologies, such as biomass and nuclear, the reference price is set as the modelled season ahead price (average wholesale price).[190] The project must achieve the reference price (on average) to receive the strike price in total for each unit of output.
- As CfD difference payments are made for electricity generated, the project is exposed to output being higher or lower than expected (although projects with a firm connection are compensated via the balancing mechanism if they are constrained off due to network congestion).
- Since CfD allocation round 4 (AR4), difference payments are not made in periods of negative wholesale market prices. This presents a source of risk for CfD project revenues.
- Under the CfD scheme, investors also retain exposure to construction cost and delay risk (i.e., the CfD strike price cannot be adjusted in the event of a cost overrun, and the CfD term will not be extended if completion is delayed).

The REMA process is considering several changes to the structure of CfDs, which could apply to new projects. The analysis in this report has not considered any reforms to the CfD regime.

[189] Our engagement with UK developers / investors for this project suggests that in practice new projects are often evaluated using this assumption. This is because while some projects will be able to secure a new contract after their CfD expires, this is not considered sufficiently certain at the time of making the investment.

[190] DESNZ (2024), *Accompanying Note to the Budget Notice for the Sixth Contracts for Difference Allocation Round*, 6 March, p. 4-5.

B.2. Nuclear RAB framework

The nuclear regulated asset base (RAB) model is assumed to apply to all nuclear technologies.

The legislative framework for the nuclear regulated asset base (RAB) model was established under the *Nuclear Energy (Financing) Act 2022*. Under this model, the project receives a licence to recover a regulated revenue allowance from consumers. Unlike some of the other support schemes described in this report, the RAB framework extends from the start of construction through to decommissioning (i.e., covers almost the full life of the project).

The RAB framework enables investors to share some of the project's construction and operating risks with consumers. This is intended to significantly lower the cost of capital and thereby the cost to end consumers. RAB models are widely used in the context of other large infrastructure developments in the UK, including electricity networks, water networks and airports.

Development phase

Under the RAB model, the Secretary of State (SoS) is able to 'designate' an eligible nuclear project if it is sufficiently mature and considered likely to provide value for money. **Development costs** to reach the required level of maturity are incurred at the risk of investors. If the project is designated, these costs can then be rolled into the RAB (if they meet certain criteria).[191]

Construction phase

Unlike the CfD scheme, the nuclear RAB model both provides a revenue allowance during the construction period and partly mitigates investors' exposure to **construction cost and delay risk**. Key features of the RAB model as it applies to the construction period include:[192]

- During construction, capital investments will be **added to the RAB as they are incurred**. In this period, the project will receive a **revenue allowance** that covers a return on the RAB ("IWACC"), contributions to the funded decommissioning plan (FDP), operating costs, and pass-through costs considered to be outside the licensee's control.
- A **capex incentive** framework aims to encourage the company to minimise construction costs where possible. If the project is delivered for less than a defined **"lower regulatory threshold"** (LRT), the project company will be able to add a percentage of the underspend to the RAB and earn a return on capital on it. If instead delivery costs exceed the LRT, only a portion of the exceedance will be added to the RAB. The LRT is expected to be set at a level above the prevailing best estimate of the project's cost.
- A **"higher regulatory threshold"** (HRT) sets an upper limit on both additions to the RAB and the amount of capital the licensee is required to invest in the project. The HRT is intended to reflect a significantly remote scenario above the licensee's view of an extreme outturn cost outcome. If the HRT is reached, the licensee can apply to add expenditure above the HRT to the RAB. The SoS can decide whether to allow this, or fund further investment from the UK Treasury. If the SoS elects to discontinue to the project, it will provide compensation to debt and equity providers under a Discontinuation and Compensation Agreement.
- There is an incentive to meet a defined **capacity performance target**, which can result in a (capped) uplift to or deduction from the RAB. If a deduction has been applied, there are avenues for the project company to partly reverse this if in future it can demonstrate that capacity has improved.

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[191] BEIS (2022), *Guidance on development costs and the nuclear Regulated Asset Base model*, November 2022. Available at: https://assets.publishing.service.gov.uk/media/6384ae9ce90e0778a2122668/development-costs-nuclear-rab-model-guidance.pdf.

[192] Consumer Scotland (2024), *Public information note on nuclear RAB and Sizewell C*, March 2024. Available at: https://consumer.scot/publications/public-information-note-on-nuclear-rab-and-sizewell-c-html/#:~:text=There%20is%20also%20an%20upper,will%20be%20required%20to%20fund.

- The company must achieve the **commercial operations date** (COD) specified in the licence, or at least by a defined longstop date. The licensee can apply to extend these dates, if the delay is attributable to a qualifying change in law, regulation or force majeure event. **Incentives** for timely completion apply, including deductions to the allowed WACC if the scheduled COD is not met.
- Key construction period parameters – including the IWACC, LRT and HRT – will be set by the SoS.

Operations phase

In the operating period:[193]

- Funding will come from a combination of energy market revenues and difference payments from the 'Revenue Collection Counterparty'. The difference payments will provide for recovery of a regulated **allowed revenue** determined by Ofgem.
- Allowed revenue will be calculated based on "building blocks" assessed over a five-year period, including:[194]
  - Allowance for operating expenditure, depreciation, return on capital, and inflation (via RAB indexation). The operation period cost of capital ("RWACC") will be set by Ofgem and periodically updated to reflect actual changes in interest rates and equity market returns, via the risk-free rate and equity risk premium parameters.
  - Allowance for contributions to the FDP.
  - Incentives linked to wholesale electricity market prices, capacity, availability, and operating phase costs. Provisions within the RAB framework limit the overall impact of the incentive mechanisms on investors.
- Under the RAB framework, the project is substantially, although not entirely, insulated from risk related to trading in the wholesale market. Due to the operation of the market price incentive, it continues to face basis risk (i.e., related to differences between actual trading income and expected income for a baseload plant) and buy-back risk (i.e., related to the risk that unplanned outages require the company to repurchase forward sales undertaken to manage basis risk).

Decommissioning

Nuclear licensees are required to make contributions to the FDP over the life of the project, which under the RAB model are funded through regulatory allowances. We assume the RAB framework will ensure licensees are not exposed to the risk of unfunded decommissioning costs.

B.3. Capacity market

A Capacity Market (CM) contract assumed to be awarded to:

- Natural gas generation
- Demand-side response aggregators
- Lithium-based storage
- New compound batteries

In addition, for these technologies the base case scenario assumes that the project does not have another long-term contract that provides revenue stability.

Interconnectors are also eligible for CM contracts, in addition to the cap and floor regime.

[193] Ofgem (2023), Guidance on our approach to the Economic Regulation of Sizewell C, 6 November 2023. Available at: https://www.ofgem.gov.uk/sites/default/files/2023-11/Guidance%20on%20our%20approach%20to%20the%20Economic%20Regulation%20of%20Sizewell%20C.pdf..

[194] While five-yearly determinations are the expectation today, Ofgem may determine a different regulatory period.

The Capacity Market (CM) provides a revenue stream for qualifying new build assets that successfully bid in to the capacity auction process. The duration is up to 15 years for new build generation or storage, and 1 year for demand response.

Capacity Providers who are successful in an auction are awarded a Capacity Agreement. This confirms the Capacity Market Obligations and level of monthly Capacity Payments they are entitled to receive. Capacity Payments, paid in return for a commitment to meet a Capacity Obligation during a delivery year, are based on the cleared price, and corresponding capacity amount procured, in the auction. For new build projects, the payment is adjusted for inflation.

Capacity Providers face obligations related to:

- Achieving construction milestones set out in the Capacity Agreement, with termination fees payable if milestones are not met.
- Being available during periods of system stress. Capacity Market Notices provide forewarning to Capacity Providers that there is an increased risk of a system stress event occurring. Penalties can be incurred for failure to make pre-agreed capacity volumes available.

Capacity Providers can also earn additional revenues through participation in other markets, including wholesale, balancing, and ancillary services. Indeed, there is evidence that a CM contract would not typically be the most material part of an asset's revenues. For example, the 2022 evaluation of the Capacity Market found that:[195]

> *"The value of Capacity Market revenues to investors is purely in their availability, and Capacity Market revenues do not typically form the bulk of an asset's revenue stream. However, the value of a Capacity Market revenue stream was found to differ by technology type. More flexible assets (i.e. revenue stackers) valued Capacity Market revenues higher in the investment case than other technologies (such as CCGTs). Capacity Market revenues are rarely a deciding factor on whether to invest in an asset, as investors typically base investment cases on fully merchant financing in the wholesale market, using Power Purchase Agreements (PPAs) or (in the case of interconnectors) arbitrage."*

B.4. Hydrogen production business model

The Hydrogen Production Business Model (HPBM) supports hydrogen electrolysers.

The HPBM provides revenue support to hydrogen producers that is intended to overcome the operating cost gap between low and high carbon hydrogen.[196] The business model is delivered through private law contracts (Low Carbon Hydrogen Agreements) between the Low Carbon Contracts Company (LCCC) and the hydrogen producer.

Key features of the HPBM include:[197]

- A 15-year contract term, starting at the latest by a specified target commissioning date.
- As for the renewable CfD, hydrogen producers remain exposed to construction cost and delay risk. If commissioning is delayed, the term will start to erode, effectively shortening the support period. The start date can be adjusted in the event of a force majeure event or, where applicable, delays by the relevant authority in establishing an electricity grid connection and/or water connection.

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[195] DESNZ (2022), *Evaluation of the Capacity Market Scheme*, December 2022, p.7. Available at: https://assets.publishing.service.gov.uk/media/6528f9342548ca000dddf234/capacity-market-evaluation-final-report-technopolis.pdf.

[196] BEIS (2022), *Government response to the consultation on a Low Carbon Hydrogen Business Model*, April 2022. Available at: https://assets.publishing.service.gov.uk/media/625006928fa8f54a89b54b9e/low-carbon-hydrogen-business-model-government-response.pdf.

[197] *Low Carbon Hydrogen Agreement - Key Terms Summary Document*, 16 December 2024. Available at: https://assets.publishing.service.gov.uk/media/67ab5d86d41dfb0b59cec493/LCHA-summary-document-december-2024.pdf.

- A contract for difference (CfD) structure, whereby the hydrogen producer is paid / pays the difference between the strike price and a reference price on qualifying volumes.
    - The strike price is expressed on a £/MWh (higher heating value, HHV) basis. The strike price is the unit price required by the producer to recover its cost of production and a return on capital. Strike prices will be negotiated on a project-by-project basis and indexed to CPI.
    - The reference price is intended to represent the market value of hydrogen volumes sold by the producer. It is defined as the higher of the producer's achieved sales price, or a pre-defined floor price. The floor price is the lower of the strike price or a natural gas reference price, but cannot be less than zero.
- To receive a difference payment, the hydrogen producer must have sold the qualifying volumes produced by its plant.
    - Under certain conditions, if sales volumes are less than 50% of expected volumes the producer will receive an additional top-up amount for each unit sold. No top-up is provided if sales volumes fall to zero.
    - Qualifying volumes are subject to an annual and total aggregate cap, above which difference payments will not be made.
- A price discovery incentive applies where the reference price exceeds the floor price.

B.5. Power CCUS business model

A Dispatchable Power Agreement (DPA) is assumed to apply to natural gas generation with CCUS.

A Dispatchable Power Agreement (DPA) has been established as a business model to bring forward power generation projects enabled with CCUS. It is based on the CfD framework for renewable technologies, with adaptations to allow gas generation with CCUS to operate as a mid-merit plant.

The key features of the model include:[198]

- A private law commercial contract between the Power CCUS plant and the LCCC. Currently, DPAs are being allocated via bilateral negotiations, linked to the wider CCUS Cluster Sequencing Process.
- Terms of 10-15 years apply to new build, repowered and retrofit projects.
- A two-part payment structure:
    - An availability payment, paid per unit of capacity that is available (regardless of dispatch). The availability payment is intended to provide a stable revenue stream that recovers capital costs and a return on investment, thus avoiding an incentive for Power CCUS to displace lower cost / carbon generators such as nuclear and renewables. The payment is similar to capacity payments under the CM, but without obligations related to system stress events.
    - A variable payment, paid per unit of output. This is intended to reduce the short-run marginal cost of Power CCUS, making it more competitive in the merit order than a notional efficient unabated CCGT plant. The variable payment will only be made if the short-run marginal cost (SRMC) of the plant – based on estimated carbon and CCUS transport and storage (T&S) network charges – is higher than a reference H Class CCGT.
- As the availability payment is set prior to construction, the project bears the risk of capital cost overruns.

[198] BEIS (2022), *Carbon Capture, Usage and Storage: Dispatchable Power Agreement business model summary,* November 2022. Available at: https://assets.publishing.service.gov.uk/media/6373993e8fa8f559604a0b8b/ccus-dispatchable-power-agreement-business-model-summary.pdf.

- There are obligations related to meeting construction milestones and contracted performance. Commissioning delay relief is available if the enabling CCUS T&S network is not completed to schedule, for reasons outside the generator's control.[199]
- A gain share mechanism applies if the generator's profits exceed an agreed equity IRR threshold, requiring the repayment of 30% of profits above the threshold.

B.6. Hydrogen to power business model

> A Dispatchable Power Agreement (DPA) – with or without a variable payment – applies to hydrogen-powered CCHT and OCHT.

A H2P business model (H2PBM) in the in the form of a DPA-style mechanism is being developed to bring forward hydrogen to power (H2P) plants, which face barriers to deployment due to a combination of first-of-a-kind (FOAK) technology risk and hydrogen fuel supply risks, due to a dependence on critical enabling infrastructure (including hydrogen production, transport, and storage).[200]

The H2P Government Response published by DESNZ in December 2024 confirmed that the H2PBM will be based on elements of the Power CCUS DPA (see Section B.5 above) but adapted to suit the needs of H2P. Further detail on the design principles and structure of the H2PBM will be published through a market engagement document in Spring 2025.[201]

The December 2024 consultation response further noted that the H2PBM could, initially, be allocated via bilateral negotiations – with scope to transition to competitive allocation over time. Indeed, the H2PBM is intended to be a potential "stepping stone", and that as the technology and enabling infrastructure matures H2P would be expected to deploy through more standard routes, including the CM.[202]

B.7. BECCS business model

> The proposed "dual" CfD business model for power Bioenergy Carbon Capture and Storage (BECCS) applies to biomass with CCUS (including conversions).[203]

In 2022, the UK Government consulted on potential business models for power BECCS.[204] The model draws on the renewable CfD design, but with modification to also provide remuneration for CO_2 removal.

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[199] The contract includes other provisions intended to mitigate the impact of problems with the enabling T&S network. In particular, in the event that the DPA is terminated by the LCCC due to the T&S network becoming unavailable for a prolonged period, the Power CCUS generator may be eligible for compensation to recover the cost of developing the project.

[200] DESNZ (2024), *Hydrogen to Power Government response to consultation on the need, and design, for a Hydrogen to Power market intervention,* December 2024. Available at: https://assets.publishing.service.gov.uk/media/6752e17620bcf083762a6caf/hydrogen-to-power-consultation-response.pdf.

[201] DESNZ (2024), *Hydrogen to power: market intervention need and* design, 9 December 2024. Available at: https://www.gov.uk/government/consultations/hydrogen-to-power-market-intervention-need-and-design.

[202] DESNZ (2023), *Hydrogen to Power: Consultation on the Need, and Design, for a Hydrogen to Power Market Intervention*, December 2023. Available at: https://assets.publishing.service.gov.uk/media/657a2ea2095987001295e071/hydrogen-to-power-need-design-for-business-model.pdf.

[203] The UK Government is considering other, transitional mechanisms for the conversion of existing large-scale biomass generators to power BECCs. These transitional mechanisms are not part of the assumed revenue model. See DESNZ (2025), *Transitional support mechanism for large-scale biomass generators: consultation document*, 10 February 2025. Available at: https://www.gov.uk/government/consultations/transitional-support-mechanism-for-large-scale-biomass-electricity-generators/transitional-support-mechanism-for-large-scale-biomass-generators-consultation-document-html#:~:text=The%20CfD%20scheme%20is%20fundamental,1.4%20GW%20of%20biomass%20generation.

[204] BEIS (2022), *Business model for power bioenergy with carbon capture and storage ('Power BECCS'),* August 2022. Available at: https://assets.publishing.service.gov.uk/media/62f4b8e7e90e076cfcd5420e/power-beccs-business-model-consultation.pdf.

While the business model was still under development at the time of writing, the March 2023 response to consultation confirmed that the Government was minded to pursue a "dual CfD" mechanism that comprises three payment streams:[205]

- **A CfD for electricity generation (£/MWh) – "CfDe".** As with renewable energy CfDs (Section B.1), the BECCS plant is paid the difference between an agreed strike price and a market reference price for volumes of electricity produced.
- **A CfD for carbon (£/tCO_2) – "CfDc".** The BECCS project is paid the difference between an agreed strike price and the prevailing carbon price for volumes of biogenic CO_2 captured.
- **A T&S charges payment**, to recover costs associated with use of the T&S network.

In combination, these payment streams are intended to enable a power BECCS plant to recover its lifetime costs, including a return on capital. However, the Government is still considering the principles that would underpin the CfDe and CfDc strike and reference prices, which may impact the risk allocation.[206]

Additional features of the proposed business model include:

- A contract length of 10-15 years.
- Measures to mitigate the cross-chain infrastructure risk associated with the T&S network, that is outside the Power BECCS plant's control. For example, this may include relief for T&S outages that would expose the generator to revenue loss and compensation in the event the CfD is terminated due to prolonged unavailability of the T&S network.
- Risks associated with construction costs, construction delays, operating risk and negative price risk would likely remain with the developer.

B.8. INTERCONNECTOR CAP AND FLOOR

The cap and floor regime, as applied to Window 3 projects, applies to interconnectors.

Point-to-point interconnectors

The cap and floor regime is an established route for developing **point-to-point electricity interconnectors**, which has been administered by Ofgem since 2014. Interconnectors earn arbitrage revenues from price differences that arise between two wholesale electricity markets. The cap and floor model limits developer's exposure to uncertainty around these market prices. When the interconnector's revenues from fall below an agreed floor, they will receive a top-up payment from consumers. Conversely, revenues in excess of the cap are returned to consumers. Within the cap and floor, the interconnector is exposed to market price risk.

The regime has undergone some evolutions since it was first introduced. For this project, we assumed that the settings used for Window 3 projects apply. Key features include:[207]

- An annual maximum (cap) and minimum (floor) on the revenues the interconnector can earn over a 25-year period. Revenues are compared against the cap and floor every five years.

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[205] BEIS (2022).

[206] For example, relevant issues include: whether the CfDe strike price would be set to recover the costs of an unabated biomass plant, with the CfDc strike price covering the incremental CCUS costs; whether the CfDe strike price would be indexed to mitigate volatility in biomass feedstock prices; and how the CfDc reference price would be set in the absence of established markets / prices for negative carbon emissions.

[207] Ofgem (2024), *Guidance – Interconnector Cap and Floor Regime Handbook*, 10 December 2024. Available at: https://www.ofgem.gov.uk/sites/default/files/2024-12/Interconnector_Cap_and_Floor_Regime_Handbook_Updated_Version.pdf.

- Cap and floor levels are set based on project costs using a standard regulated asset base (RAB) model. The floor is set to provide for recovery of capital and operating costs, plus a low rate of return on capital (equal to a cost of debt index) applied to 100% of the RAB. A higher rate of return is applied to 100% of the RAB to set the cap.
- The interconnector is subject to incentives to meet availability targets. The cap is adjusted annual by up to +/- 2% if availability exceeds or falls short of the target level. The interconnector will no longer be eligible for floor payments if availability is less than 80% on average over a year.
- The regime provides for some mitigations related to capital and operating cost risk:
    - The RAB is set at the post-construction review (PCR), after the project has been completed and based on an assessment of actual capital costs incurred. However, Ofgem may not allow cost increases above the pre-construction estimate, if the costs were within the control of the developer and are not considered to be efficient.
    - Controllable operating costs underpinning the cap and floor are initially determined at the PCR. These are fixed for the duration of the regime, save for one opportunity to review after a minimum 10-year period. Controllable operating costs may be adjusted if Ofgem deems this to be efficient. Non-controllable operating costs are subject to a pass-through arrangement.
    - The interconnector is responsible for decommissioning. The associated costs are estimated at the PCR stage and reflected in the cap/floor level. If legislative requirements result in unforeseen changes to decommissioning costs, these can be adjusted following review by Ofgem.

Offshore hybrid assets

Since 2022, Ofgem has operated a pilot regulatory regime for offshore hybrid assets (OHAs).[208] These differ from point-to-point interconnectors, that connect GB to an electricity market in another jurisdiction. OHAs take multiple forms:

- Multi-purpose interconnectors (MPIs) are projects that both (i) link GB and the connecting jurisdiction and (ii) provide transmission to offshore generation assets (located in GB and/or the connecting jurisdiction).
- Non-standard interconnectors (NSIs) link GB and the connecting jurisdiction and provide transmission to offshore generators in the connecting jurisdiction only (and not in GB).

Ofgem has decided to apply a "narrow cap and floor regime" to NSIs, although the detailed design of the regime is still progressing.[209] Although a decision on MPIs is still pending, Ofgem has expressed a preference to also apply a narrow cap and floor to MPIs. A narrow regime reduces the band between the cap and floor, relative to that used for point-to-point interconnectors, to account for the perceived higher risks and increased revenue uncertainty for OHAs.[210] As the cap and floor band reduces, the closer the regime becomes to a pure RAB-based regime.

B.9. LDES CAP AND FLOOR

The cap and floor regime (in its currently proposed form) applies for long-duration energy storage, including pumped hydro energy storage and novel LDES.[211]

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[208] Ofgem (2024), *Decision on the Regulatory Framework for the Non-Standard Interconnectors of the Offshore Hybrid Asset pilot scheme*, 8 February 2024. Available at: https://www.ofgem.gov.uk/sites/default/files/2024-02/NSI_Decision.pdf

[209] Ofgem (2024).

[210] Ofgem (2023), *Consultation on the Regulatory Framework for Offshore Hybrid Assets: Multi-Purpose Interconnectors and Non-Standard Interconnectors*, 2 June 2023. Available at: https://www.ofgem.gov.uk/sites/default/files/2023-06/Consultation%20on%20the%20Regulatory%20Framework%20for%20Offshore%20Hybrid%20Assets-%20Multi-Purpose%20Interconnectors%20and%20Non-Standard%20Interconnectors.pdf

[211] As noted in Section 2.2, some lithium BESS projects may also be eligible for the LDES cap and floor scheme.

In October 2024, DESNZ published its response to consultation on a cap and floor support mechanism for LDES. This is similar to the model applying to interconnectors, with the LDES developer exposed to market price risk between the cap and floor. The mechanism is intended to overcome identified barriers to LDES deployment, including high upfront capital costs and long construction times.

The consultation response confirmed the cap and floor regime as the preferred model for LDES. Key "minded-to" features of the scheme include:[212, 213]

- As for interconnectors, the floor would be set to allow the project to recover a return on debt, and the cap to recover a return on equity. Some stakeholder responses suggested that the floor should allow a partial return on equity, reflecting perceptions of higher construction and market risk for PHES projects compared to interconnectors.
- The cap and floor thresholds would be set on a gross margin basis. Gross margin is the difference between revenues earned by the asset from being dispatched to electricity and other services, and the costs of purchasing energy to charge the asset.
- Mitigations will be introduced to avoid operational distortions from the cap and floor (e.g., once an asset has reached the cap, it no longer has an incentive to operate even if this delivered a benefit to the market). The minded-to position is to introduce soft caps that would gradually increase the proportion of gross margin above the cap that is returned to consumers.
- Cap and floor projects will be able to participate in the CM.
- The contract duration will be based on either the project length up to the first refurbishment, or up to 25 years.
- There will be two routes for developers to apply for a cap and floor, with stream 1 focussing on established technologies (e.g. TRL 9) and stream 2 on more novel technologies (e.g. TRL 8).

Further engagement on the detailed design, including the elements noted above, is expected prior to a final decision.

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[212] DESNZ (2024), *Long duration electricity storage consultation: Government Response*, October 2024. Available at: https://assets.publishing.service.gov.uk/media/670660eb366f494ab2e7b57a/LDES-consultation-government-response.pdf.

[213] DESNZ (2024), *Long duration electricity storage consultation*, January 2024. Available at: https://assets.publishing.service.gov.uk/media/659bde4dd7737c000ef3351a/long-duration-electricity-storage-policy-framework-consultation.pdf.

Appendix C RISK ANALYSIS

This appendix provides more detail in support of the risk analysis set out in Section 3.

As described in Section 3.1, our starting point for the risk analysis was the risk categories considered by DESNZ to assess the impact of REMA reforms. However, we determined that some of these risks were not relevant for our purpose. The reasons are summarised in the table below and discussed in more detail after the table.

During the project, we also considered risks relating to future liabilities for decommissioning costs, which was not captured in DESNZ's REMA framework. However, further analysis indicated that these risks were in practice unlikely to differ materially across the technologies. The investor survey also indicated that few stakeholders considered decommissioning to be a material driver of hurdle rates.

Table C.1: Risk sub-categories considered not relevant

Risk category		Risk sub-category	Description
Development risk		Allocation Risk	Risk that developers are not among the investors that receive funding through their chosen business model (e.g., a CfD). **We consider that there is insufficient evidence to assess whether this risk driver hurdle rates differences across the technologies.**
		Political Risk	Risks associated with the wider governance of the UK (e.g. country instability, sanctity of contract, special taxes). **We consider that this risk is not a material driver of hurdle rate differences between technologies.**
		Policy Risk	Risk that the policy support for asset, or enabling infrastructure, is limited or reduced in the future. **We consider that this risk is not a material driver of hurdle rate differences between technologies.**
Construction risk		Network Connection	Risk that the power connection required by the plant is not available at the time of construction, despite a previous agreement with the network operator. **We consider that this risk is not a material driver of hurdle rate differences between technologies.**
Operational Risk	**Price Risk**	Basis Risk	Risk that generator cannot sell at the same price as the reference price in their contract (e.g., a CfD). **We consider that there is insufficient evidence to assess whether this risk driver hurdle rates differences across the technologies.**
		Policy Driven Electricity Price Risk	Risk that a policy change results in a change in electricity prices (incl. carbon price). **We consider that this risk is not a material driver of hurdle rate differences between technologies.**
		Locational Price Risk	Risk investors are exposed to changes in the value of the locational signal i.e. in the case of LMP, the spread between the local price and system average price. **We consider that this risk does not apply, as currently wholesale market prices do not vary with location in the UK.**

Risk category		Risk sub-category	Description
	Volume Risk	Commercial Demand Risk	Risk that the demand for electricity is lower than expected due to market factors (for example innovation in consumer end use appliances). **We consider that this risk is not a material driver of hurdle rate differences between technologies.**
		Policy Driven Demand Risk	Risk that the demand for electricity is lower than expected due to policy-driven factors. This relates to a shift in the average demand for electricity. **We consider that this risk is not a material driver of hurdle rate differences between technologies.**
		Economic Curtailment Risk	The risk that asset does not generate due to higher than expected economic curtailment. **This has been considered under 'other price risk'.**
		Locational Volume Risk	The risk that the network is not able to physically accommodate the plant's output. **We consider that this risk is not a material driver of hurdle rate differences between technologies.**
	Cost Risk	Locational Cost Risk	Locational cost risk – Risk that the locational charges (e.g. TNUoS) are higher than expected/forecasted. **We consider that there is insufficient evidence to assess whether this risk drives hurdle rates differences across the technologies.**

Source: DESNZ, REMA Risk Framework.

C.1.1. Allocation risk

In their 2015 generation hurdle rates study, NERA reported a significant increase in perceived allocation risk faced by new projects – linked to the (then) recent shift to the competitive allocation of revenue support through the CfD auction process.[214]

We consider that allocation risk is challenging to assess, because it depends on a combination of factors:

- the rules for future CfD allocation rounds (which may not be the same as in the past);
- how developers will respond to these rules (which is ambiguous – for example, does a ring-fenced budget for tidal projects reduce allocation risk for that technology by making it more likely that at least some tidal projects will be awarded a CfD, or increase allocation risk by encouraging more tidal projects to apply and potentially reducing success rates?);
- how the auction rules interact (e.g., the interaction between the size of each pot and the constraints placed on technologies within it – such as maximum awards to certain technologies – make it challenging to assess what the implications for success rates are likely to be);
- assumptions regarding the level of capital that is invested before the CfD allocation round results are known, and whether this could differ by technology type; and
- the materiality of success in the CfD auction for a given project's overall route to market (which may have a technology-specific dimension – for example, well-established technologies such as solar PV and onshore /

[214] NERA (2015), *Hurdle Rates for Electricity Generation*, p.vii.

offshore wind may have more alternatives in the form of commercial PPAs relative to nascent technologies).

Further, in 2015 NERA observed that perceived allocation risk could diminish in future as developers gained familiarity with the CfD allocation process – for example, resulting in only the most competitive projects being put forward in auctions (leading to higher success rates) or more efficient spending on project development prior to the CfD auction (leading to less capital subject to allocation risk). Europe Economics' 2018 report assumed that there had been a reduction in allocation risk, although this was not tested through surveying investor perceptions. While the first four CfD allocation rounds were held roughly every two years, from AR5 in 2023 they have been held annually.[215] This too may have contributed to a reduction in allocation risk, because unsuccessful projects now have a shorter time to wait before reapplying.

In light of the considerations above, we have decided not to place weight on this factor.

C.1.2. Political risk

Whilst the level of political risk faced is relevant when considering the absolute value of hurdle rates, we do not consider that, in the UK, the level of political risk faced varies across the technologies. Further, based on the definition of political risk, we consider this to be low, at least at present for renewable and low-carbon technologies, within the UK. Accordingly, we do not assess this risk.

C.1.3. Policy risk

Our assessment is largely based on the Labour Party Manifesto, given the 2024 UK Parliamentary election results. Within the general election manifesto, the Labour Party pledged to support renewable generation and deliver zero-carbon electricity by 2030. There is also the pledge to create Great British Energy, a publicly owned investment company that will co-invest in renewable technologies to help deliver clean energy, and establish a National Wealth Fund to support growth and clean energy plans. This suggests that, overall, the risk of policy support for renewable and low-carbon technologies reducing in the future is low.

C.1.4. Network connection risk

Securing a grid connection is identified as one of the major barriers for generation projects in the UK in part due to a lack of grid capacity.[216] The average delay for a project applying to connect to the transmission network is over five years, with more than 20% of projects waiting over ten years.[217] This time taken to obtain a grid connection has become a notable source of uncertainty for developers, and appears to be adding costs and delays onto projects.[218] Ofgem has announced a new policy to speed up grid connections in November 2023, and DESNZ and Ofgem have also introduced a Connections Action Plan.

Aside from remote island wind, we did not identify evidence that the risks surrounding obtaining a grid connection vary materially by technology:

- In December 2022, Ofgem launched a pilot model to accelerate investment in connecting offshore wind projects.[219] This suggested that offshore wind may have had a higher grid connection risk compared with other technologies – but that successful implementation of the proposed reforms could address this. Ofgem have since announced a new policy to speed up grid connections that applies to all technologies (see solar PV), and it is therefore, not clear that offshore wind faces a materially different level of connection risk.
- The risk faced by remote island wind may be higher than other technologies given some remote islands have no connection to the mainland (i.e., electrically isolated), and others have distribution network

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[215] CfD Allocation Round Resource Portal: https://www.cfdallocationround.uk/about.

[216] House of Commons (2024), *Planning for Solar Farms Research Briefing*, May, p. 41.

[217] The Department for Energy Security and Net Zero and Ofgem (2023), *Connections Action Plan,* November, p. 97.

[218] House of Commons (2024), *Planning for Solar Farms Research Briefing*, May, p. 42.

[219] Ofgem (2022), *Decision on accelerating onshore electricity transmission investment*, December, p. 4.

connections with no or very little capacity.[220] The cost, and time requirements, to install subsea connection assets to connect the islands to the main electricity grid, may set this technology apart from onshore technologies. However, it is not clear whether Ofgem's initiatives noted above will equalise this risk across remote island wind and the other technologies.

The impact of these delays, and the associated uncertainty, may be a more material risk for the development of emerging technologies than those more established – although evidence of this is limited.[221] On balance, we have treated network connections as a risk that does not vary materially by technology.

C.1.5. Basis risk

In the context of this report, basis risk arises when a generator is unable to achieve the reference price reflected in their CfD. For instance, a CfD might be referenced to the day-ahead market price – which requires that the generator is actually able to achieve this price on its output via its trading arrangements, in order to receive the CfD strike price in total.

Under the current CfD arrangements, there are different reference prices for intermittent and baseload generators:[222]

- The intermittent market reference price (IMRP) is calculated on an hourly basis from the day-ahead hourly price.
- The baseload market reference price (BRMP) is calculated on a seasonable basis using a volume-weighted average of forward contract prices for the season.

Broadly, the reference prices reflect the wholesale market prices that intermittent and baseload generators could respectively achieve, given their characteristics. If the different reference price methodologies fully accounted for this, basis risk could be considered not to vary materially across technologies. In practice, there will still be some differences in the extent to which technologies within the intermittent and baseload categories can in practice capture their CfD reference price. This is captured in DESNZ's ASP methodology – for example, in that individual wholesale reference price series are estimated for offshore wind, onshore wind, solar PV and hydro – reflecting the estimated average wholesale price that each technology could likely to achieve given when they are expected to generate.[223] However, we have not identified a practical basis for accurately assessing the level of basis risk faced by a given technology type (noting that this may also vary by location).

C.1.6. Policy driven electricity price risk

We have not identified reasons to think that policy driven changes in future electricity prices are likely to impact one technology more than another.

C.1.7. Locational price risk

We have not explored this risk because under the current electricity market arrangements, generators in the UK do not face wholesale market prices that vary by location. While zonal pricing is being considered through REMA, the hurdle rates we are developing in this project assume that the current market arrangements continue (the impacts of REMA reforms are being considered through a separate project).

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[220] Department for Business, Energy and Industrial Strategy, *Classifying remote island wind as a separate technology in the Contracts for Difference (CfD) scheme,* p. 3. Available at: https://assets.publishing.service.gov.uk/media/5b16baa340f0b634c61412fd/F_-_RIW_Impact_Assessment.pdf.

[221] UK Marine Energy Council, *Energy Security and Net Zero Select Committee inquiry Securing the domestic supply chain Marine Energy Council response. A*vailable at: https://www.marineenergycouncil.co.uk/media/pages/latest-updates/publications/cd65f64034-1713366094/esnz-select-committee-supply-chain-consultation-mec-response.pdf, p. 5.

[222] LCC, *Forecast market reference prices*. Available at: https://dp.lowcarboncontracts.uk/dataset/forecast-market-reference-prices#:~:text=Baseload%20Market%20Reference%20Price%20is,and%20October%20of%20each%20year.

[223] DESNZ (2023), *Contracts for Difference – Methodology used to set Administrative Strike Prices for CfD Allocation Round 6*, November 2023, p.20.

C.1.8. Commercial and policy driven demand risk

These risks have not been explored in our assessment, as it is not evident that exposure differs by technology.

C.1.9. Economic curtailment risk

Economic curtailment refers to a scenario where an intermittent generator chooses to sell below its available output at certain times, for example because an excess supply of intermittent generation relative demand results in wholesale prices falling to zero (or below). From AR4, the CfD scheme does not make difference payments during any hour when the day-ahead price is below zero.[224] Accordingly, this risk may be higher for intermittent generators whose output is likely to be correlated with low wholesale market prices, than for dispatchable generation assets.

Responses to the investor survey suggest that respondents viewed this as part of price risk. To avoid overlap, we have therefore considered it as part of the assessment of 'other price risk'.

C.1.10. Locational volume risk

Locational volume risk encompasses the risk that a generator is unable to sell electricity that it has, or planned to, generate due to constraints on the network. This may affect technologies differently, depending on where they are located. Similarly, location can play a key role in whether a project is subject to locational volume risk, particularly when projects with similar generation profiles are co-located and require the use of the network at the same times.

In practice however, generators' exposure to locational volume risk depends on their access rights. The GB electricity market design is based on the principle that, in general, transmission-connected market participants have financially firm access rights to the entire transmission network. Under this model, they are compensated via a constraint payment for any curtailment relative to their planned output. [225] These payments are funded through BSUoS charges from consumers. While the frequency of constraints is anticipated to increase as more renewable generation connects to the grid – DESNZ anticipates that economic curtailment will become more prevalent from the late 2020s[226] – this will not impact generators with firm access.

However:

- Parties that connect to the transmission network can also choose a non-firm or flexible connection – which provides that their output may be curtailed due to network limitations without financial compensation. We understand that non-firm connections have been more common in certain locations – for example, in Scotland where waiting for the transmission network augmentations necessary to provide firm access could result in material costs and delays.[227]
- Parties connected to the distribution network are not compensated if their planned output is constrained – although over time the connection offer will become firm as the network is developed. Before an investment decision is made, the network operator will provide the project developer with expected curtailment rates, so that the risk can be assessed.

In principle, it is possible that certain technology types could more commonly opt for a non-firm connection or are more likely to be connected at the distribution network level. Feedback from DESNZ indicates that baseload and

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[224] DESNZ (2024), *Accompanying Note to the Budget Notice for the Sixth Contracts for Difference Allocation Round 2024*, 6 March 2024, p.12. Available at: https://assets.publishing.service.gov.uk/media/65e85ea45b6524001af21a72/cfd-ar6-budget-notice-accompanying-note.pdf.

[225] DESNZ (2024), *Review of Electricity Market Arrangements Second Consultation Document*, March 2024, p.98. Available at: https://assets.publishing.service.gov.uk/media/65ef6694133c220011cd37cd/review-electricity-market-arrangements-second-consultation-document.pdf. NESO, *What are constraints payments?* Available at: https://www.nationalgrideso.com/electricity-explained/how-do-we-balance-grid/what-are-constraints-payments.

[226] DESNZ (2024), *Contracts for Difference for Low Carbon Electricity Generation – Consultation on proposed amendments for Allocation Round 7 and future rounds*, January, p. 17.

[227] ENA (2020), *Access and Forward-looking charges*, 25 September 2020, p.4. Available at: https://www.nationalgrideso.com/document/293156/download.

dispatchable technologies may face lower risks on this factor, while there is some risk for offshore and onshore wind, and solar likely having the highest risk.

However, the investor survey presented a more mixed picture on the relevance of this risk:

- Some respondents considered that network access was not a material driver of hurdle rates (including for wind and solar) under the current electricity market arrangements.
- Some respondents who had selected "network congestion" as a relevant risk later clarified in follow-up interviews that they were referring to the queueing process to obtain a grid connection, rather than network congestion during operations.

Given this feedback, we have not emphasised network congestion in the assessment.

C.1.11. Locational cost risk

We understand that potential reforms to TNUoS charges have created a degree of future cost uncertainty for developers. Uncertainty and volatility in TNUoS charges impacts all technologies to some extent.[228] 2021 analysis conducted by SSEN found that regardless of location and technology, generators faced TNUoS unpredictability (deviations between actual and forecast charges) and volatility (year-on-year movements in charges).[229] This suggests that the risk faced by the various technologies is broadly similar. On the other hand, the impact may be more material (or this risk may receive more focus) for transmission-connected projects in more expensive TNUoS zones, particularly wind technologies.[230] On balance, we have not placed significant weight on this as a factor contributing to differences in risk across the technologies.

[228] SSEN, *TNUoS*. Available at: https://www.ssen-transmission.co.uk/information-centre/tnuos/.

[229] SSEN (2021), *Transmission Charges,* February 2021. Available at: https://www.ssen-transmission.co.uk/globalassets/documents/tnuos/tnuos-charging-paper---february-2021.pdf.

[230] DESNZ (2023), *Methodology used to set Administrative Strike Prices for CfD Allocation Round 6*, p. 22.

Appendix D CAPM-BASED ESTIMATES

This appendix sets out further detail on some of the parameters that are used to calculate hurdle rates under the CAPM-based methodology described in Section 4.

In particular, while we consider that the methodology set out in Section 4 is a reasonable approach to deriving hurdle rate estimates in the context that DESNZ will be using them, we recognise that there are alternative approaches. Where relevant, we highlight these alternatives – and their potential implications – in this appendix.

D.1. TECHNOLOGY SPECIFIC PARAMETERS

D.1.1. Asset beta

Estimation approach

We have taken the following quantitative approach to estimating asset beta. This is broadly consistent with UKRN principles and guidance on the cost of capital but adapted to reflect the specific requirements of this exercise.[231] The six steps of our approach are:

- **Step 1:** We gathered a longlist of potential beta comparators that span a range of systematic (beta) risk characteristics. The longlist considers international evidence from comparable markets, to develop a relatively broad sample. Specifically, we have extracted comparators that:
    - Are listed under the following Bloomberg Industry Classifications (BICs): Energy – Renewable Energy Project Development; Industrials – Energy Infrastructure Construction; Utilities – Electric Utilities; Utilities – Electricity and Gas Marketing and Trading.
    - Had at least two years of stock market data available as of 31 December 2024.
    - Are listed in the following countries / regions: UK, Europe, USA, Canada, Australia and New Zealand.
- **Step 2:** We adopted a set of criteria to create a shortlist of beta comparators. These were:
    - A maximum bid-ask spread of 1% as an indicator of liquidity.[232]
    - Whether the comparators were primarily engaged in electricity generation. We excluded comparators where non-generation activities (e.g., networks) accounted for more than ~20% of their value.[233] This was based on a first-pass review of Bloomberg company descriptions, followed by a more detailed examination of segmented financial accounts for the most recent year available.

[231] For example, in other contexts we may recommend conducting a detailed review of how asset beta estimates for individual comparators have evolved over time, partly with a view to understanding the potential drivers of this variation. However, this type of analysis is not practical in this context, where we have developed a broad comparator sample to capture a range of different technologies.

[232] The bid-ask spread measures the gap between the price at which shares are offered for sale (ask) and requested for purchase (bid), expressed as a percentage of the average of the two prices. It is a widely used measure of liquidity. An acceptable level of liquidity provides confidence that the results of the regression with stock prices and market index prices is robust. While there is no hard-and-fast rule on the appropriate threshold, 1% is commonly adopted. We checked that this approach did not inadvertently rule out any highly relevant comparators that marginally exceeded the threshold.

[233] The contributions of different activities to value are difficult to measure consistently across the comparators. Where available, we relied on contributions to EBITDA as a proxy for value. In some cases where EBITDA was not available, we relied on revenue. We note that both measures are imperfect, as they reflect a point-in-time snapshot of the company's activities. In practice, value will also be impacted by the entity's forward development pipeline, which is difficult to observe.

  - Whether the comparators covered the technologies of interest. We excluded comparators where the technologies of interest appeared to make up less than half of the company's activities.[234] We have considered the breakdown of technologies in determining where on the spectrum of observed beta estimates to place the various risk categories.
  - Whether the comparator's activities were actually concentrated in the target geographies noted above. We exclude comparators with a majority of assets in other markets (e.g., Latin America, China, India, Africa).
  - We also examined the comparators' contracting arrangements, as far as this was possible from publicly available information. We excluded comparators with primarily uncontracted cashflows. We have considered this in our interpretation of the evidence – for example, in determining where on the spectrum of observed empirical betas each of the risk categories should sit.

- **Step 3:** We estimated raw equity betas over a range of horizons (spot estimates for 2, 5 and 10 years) based on a daily returns specification.[235] Estimates were calculated against the FTSE All Share Index for UK-listed firms and a diversified local index in the relevant country for international comparators (e.g., the Eurostoxx 600 index for European firms). [236]
- **Step 4:** We used net debt and market capitalisation measures to calculate gearing for the comparators.[237] Gearing is calculated over the same period as the raw equity beta estimates. We adopted a minimum level of gearing of 0% (i.e., in cases where observed gearing is negative).[238]
- **Step 5:** We used the practitioner's formula to convert raw equity betas into asset betas, using a zero-debt beta assumption.[239]
- **Step 6:** We established a distribution of asset beta estimates based on this evidence.

We used R code to streamline certain aspects of the data collection and estimation process, as this is a robust approach to dealing with large quantities of data.[240]

Within this 'core' sample, we have identified where there are comparators that are primarily active in a particular technology. While this has provided some reference points, none of these technology-specific sub-samples are large enough to consider using in isolation.

In addition to the core sample, we have also considered two separate samples as a cross-check for the following technologies:

- **Nuclear:** We considered a sample comprised of US utilities that are regulated under a rate base framework. The utilities in this sample develop and operate nuclear generation assets, in addition to other generation types and (in many cases) network assets. There are some significant differences between these comparators and standalone new build nuclear project. As noted above, the companies include non-

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[234] Again, this was based on a review of segmented accounts and has the same limitations as noted above. We relied on (in order of preference) contributions to EBITDA, revenue, generation output, and generation capacity – depending on what information was publicly available.

[235] Specifically, a 'spot 2-year estimate' means that a regression of the relevant stock and market index prices was run based on data from the 2-year period leading up to 30 June 2024. A daily returns specification means that the regression is based on daily observations of prices during this period (rather than, for example, weekly observations).

[236] We used default relative indices to capture evidence on non-European comparators.

[237] I.e., gearing = net debt / (net debt + market capitalisation).

[238] The impact of this on the beta estimates is negligible.

[239] $Beta_{Asset} = Beta_{Equity} \times \left(1 - \frac{Debt}{Debt + Equity}\right) + Beta_{Debt} \times \left(\frac{Debt}{Debt + Equity}\right)$

[240] Specifically, we used R to: extract the long-list of comparators and information required for filtering the sample; run the regressions of stock and market index prices to estimate raw equity betas for each comparator; calculate average gearing and de-lever the equity betas to derive asset betas.

nuclear assets; in most cases the proportion of nuclear generation is less than 50%, and in some cases as low as ~10%. Further, the sample includes operating assets – that we would expect to have a lower risk profile than we are seeking for a 'whole life' hurdle rate estimate. Nonetheless, given the nature of the regulatory framework that applies to the comparators, we consider that this provides a relevant cross-check to projects operating under the nuclear RAB regime. This is consistent with CEPA's 2024 advice to Ofgem on the approach to estimating asset beta for nuclear licensees.

- **Hydrogen electrolysers:** We considered a range of comparators that could potentially better represent the systematic risk of this technology, as it is not well represented in the core sample. We identified two that both pass the liquidity / trading history filters and have a reasonably high proportion of their business linked to hydrogen production or similar activities: Air Liquide and Air Products and Chemicals. Neither is a perfect comparator for a hydrogen electrolyser operating under the hydrogen production business model. A sample of two comparators is also rather limited. Nonetheless, we present this comparison for transparency.

We have used these samples to cross check where nuclear and hydrogen electrolysers are positioned relative to the core sample. We think it is preferable to use the core sample for these technologies and apply a cross-check, rather than use the individual samples to set the asset beta directly. This is to make sure that the relativity between the hurdle rate estimates is aligned with the risk category they are assigned to.

Comparators

The comparators included in each of our samples are listed in the tables overleaf.

Table D.1: Beta comparators – Core sample

Comparator	Country	Technology specific sub-sample	Comparator	Country	Technology specific sub-sample	Comparator	Country	Technology specific sub-sample
7C Solarparken	Germany	Solar	**Enel**	Italy	n/a	**Northland Power**	Canada	Onshore wind
Acciona	Spain	Onshore wind	**EnergieKontor**	Germany	Onshore wind	**Ormat Technologies**	US	Geothermal
AGL Energy	Australia	n/a	**ERG**	Italy	Onshore wind	**Orsted**	UK	Onshore / offshore wind
Alerion	Italy / Spain	Solar, onshore wind	**Genesis Energy**	New Zealand	Gas	**Solaria Energia**	Spain	Solar
Atlantica	US	Solar	**GreenVolt**	Portugal	n/a	**PNE**	Germany	Onshore wind
Audax	Spain	Solar, onshore wind	**Innergex**	Canada	Onshore wind	**RWE**	US and Europe	n/a
Boralex	Canada	Onshore wind	**Manawa Energy**	New Zealand	Hydro	**Verbund**	Austria	Hydro
Clearway Energy	US	Onshore wind	**Mercury**	New Zealand	n/a	**Vistra Corp**	US	Gas
Contact Energy	New Zealand	Hydro	**Meridian Energy**	New Zealand	Hydro			
Drax	UK	Biomass	**Neoen**	Australia and Europe	n/a			
EDP Renovaveis	US and Europe	Onshore wind	**NextEra Energy**	US	Onshore wind			
Encavis	Europe	Solar	**NRG Energy**	US	n/a			

Source: CEPA analysis.

Table D.2: Beta comparators – Cross check samples

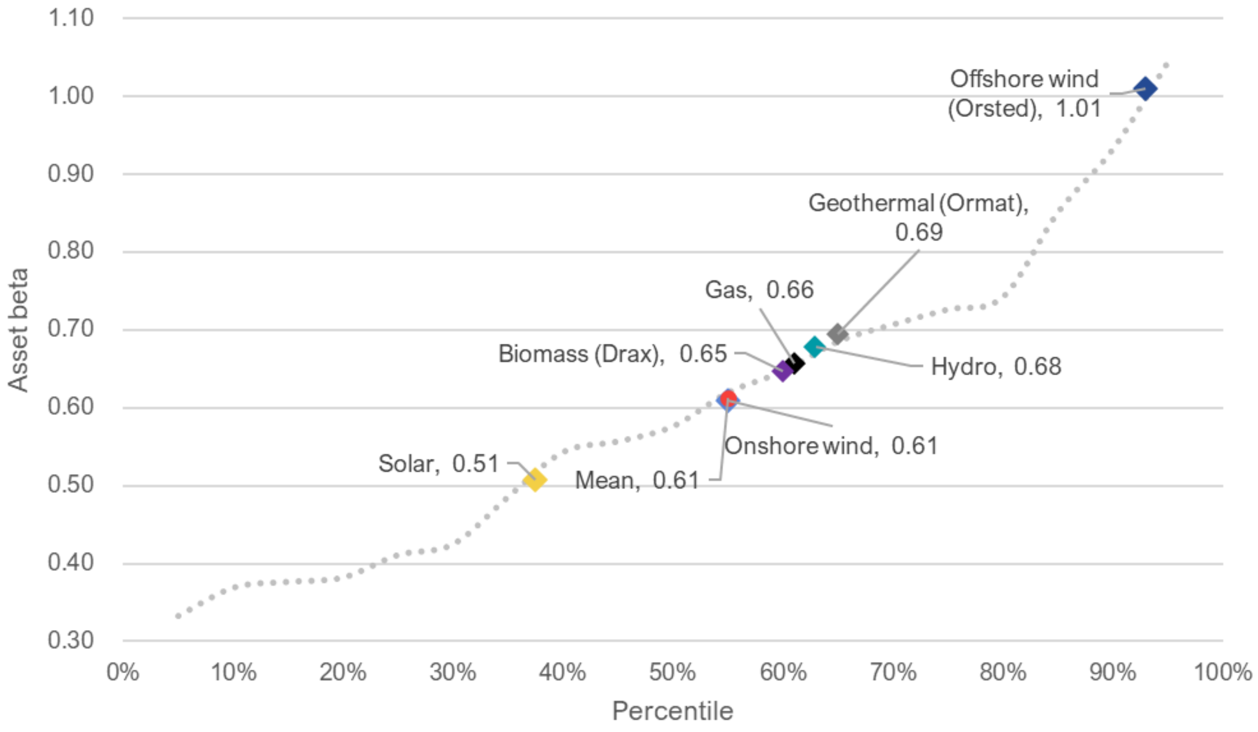
Comparator	Country	Cross check sample	Comparator	Country	Cross check sample
Ameren	US	Nuclear	**Air Liquide**	Europe	Hydrogen
American Electric Power	US	Nuclear	**Air Products and Chemicals**	US	Hydrogen
Avangrid	US	Nuclear			
CMS	US	Nuclear			
Consolidated Edison	US	Nuclear			
Dominion Energy	US	Nuclear			
Duke Energy Edison	US	Nuclear			
Entergy	US	Nuclear			
Evergy	US	Nuclear			
First Energy Corp	US	Nuclear			
Pacific Gas & Electric	US	Nuclear			
Pinnacle West	US	Nuclear			
PNM Resources	US	Nuclear			
Sempra	US	Nuclear			
Southern Company	US	Nuclear			
Xcel Energy					
WEC	US	Nuclear			

Source: CEPA analysis.

Estimates

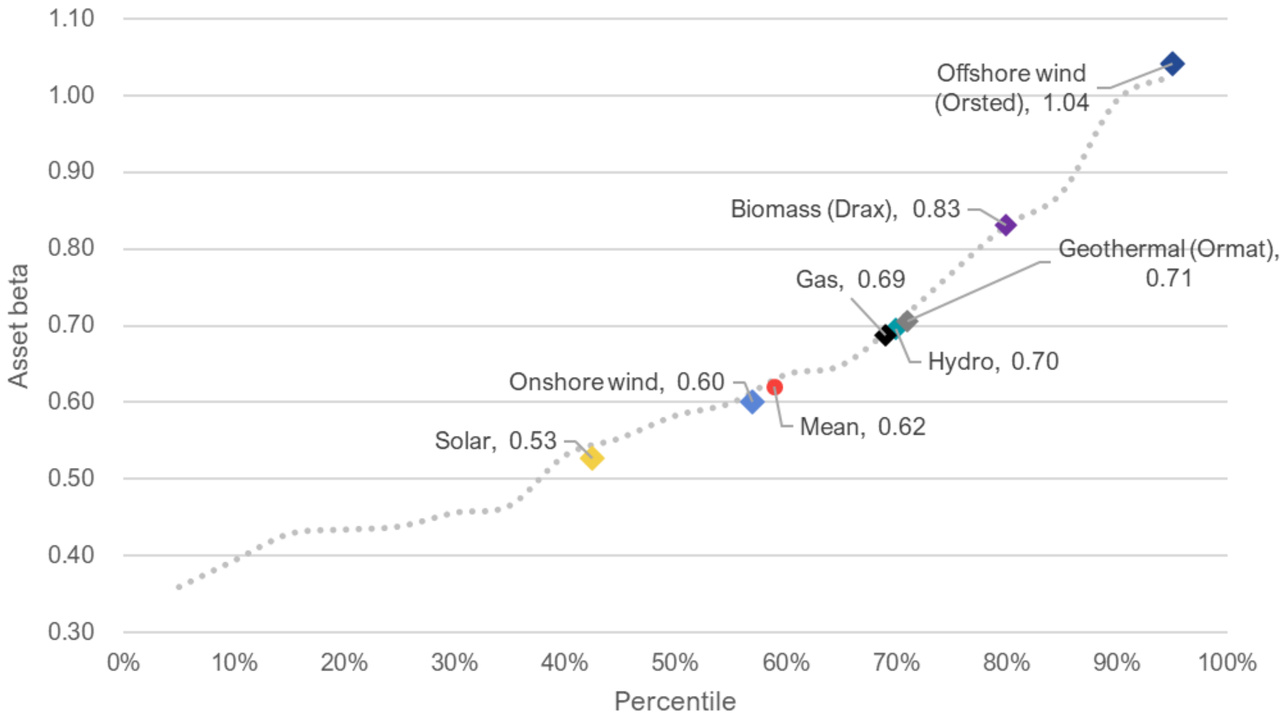
Section 4.3.1 focused on 5-year beta evidence. The figures below provide estimates for 2-year and 10-year horizons.

Figure D.1: 2-year daily beta estimates (spot, 31 December 2024)



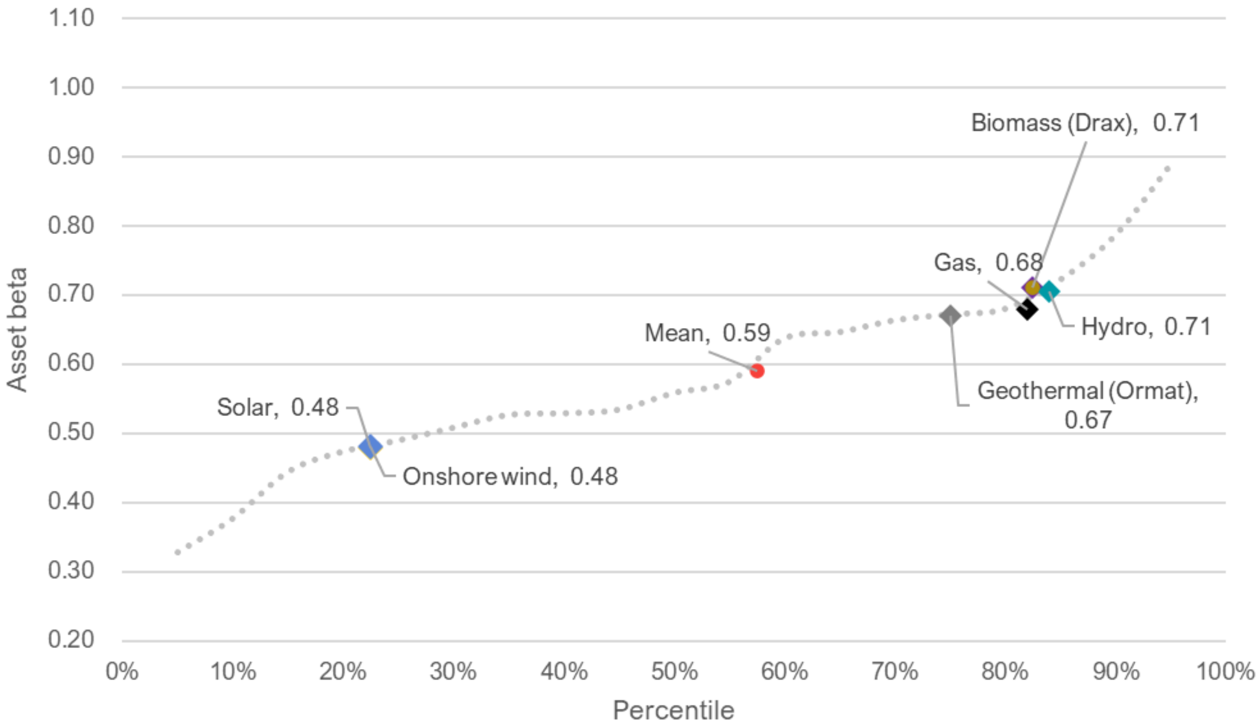
Source: CEPA analysis.

Figure D.2: 2-year weekly beta estimates (spot, 31 December 2024)



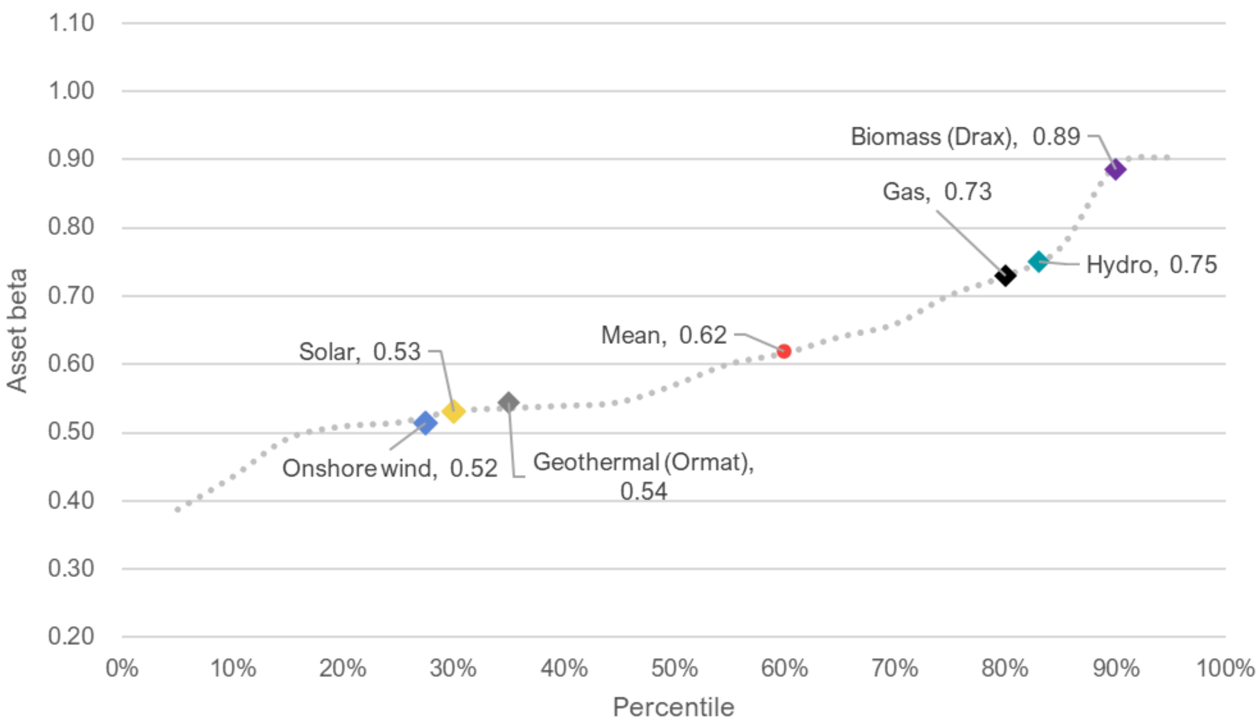
Source: CEPA analysis.

Figure D.3: 10-year daily beta estimates (spot, 31 December 2024)



Source: CEPA analysis.

Figure D.4: 10-year weekly beta estimates (spot, 31 December 2024)



Source: CEPA analysis.

Cross-checks

The tables below set out the cross-checks we have considered for the assumptions that apply to each technology, highlighting some key uncertainties.

For some technologies, the cross-checks suggest values that are *lower* than the proposed asset beta estimates. However, as discussed in the tables, we have not proposed to adjust the asset beta assumptions in response to this. This is because:

- As noted in the tables below, some of the cross-check evidence is itself not strong. For example, there are cases where we have one comparator that primarily invests in a particular technology – which does not in and of itself provide strong evidence that the assumption is right or wrong. While for transparency we have aimed to present all potential cross-checks that we identified, the strength of the cross-check has affected how much weight we have placed on it.
- As discussed in Sections 1.2 and 3.1.2, in this report we are aiming to estimate hurdle rates – rather than a 'pure' CAPM-based WACC. Therefore, although under the CAPM framework the asset beta is intended to only capture systematic risk, the way we have constructed the asset beta estimates (i.e., how we have positioned the risk levels against the comparator sample) reflects both systematic risk and non-CAPM risks.[241] However, in some cases the cross-checks may be more representative of a pure CAPM asset beta assumption.

In light of these factors, we have applied a high bar for making changes to the proposed asset beta assumptions – and in fact have not made any changes based on the cross-check evidence. However, we have considered the directional impact implied by asset beta cross-checks together with the investor survey results, and other evidence, in Section 4.6 where we discuss the overall hurdle rate estimates.

Table D.3: Proposed asset beta assumptions – Low risk

Technology	Risk rating	Asset beta	Cross checks
Solar PV	L	0.50 (0.45 – 0.55)	The upper end of the range is consistent with: • solar comparator sub-sample (0.55 average across 5-year daily/weekly, although a limited sample). The mid-point of the range (0.50) is consistent with: • the findings of CEPA 2023 survey of Australian investors[242]; and • CEPA internal references of betas used in recent equity analyst valuations for solar assets (small sample). CEPA's 2023 study of hurdle rates for Australian generators found that asset betas of 0.6-0.7 had been used in independent valuations of solar assets for takeover bids (although this was a small sample).[243] This is consistent with the higher end of the range being appropriate.

[241] The proposed asset beta for large-scale nuclear generation provides one example of this. Specifically, the risk rating discussion in Section 3.2.1 takes into account construction risk (and some assumptions around how the nuclear RAB regime might mitigate this). While construction risk may have a systematic component, other elements may be more idiosyncratic – i.e., specific to the nuclear project and diversifiable.

[242] The survey obtained evidence on pre-tax real cost of equity and overall hurdle rates, and not asset beta directly.

[243] This refers to analysis of independent expert reports prepared to advise shareholders on whether a proposed takeover offer is fair and reasonable, as required in some circumstances by the Australian Corporations Act and ASX listing rules. We found only a limited number of such reports that considered the technologies of interest, namely two for solar PV and four for onshore wind.

Table D.4: Proposed asset beta assumptions – Low-medium risk

Technology	Risk rating	Asset beta	Cross checks
Onshore wind	L-M	0.60 (0.55 – 0.65)	The mid-point of the range is: • Directionally consistent with the risk rating relative to solar PV. • The onshore wind sub-sample (0.59 average across 5-year daily/weekly, although a limited sample); and • CEPA internal references of betas used in combined offshore/onshore wind asset valuations (a small sample). Some cross checks support an assumption towards the lower end of the range (e.g., 0.55). CEPA's 2023 study of hurdle rates for Australian generators found that asset betas of 0.5-0.6 being used in independent valuations of wind assets for takeover bids (again, this was a very small sample). The same study also found no appreciable difference in the cost of equity / hurdle rates reported in an Australian investor survey. However, the context of the Australian investor survey was different to the UK. For example, there were no reported concerns of onshore wind facing materially higher planning and consent hurdles compared to solar PV.
AD	L-M	0.60 (0.55 – 0.65)	Consistent with risk being similar to onshore wind. We did not identify any corroborating evidence for this group of technologies.
Sewage gas			
Landfill gas			

Technology	Risk rating	Asset beta	Cross checks
Large scale nuclear	L-M	0.60 (0.55 – 0.65)	Consistent with risk rating being similar to onshore wind. The regulated US utility cross-check sample produces lower betas of 0.47 for the 5-year estimates (and lower values for the 2-year and 5-year estimates). This is significantly lower than the proposed mid-point assumption of 0.60, and below the lower end of the range. There are some complexities to consider in assessing how we should interpret this cross-check in the context of this study. • Firstly, this sample may reflect a regulatory regime that is similar to the RAB model, in the sense of providing a greater degree of surety over long-term asset values and mechanisms that reflect changes in discount rates and costs in allowed returns (in contrast to the types of contractual arrangements reflected in the comparator sample). This factor points to a range of 0.55-0.65 being too high. • Secondly, while the US utility sample reflects companies that invest in nuclear assets, these do not always form a significant proportion of their activities. In some cases, the cross-check comparators include network assets. This somewhat reduces the relevance of the cross-check and indicates that the core comparator sample (which reflects generation assets, and not network assets) may be more relevant on this dimension. • Thirdly, the cross-check sample reflects a mix of operating assets and development pipeline. We might therefore expect these estimates to reflect lower risk compared to a new build asset – noting that under the nuclear RAB model, there is still a degree of construction risk exposure for investors. As described in Section 3.2.1, we have assumed that the development and construction risk rating for nuclear projects is “medium”, after taking the RAB regime into account. If this assessment is correct (noting that it depends partly on how the RAB regime is calibrated in future), this is one reason why the cross-check beta might sit below an appropriate level. • Finally, as discussed at the start of this section, construction risk is not necessarily entirely systematic. This is another reason why the proposed asset beta assumption – which in the context of this project attempts to capture both systematic and unsystematic risk – might sit above the level suggested by the cross-check. Overall, this cross-check could support an asset beta range that is in line with the “low” risk rating. Although we have not adjusted the asset beta assumption on this basis, the case for doing this would be stronger if in future: (i) the application of the nuclear RAB regime results in a materially lower degree of construction / operating risk exposure than we have assumed in the risk assessment and (ii) if the cross-check sample is found to be more relevant for a nuclear licensee under the RAB regime. As discussed in Section 5.1.12, information released in relation to the July 2025 Sizewell FID will likely be relevant to future consideration of these points.

Technology	Risk rating	Asset beta	Cross checks
Inter-connectors	L-M	0.60 (0.55 – 0.65)	Consistent with the risk rating being similar to onshore wind. We did not identify any corroborating evidence for interconnectors.
PHES	L-M	0.60 (0.55 – 0.65)	Consistent with the rating for interconnectors under a similar cap and floor regime. We did not identify any corroborating evidence for PHES.

Table D.5: Proposed asset beta assumptions – Medium risk

Technology	Risk rating	Asset beta	Cross checks
Offshore wind	M	0.75 (0.65-0.85)	Consistent with a value between two pieces of evidence, although the range is extremely wide: • CEPA internal references of betas used in combined offshore/onshore wind asset valuations (small sample), ~0.60. • The average of 5-year betas across weekly and daily estimates for Orsted, which is ~1.0. However, this is just one comparator. Directionally consistent with risk rating for onshore vs. offshore wind.
Hydro	M	0.75 (0.65-0.85)	Consistent with risk being similar to offshore wind. Consistent with the hydro sub-sample (0.80 average across 5-year daily/weekly), although the sample is rather small. We did not identify any other corroborating evidence for hydro.
Remote island wind **ACT** **EfW** **Lithium BESS**	M	0.75 (0.65-0.85)	Consistent with risk being similar to offshore wind. We did not identify any corroborating evidence for these technologies.
Demand response aggregator	M	0.75 (0.65-0.85)	Consistent with risk being similar to lithium BESS. We did not identify any corroborating evidence for demand response aggregators.
Biomass (unabated)	M	0.75 (0.65-0.85)	Consistent with risk being similar to offshore wind. Drax provides an example of a biomass comparator (average 0.68 5-year asset beta across daily and weekly), which sits below the mid-point of the proposed range. However, this is just one comparator and there are differences. For example, we understand that only one of the units operated by Drax has a CfD and that other revenues appear to be based on shorter-term contracting / hedging.
SMRs **AMRs**	M	0.75 (0.65-0.85)	Consistent with risk being higher than large-scale nuclear. We did not identify any corroborating evidence for these technologies.
Gas (unabated)	M	0.75 (0.65-0.85)	Consistent with risk being similar to offshore wind. A value below the mid-point (but above the lower end of the range) is consistent with the gas sub-sample (0.70 on average for the daily / weekly 5-year estimates). However, this is a small sample.

Table D.6: Proposed asset beta assumptions – Medium-high risk

Technology	Risk rating	Asset beta	Cross checks
Geothermal	M-H	0.90 (0.80-1.00)	Consistent with 80th – 95th percentile of observations, reflecting medium-high rating (i.e., lower range overlaps with the upper range for the medium risk technologies). The sample includes Ormat Technologies, a firm located in the US that focusses on geothermal developments. Ormat's asset beta (0.56 – 0.69 for the 5-year estimates) is much lower than the assumption proposed here. Ormat's revenues appear to be based on PPAs. However, this is just one comparator.
Biomass (CCUS)	M-H	0.90 (0.80-1.00)	Consistent with risk being higher relative to biomass without CCUS. We did not identify any corroborating evidence for this technology.
Gas (CCUS)	M-H	0.90 (0.80-1.00)	Consistent with risk being higher relative to gas generation without CCUS. We did not identify any corroborating evidence for this technology.
Novel LDES	M-H	0.90 (0.80-1.00)	Consistent with risk being higher relative to PHES under the same revenue model. We did not identify any corroborating evidence for this technology.
Hydrogen electrolysers	M-H	0.90 (0.80-1.00)	Consistent with the risk assessment. The hydrogen cross-check sample produced an estimate of 0.73 (daily / week 5-year estimates). This is materially below the assumption proposed here. However, the sample is small and reflects a range of well-established activities that are not limited to hydrogen production.
Hydrogen CCHT / OCHT		0.90 (0.80-1.00)	Consistent with risk being higher relative to conventional gas generation. We did not identify any corroborating evidence for this technology.

Table D.7 Proposed asset beta assumptions – High risk

Technology	Risk rating	Asset beta	Cross checks
Floating offshore wind	H	1.05 (0.95-1.15)	Consistent with 90th+ percentile of observations, reflecting high rating (i.e., sitting above the medium-high technologies). While focussing on the top end of observed asset betas could appear excessive, the comparator sample does not include firms that are involved in developing these projects (with the exception of Orsted and RWE in relation to floating offshore wind demonstration projects – although we understand that this is not currently a large proportion of the future pipeline for these companies). We did not identify any corroborating evidence for these technologies.
Tidal stream			
Tidal range			
Wave			
New compound batteries			

Interpreting the evidence

While we consider that the way we have proposed to use the comparator evidence is a reasonable approach, it is important to highlight some challenges and alternative methodological choices.

Firstly, there are a range of challenges related to differences between the comparator sample firms and the technologies of interest:

- **Contracting:** The majority of the sample appears to have some long-term visibility over future sales quantities and prices for electricity output. This includes comparators with government-backed revenue stabilisation contracts, corporate PPAs, and also several firms with their own retail portfolio. This could all else equal, lead to higher or lower risk, depending on the assumed revenue model for each technology. For example:
    - We might expect the mid-point of the sample to reflect slightly higher risk compared to technologies with a UK government CfD. This is because comparators with corporate PPAs / retail portfolios within the sample may face a higher degree of counterparty risk, compared to CfDs that are backed by the UK Government. While the information on the comparators' contracting arrangements is incomplete, it also broadly suggests average contract durations similar to or less than the 15-year term of the CfD (although this varies across the sample). This too may point to the sample reflecting higher price risk than a CfD-eligible technology, and even higher risk when compared to the cap and floor (interconnectors, LDES) and nuclear RAB regimes, which have much longer durations.
    - We might expect the mid-point of the sample to be, all else equal, substantially lower risk than the technologies that are assumed to have a capacity market contract but otherwise operate on a primarily merchant basis (e.g., unabated gas, lithium BESS).
- **Technology type:** The core sample appears to primarily reflect onshore wind and solar PV assets. Indeed, many of the nascent technologies considered in this report are not included in the sample at all. Accordingly, we might expect the mid-point of the sample to be more representative of these technologies than others. Even for the technologies that are represented in the sample, there are challenges making direct comparisons (for example, using a sub-sample of comparators that primarily invest in solar PV to set the asset beta assumption for solar PV) because of the other differences listed here.
- **Existing and new assets:** The comparator sample asset betas will reflect both existing operational assets and the firms' development pipeline. This suggests that, all else equal, the sample overall may have lower risk than a new build asset, noting that required returns for investing in an asset are likely to be lower once construction has been completed.
- **Other factors:** There are a wide range of other factors that could mean that the observed asset betas for the comparator sample do not closely reflect the systematic risks faced by the technologies of interest. These include differences in electricity market arrangements, noting that the sample mainly reflects assets that are not located in the UK.

On balance, while it is important to be aware of these factors, we do not think that there is practical way to control for their impact. Therefore, we have assumed that this evidence can helpfully inform the range that our hurdle rate estimates should span.

Secondly, we have proposed to place most weight on 5-year daily and weekly observations (rather than 2-year or 10-year estimates). While in other work (including for other sectors such as water or energy networks) CEPA emphasises the importance of "looking through" short-term or "noisy" fluctuations in observed betas, in this case we have made a judgement that 5-year evidence may best capture expectations regarding the future evolution of the electricity generation sector – in a context where technology, regulatory and policy settings are evolving rapidly. This choice also reflected that some comparators who focus on the technologies of interest do not have sufficient trading data for inclusion in the 10-year estimates. However:

- We note that the 2-year and 10-year asset beta estimates generally produce lower estimates. This is particularly the case when we compare the lower percentiles, which are used to derive the assumptions for the "low" and "low-medium" risk categories. Accordingly, placing more weight on either the 2-year or 10-year evidence would have produced lower estimates.

- There are alternative specifications of betas that could be considered. For example, the New Zealand Commerce Commission considers 4-weekly beta estimates in its regulatory decisions. We have focused on daily and weekly specifications, noting UKRN guidance that *"[t]he use of daily data should be reasonable for the types of stocks generally considered (as they tend to be highly traded liquid stocks) rather than weekly or monthly data in regressions, as these significantly increase the analytical work involved but without necessarily producing more reliable results"*.[244] However, considering 4-weekly or monthly beta values could have produced a different set of estimates.

Finally, we have also made choices regarding how the risk levels are mapped across the distribution of observed betas, that have implications for the resulting assumptions.

- For example, the 2-year, 5-year and 10-year estimates produce distributions with different shapes. For example, in the distribution of the 5-year estimates there is a more pronounced jump between the 5th and 10th percentiles, compared to the 10-year estimates (see Table 4.1). This illustrates that the mapping of risk levels to the distribution may be sensitive to the shape of the distribution. If in future the asset beta estimates are refreshed, it is possible that the shape of the distribution could change, and that this would alter the assumptions for each risk level.
- More generally, we note that the mapping of risk levels to the distribution implicitly assumes that the comparators are distributed evenly in terms of their risks (for example, assumed that the distribution is not skewed by a disproportionate number of relatively high or relatively low risk comparators). We have attempted to account for this by removing comparators that do not appear to have a high proportion of revenues under contract, and by recognising in the mapping that the sample predominantly reflects mature technologies. However, it is difficult to precisely control for this issue.

While we consider that the methodology we have proposed is a reasonable use and interpretation of the evidence, the factors outlined above indicate that the results are of course sensitive to the approach. This highlights the importance of considering relevant cross-checks to the *overall hurdle rate* estimates, as are set out in Section 4.6.

D.1.2. Credit rating

As outlined in Section 4.4.5, we propose to adopt a common gearing assumption for all technologies.[245] This means that the credit rating assumption is used to reflect technology-specific differences in risk in the cost of debt estimate. Conceptually, we are attempting to establish a reasonable credit rating for each technology, at the assumed level of gearing.

We have reviewed different sources of evidence to establish a spectrum of credit ratings that could potentially apply to the technologies of interest:

- Beta comparator sample evidence – however, only some of the listed comparators have a credit rating.
- A distribution of credit ratings from a much wider range of rated UK and European electricity generators and utilities issuing active bonds. While this includes firms that are less relevant for our purpose, as we outline below the broad distribution provides a helpful point of reference.
- Targeted investigation of non-listed firms, not included in the beta comparator sample, that reflect the technologies of interest. This was based on a review of ratings issued by S&P and Moody's.

This evidence is summarised in the figures overleaf, which show:

- A distribution of credit ratings from the wide sample of UK and European electricity sector firms described above (providing a general indication of a reasonable spectrum of ratings). Within this sample, ratings of

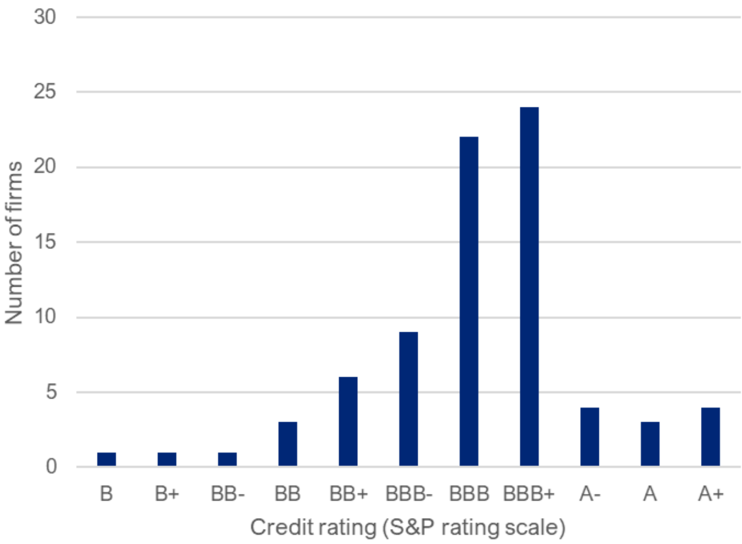
[244] UKRN (2023), p.23.

[245] Although as noted in Section 4.4.5, we consider several gearing scenarios.

BBB and below are more commonly observed for generation-only comparators, while those with ratings of BBB+ and above are more likely to include network activities.

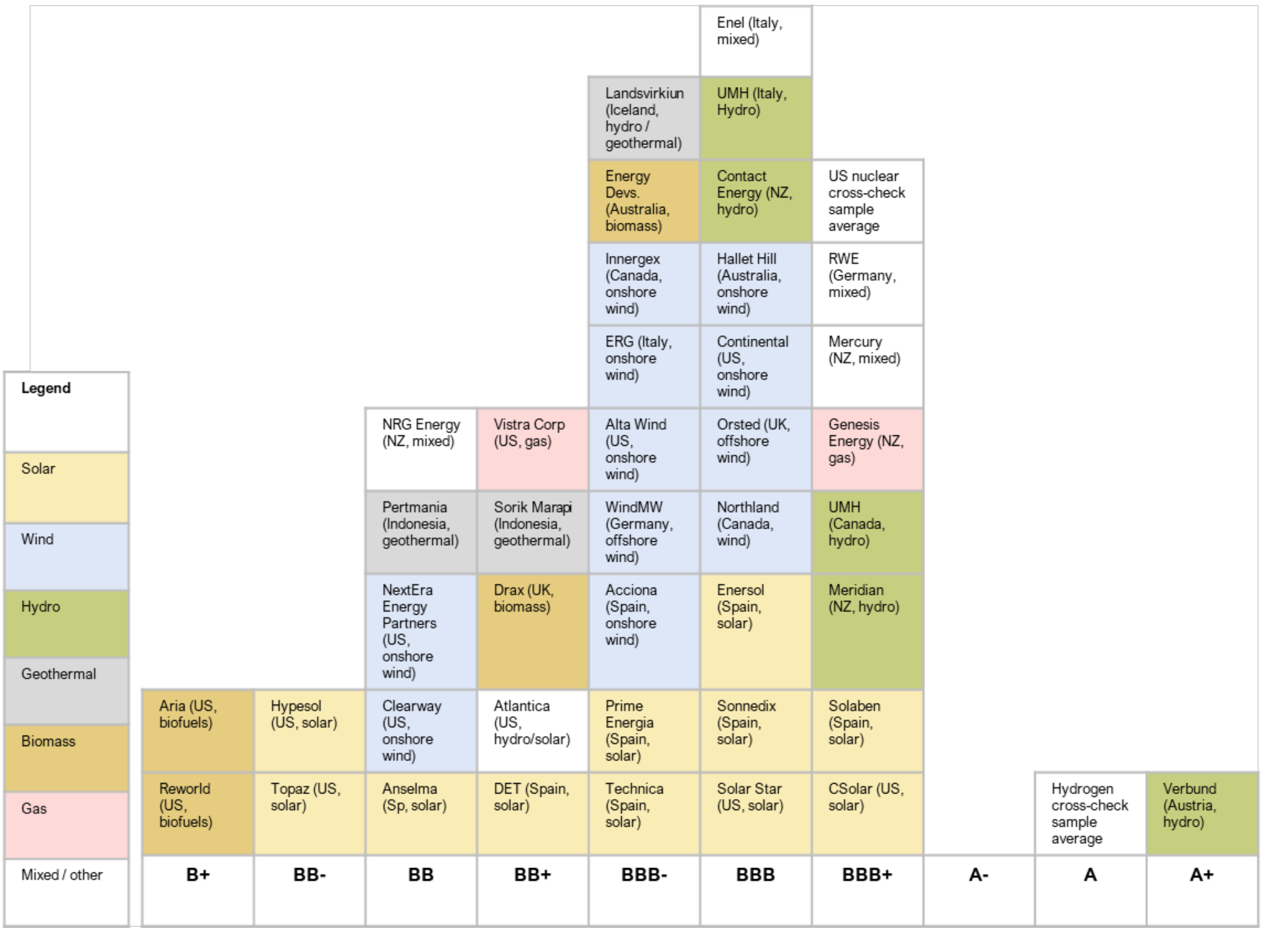
- Relevant individual comparators that represent a more targeted group than the wide sample.
- The ratings indicated have been converted to the S&P rating scale, although they may have been issued by other agencies.

Figure D.5: Distribution of electricity sector credit ratings – wide EU and UK sample



Source: CEPA analysis

Figure D.6: Distribution of credit ratings by technology – targeted sample



Source: CEPA analysis

We can make two main observations in relation to the figures above:

- In the sector broadly, ratings are concentrated in the BBB- to BBB+ band, although the latter includes a number of companies that undertake regulated network activities, to varying extents. At the lower end of the range, the observed frequency of ratings tails off below BB.
- There is a spread of ratings for entities that are focused on the same technology. This not surprising, as credit ratings reflect a range of factors that are *not* technology-related but rather reflect specific company characteristics. For example, these include whether the rated entity is diversified in terms of the type and location of its assets, its competitive position within the electricity market and the characteristics of the market itself, the counterparty to any electricity sales contracts (whose credit ratings may place a cap on the entity's own rating), its capital structure and financial management policies, and the terms and structure of the debt being issued.

As noted above, in principle, we are attempting to establish a reasonable credit rating for each technology, at the assumed level of gearing. The table below sets out the average gearing level (over the two-year period to 31 December 2024) for the listed comparators that fall within each credit rating level (for all samples). We have considered 2-year gearing here (rather than the five-year period considered for asset beta), because the credit ratings are as of 31 December. For the rated comparators in the core sample, this indicates that:

- Higher gearing levels are associated with weaker credit ratings.
- A gearing level of ~50% (in line with our suggested base case assumption) is broadly consistent with a credit rating in the BB to BBB- range.

To an extent the same pattern is observable in the nuclear, interconnector and hydrogen cross check samples, all these contain far fewer comparators.

Table D.8: Comparator average gearing compared to credit rating

Credit rating (S&P rating scale)	Average 2-year gearing			
	Core sample	Nuclear cross check sample	Interconnector cross check sample	Hydrogen cross check sample
A+	8%			
A				12%
A-		43%		
BBB+	24%	46%	27%	
BBB	35%	54%	50%	
BBB-	45%			
BB+	42%			
BB	56%	60%		
BB-	65%			
B+				
B				
B-				

Source: CEPA analysis of Bloomberg data. Note: Blank cells indicate that no comparators had that credit rating.

Finally, we can also consider the criteria that rating agencies have put in place to guide their decisions. Moody's rating methodology provides an indication of the broad rating bands that may apply to assets with certain cash flow characteristics and technology profiles. We reproduce these indicators in Table D.9 overleaf. This suggests it is reasonable to assume that the technologies would fall within the broad Baa-Ba (BBB-BB) bands.

- The mature technologies that are assumed to have a long-term revenue support mechanism are generally consistent with the broad Baa (BBB) band in relation to the predictability and sufficiency of cash flows factor.
- Some less mature technologies, or those with a lower proportion of contracted revenues, may fall into lower rating bands, such as B or Caa (B or C) in relation to the technology and operating performance factor. Less proven technologies with higher construction period risk could also be adjusted downwards.
- Assumptions within the Baa-Ba (BBB-BB) range sit between these two reference points and are also consistent with the distribution shown in Figure D.5 and Figure D.6 above.

In practice, the actual ratings for individual projects will depend on a wide variety of factors that are not specific to the technology in question.

Table D.9: Technology-specific elements of Moody's power generation project scorecard rating methodology

Broad rating bands (S&P equivalent)	**A (A+, A, A-)**	**Baa (BBB+, BBB, BBB-)**	**Ba (BB+, BB, BB-)**	**B (B+, B, B-)**	**Caa**
Predictability and sufficiency of cash flows	Highly predictable, fully contracted cash flow with off-taker rated Aa3 (AA-) or better. Contracts extend for full term of financing. AND Contracts pass through opex / capex without material conditions. No fuel/resource risk. OR 5+ years strong operating and financial performance.	Highly predictable, fully contracted cash flow with off-taker rated Baa3 (BB-) or better. Contracts extend for full term of the financing and have escalators tied to inflation. AND 5+ years strong operating and financial performance.	At least 50% cash flow contracted/hedged over medium term (3-5 years). Unhedged cash flow has low year-to-year volatility. Some fuel supply / resource risk. AND 5+ years strong operating and financial performance.	Less than 50% cash flow contracted/hedged over medium or short term. Unhedged cash flow vulnerable to year-on-year volatility. High fuel supply / resource risk.	Cash flows, irrespective of contractual arrangements, likely to be insufficient to meet debt obligations.
Consistency with technology revenue models	*Certain revenue models have some characteristics that are consistent with this.* *For example, the nuclear RAB model allows for efficient costs to be passed through to consumers, albeit subject to incentives. Similarly, the cap and floor regime provides for a review of capex after construction However, this is not the same as a full pass through.* *The other assumed revenue models also do not have a cost pass-through feature, and so may fall below the broad A band on this factor.*	*We would expect all revenue models (other than for unabated gas, lithium BESS, demand response aggregators and new compound batteries) to be consistent with the broad Baa band on this factor.* *This is because they provide a contracted cash flow stream of at least 10-15 years (or more, in the case of the cap and floor / nuclear RAB regimes). Further, contracts are backed by the UK Government, which are better than counterparty requirement for the band. Finally, the revenue models provide for CPI indexation (or other indices in some cases).*	*Given the assumed revenue model (i.e., a capacity market contract, but otherwise no long-term security over revenues), it is reasonable to assume that unabated gas / lithium BESS / demand response aggregators / new compound batteries could sit in the Ba band on this factor.* *It is possible that these technologies could fall into the broad B band on this factor, if they do not engage in some form of short-term hedging for at least 50% of revenues.*		*We do not consider that this band is relevant – a new build project would not proceed if this was the expectation.*

Broad rating bands (S&P equivalent)	A (A+, A, A-)	Baa (BBB+, BBB, BBB-)	Ba (BB+, BB, BB-)	B (B+, B, B-)	Caa
Technical and operating performance	Simple, commercially proven technology with few moving components. Warranties from creditworthy OEM are in place for term of financing.	Commercially proven technology that is well understood and considered standard. Agreement with creditworthy OEM in place for several years.	Commercially proven technology with several complex elements requiring specialised skills to operate and maintain.	Most of technology considered proven, but certain elements untested or have limited operating history.	Technology unproven and untested with very limited operating track record, or technology has high obsolescence risk.
Consistency with technologies	*Low-risk and low-medium technologies may fall into this band (or better).*	*Medium-risk technologies (and potentially some of the medium-high technologies) may fall into one of these bands.*		*The high-risk technologies (and potentially some of the medium-high risk technologies) may currently fall into one of these bands.*	

Source: CEPA summary of relevant elements of Moody's rating methodology for power generation project

D.1.3. Cost of debt

To translate the credit ratings to a nominal cost of debt, we consider evidence of corporate bond yields at the relevant rating, sourced from Markit iBoxx. The estimates presented below are a 1-month trailing average (i.e., an average over the month preceding 31 December 2024), consistent with the approach to the risk-free rate.

As explained in Section 4.3.3, we have based our cost of debt assumptions on the iBoxx index for corporate bonds with a 10+ year term to maturity, as this provides information across the broad BBB, BB and B bands (which we require for the credit rating assumptions noted above). **We consider that this is broadly consistent with an assumed 15-year investment horizon** (see Appendix D.2.1 below). However, in some cases this index may include very long-term bonds and there may be a slight overestimate (e.g., for A rated debt the average maturity may be more consistent with 20+ years). For comparison, below we also report yields from the iBoxx 10-15 and 5-15 year corporate indices.

Table D.10: Markit iBoxx - 1-month trailing average of nominal corporate bond yields (31 December 2024)

Series / rating band	A	BBB	BB	B
10+ years	5.68%	6.11%	7.48%	8.63%
15+ years	5.79%	6.24%	n/a	n/a
5-15 years	5.37%	5.76%	n/a	n/a
10-15 years	5.52%	5.89%	n/a	n/a

Source: CEPA analysis of Markit iBoxx data. Notes: 'n/a' means no index is provided for the rating band.

D.2. TECHNOLOGY NEUTRAL PARAMETERS

D.2.1. Term of the cost of capital

The term of the cost of capital refers to the time horizon over which returns are estimated. For example, the choice of horizon impacts the estimation of the risk-free rate (i.e., through the chosen tenor of government bonds used as a proxy for the risk-free rate), the cost of debt (i.e., through the chosen tenor of corporate bonds used to determine the debt premium), and inflation (i.e., whether inflation expectations are estimated over a 5-year, 10-year or other horizon). We propose to apply a common term for estimating hurdle rates, across all technology types.

There are theoretical and practical arguments both for and against this approach. One argument against is that the term should be aligned to the economic life of the asset, as the required return should be earned over this period. This would suggest adopting different horizons (therefore different risk-free rate and cost of debt assumptions) for different technologies.

On the other hand, this is not necessarily how investors construct hurdle rates in practice and there is evidence of investors using a 10-year discount rate when making decisions on infrastructure investments with economic lives longer than 10 years.[246] For example, investors may assume the asset will be held for a time period consistent with the horizon of their fund (e.g., 10 years).

There are also pragmatic reasons to adopt a common term. The cost of debt and risk-free rate (hence cost of equity) will vary by time horizon. Depending on the shape of the yield curve, this will drive differences between technologies. At certain times, the yield curve will be inverted, meaning that short-term rates will be higher than long-term rates – potentially producing a higher cost of capital for technologies with shorter operating lives. However, technologies with shorter operating lives are not necessarily lower risk. Accordingly, adopting a technology-specific term could, inadvertently, produce counterintuitive hurdle rate estimates that do not reflect qualitative views on risk. A common investment horizon for both equity and debt minimises this risk.

[246] AER (2022), *Draft Rate of Return Instrument – Explanatory Statement*, June 2022, p.14. Energy Networks Australia (2021), *The term of the rate of return – Response to Draft AER Working Paper*, 2 July 2021, p.7 and p.9.

The UKRN notes that investment horizons of 10 to 20 years are likely to be suitable for most sectors considered by its member regulators.[247] We understand that the hurdle rate estimates developed by NERA and Europe Economics assumed a common term for the cost of capital across technologies, with a time horizon of 15 years.

Taking the factors above into account, we have also adopted a term of 15 years, which is reflected in the sections on risk-free rate, cost of debt and inflation below. A term of 15 years aligns with the duration of the revenue models available to many of technologies, which may also mean that it is a relevant point of reference for investors when considering hurdle rates for projects under these models. However, it is possible that the revenue models with longer durations – in particular the cap and floor and nuclear RAB regimes – could potentially imply a longer term.

D.2.2. Risk-free rate

Within the CAPM, the risk-free rate represents the required return on a riskless asset. Although this is a theoretical construct, a common approach is to use rates on government-issued debt as a proxy.[248]

As explained in Section 4.4.2, to derive a real estimate of the risk-free rate, we propose to use adopt a one-month trailing average of UK indexed-linked gilt (ILG) yields. This means averaging observations of ILG yields over the one-month period prior to the estimation date (in this report we adopt an estimation date of 30 December 2024). ILGs are referenced to the Retail Price Index (RPI) and therefore produce a 'real RPI' risk-free rate estimate. As we require hurdle rates that are expressed in nominal, real CPI and real GDP deflator terms, we have therefore converted the ILG yields to this basis using the inflation assumptions set out in Section 4.4.4 (and expanded on in Appendix D.2.4).

This averaging period is consistent with UKRN guidance and aligns with recent proposals from Ofgem and Ofwat. [249] Regulators previously have looked at 3-12 month trailing averages, but more recently there has been a greater focus on nearer-term estimates.

While this approach relies on current spot rates, it is nonetheless intended to provide a *forward-looking* estimate of the risk-free rate over the investment horizon. Some regulators (and Europe Economics in 2018) have attempted to reflect changes in interest rates in their risk-free rate estimates, by adjusting the spot rate to account for future movements implied by yield curves. However, the UKRN points out that this approach may not provide better predictions of future rates than simply using spot rates and the majority of regulators now no longer use forward projections.[250] Accordingly, we consider it is reasonable to adopt spot rates as the methodology for this project.

We have not adjusted the estimate of the risk-free rate for factors such as liquidity or convenience yield – a position that is also consistent with UKRN guidance.[251]

D.2.3. Total market return and equity risk premium

The Total Market Return (TMR) reflects the return expected by an investor holding a diversified portfolio (i.e., matching the composition of the overall market). The TMR can be thought of as the risk-free rate plus an equity risk premium (ERP), where the ERP reflects the additional compensation that investors require to invest in the market compared to a risk-free asset.[252]

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[247] UKRN (2023), p.14.

[248] UKRN (2023), p.12.

[249] See Ofwat (2024), *PR24 final determinations: Aligning risk and return – allowed return appendix*, 19 December 2024, p.37. Available here: https://www.ofwat.gov.uk/publication/pr24-final-determinations-aligning-risk-and-return-allowed-return-appendix/. CEPA supported Ofwat in the PR24 process. And Ofgem (2024), *RIIO-3 Sector Specific Methodology Decision – Overview Document*, 18 July 2024, p. 17, Table 1. Available at: https://www.ofgem.gov.uk/sites/default/files/2024-07/RIIO_3_SSMD_Overview.pdf.

[250] UKRN (2023), p.13.

[251] UKRN (2023), p.14 and p.16.

[252] The ERP is sometimes also referred to as the market risk premium (MRP).

Approach

As outlined in the 2023 UKRN guidance, a wide range of evidence may be considered to estimate the TMR, including:

- 'Historical ex-post' approaches – which use observed historic equity market returns to estimate investors' current forward-looking expectations.
- 'Historical ex-ante' approaches – which are similar to historical ex-post but adjust the data to remove the effect of past events that are not considered likely to be repeated.
- 'Forward-looking' approaches – which captures a range of different approaches. These include using dividend discount models (which infer the TMR from current stock market prices and assumptions around long-run growth in dividends) and surveys.

The UKRN recommends placing most weight on historical approaches to estimate the TMR noting concerns around the robustness of forward-looking approaches.[253]

The UKRN's approach also reflects long-standing UK regulatory practice, which assumes that the TMR is more stable than the ERP. In practical terms, this assumption means that regulators tend to estimate a real TMR based on long-run historical stock market returns. The ERP is then calculated by deducting the real risk-free rate (calculated as a spot or near-term average) from the TMR estimate. This implies that while the TMR stays constant in real terms, the ERP fluctuates in line with movements in the real risk-free rate. This is not the only assumption that could be made. An alternative – which is adopted by international regulators, including in Australia and Europe – is to assume that the ERP is the more stable parameter.[254]

While the UKRN recognise some downsides of assuming that the TMR is stable and the ERP fluctuates, on balance this remains their recommendation (**CEPA emphasis**):

> *"There is significant alignment amongst regulators in the overall approach to the TMR/ERP, namely that in recent determinations UK regulators assume greater stability in the TMR and therefore estimate it directly from historical equity returns data. In the interests of maintaining consistency across sectors and also across time, continuing with this approach remains preferable. This approach does not imply that regulators should simply pick the same fixed value for the TMR in each decision for all time, but that the TMR would be relatively less variable than the underlying RFR. This would support greater stability in the cost of equity allowances over time.* ***This policy choice seems appropriate in the wider context of the aspiration for greater predictability and transparency in the regulators' methodologies for estimating the allowed rate of return, and one that is fair to investors and customers over time.***
>
> ***However, it is important to recognise that depending on the macroeconomic environment, this largely 'through-the-cycle' approach could either overstate or understate returns required by investors in a specific price determination. In the low interest rate environment following the 2008 Financial Crisis, such an approach likely overestimated the TMR expected by the market. This is in part because there is empirical evidence of a positive relationship between real interest rates and real returns on equity, for example, as shown in the*** **[Global Investment Returns Yearbook ("DMS Yearbook")]***."*

Adopting an alternative methodology could indicate a different value for the ERP. For example, one alternative (that is common practice among Australian regulators) would be to estimate an ERP based on the historic TMR minus the historic (rather than spot) risk-free rate. However, in this context we think it is reasonable to anchor the DESNZ methodology in UK regulatory practice – and accordingly adopt the methodology recommended by the UKRN.

[253] UKRN (2023), p.21.

[254] UKRN (2023), p.16.

Implementation

Implementing the approach recommended by the UKRN involves a range of detailed estimation choices – for example, in relation to the time horizon that is considered to derive historic estimates of TMR, the approach to converting historic data to real / nominal terms, the averaging approach (arithmetic vs geometric), and the data sets that are relied on.

Given the range of evidence considered for the TMR, we suggest that estimating this parameter directly is not the best approach in this context. This is because in future hurdle rate updates, this would require DESNZ to refresh a large number of TMR estimates and exercise judgement in interpreting these. We suggest that a more practical (but still reasonable) approach is to derive real TMR estimates from UK regulatory precedent, which is relatively tightly grouped on estimates of the real TMR. DESNZ would be able to replicate this approach in future by referring to new relevant precedent.

At this point in time, Ofwat's PR24 final determination provides a suitable benchmark.[255] For PR24, Ofwat considered both ex-post and ex-ante estimates of the TMR. As described above in relation to the UKRN methodology, ex-post approaches assume that investors expect returns that are similar to those realised in the past. Ex-ante approaches attempt to adjust for features in the historic data that are considered unlikely to apply in future. [256]

Ofwat's upper and lower-bound estimates for TMR (on a real CPIH basis) are shown in the table below. Consistent with the final determination, we propose to adopt the mid-point. We consider that this is a suitable value to adopt, due to the recency of the decision.

Table D.11: Real CPIH TMR estimates

Term	Lower	Upper	Mid-point
Estimates	6.68%	6.98%	6.83%

Source: Ofwat (2024), p. 37, Table 8.

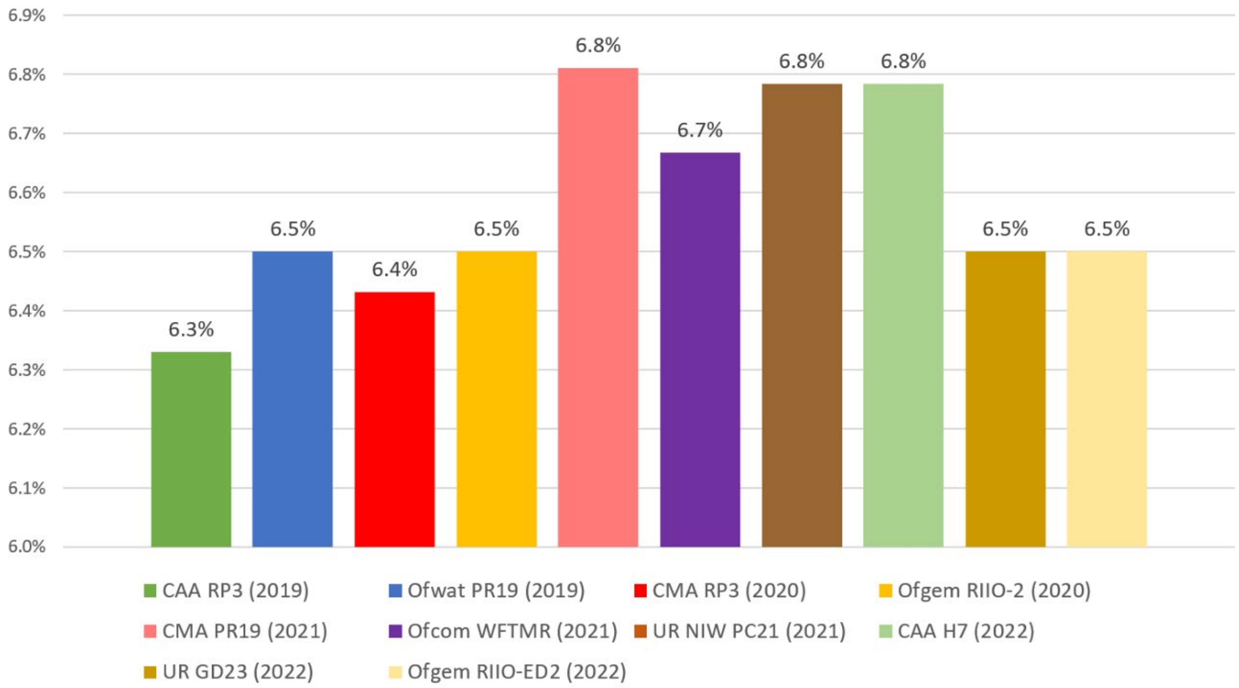
We note that Ofgem's sector specific methodology under the RIIO-3 price review process for energy networks proposes a TMR (real CPIH) range of 6.5% to 7.0%, which would provide a similar range and mid-point.[257] Ofwat's determination is also broadly consistent with the range of recent UK regulatory precedent, which falls between 6.3% to 6.8% (CPIH-real). This is illustrated in the figure below from the UKRN cost of capital guidelines.

[255] See Ofwat (2024), *PR24 final determinations: Aligning risk and return – allowed return appendix*, 19 December 2024, p.37. Available here: https://www.ofwat.gov.uk/publication/pr24-final-determinations-aligning-risk-and-return-allowed-return-appendix/. CEPA supported Ofwat in the PR24 process.

[256] Ofwat (2024, p.23-24 provides a summary of their approach to TMR.

[257] Ofgem (2024), *RIIO-3 Sector Specific Methodology Decision – Overview Document*, 18 July 2024, p. 17, Table 1. Available at: https://www.ofgem.gov.uk/sites/default/files/2024-07/RIIO_3_SSMD_Overview.pdf.

Figure D.7: TMR in recent UK regulatory decisions (CPIH-real)



Source: UKRN (2023), p.17.

Adopting a real TMR based on UK regulatory precedent has some implications for how we take account of historic inflation, discussed in the next section.

D.2.4. Inflation

DESNZ requires real hurdle rate values that are consistent with the GDP deflator, rather than CPI, CPIH or RPI – reflecting Green Book guidance. DESNZ requires GDP deflator real estimates for a variety of other purposes, but at times may also need to use nominal estimates or CPI real estimates. Accordingly, the methodology needs to allow DESNZ to make these adjustments.

Calculating GDP deflator real hurdle rates has two data requirements:

- **Historical data on the GDP deflator.** This would be used to convert historic data expressed in nominal terms to real GDP deflator terms. Specifically, this is required to estimate TMR using historical approaches – i.e., to convert historic nominal equity market returns to 2024 GDP deflator real terms.
- **Forward-looking expectations of the GDP deflator.** This is used to convert forward-looking estimates between real and nominal terms. For example, in the first instance we derive a real risk-free rate, because the direct data inputs (ILG yields) are expressed in real terms. We need to add expected inflation to these estimates to derive nominal values.

In practice, adopting a GDP deflator approach for historical data may not produce a materially different outcome to an approach based on CPI, and may also create complexity. Forward looking estimates are more straightforward. We discuss this below.

Historical data

Generally, historic TMR approaches consider a long series of equity market data from 1899 to the present.[258] To create a consistent GDP deflator series over this period, we would need to draw on two datasets:

[258] While this may appear a surprisingly long time period, this approach is widely adopted with a view to achieving statistical reliability. While there have been structural changes in the economy over time, it is generally accepted that over sufficiently long periods returns have been stable.

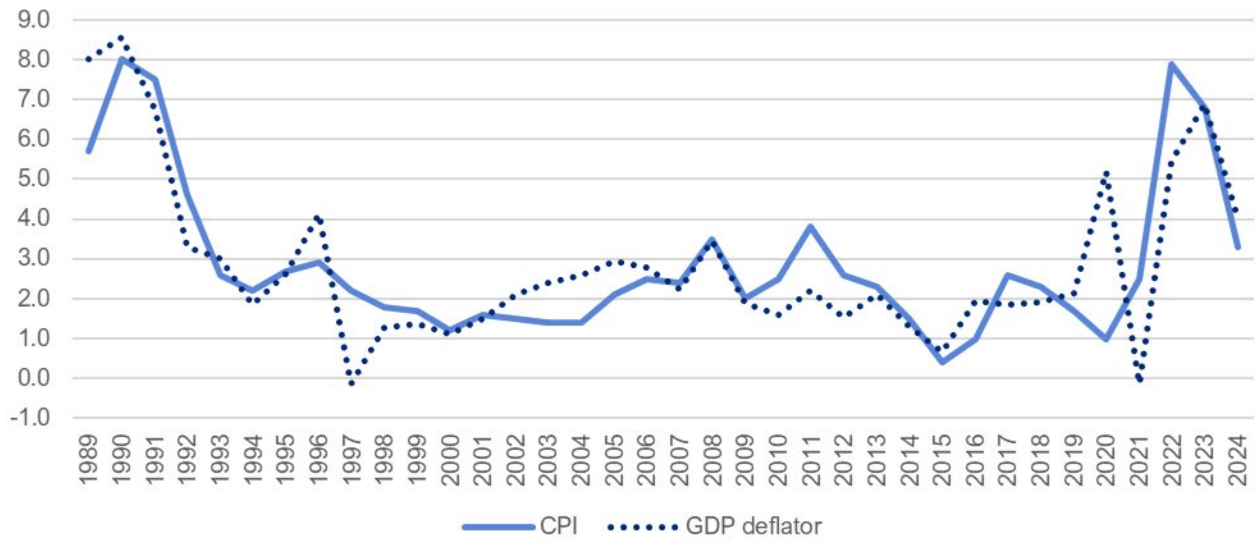
- Historical GDP deflator data is published by HM Treasury from 1955 onwards.[259]
- Historical GDP deflator data is published by the Bank of England from 1270 to 2016 in their 'A millennium of macroeconomic data for the UK' dataset.[260]

In principle it is possible to combine the two datasets to create the required series. However, we would need to examine whether there are any inconsistencies with overlapping years which might need to be resolved, which is a substantial exercise. The implications for the various ex post and ex ante TMR estimation methods would also need to be carefully considered.

The figure below shows the GDP deflator and CPI since 1989. This illustrates that in recent history, the CPI and the GDP deflator broadly follow each other. The average difference is just 0.04%, with average CPI sitting at 2.88% and the average GDP deflator sitting at 2.84%. If we take the period following the introduction of inflation targeting by the Bank of England, which would be 1993 onwards, we find the average gap to be slightly larger at 0.06 %.

This suggests that the real TMR estimates reported in the section above could reasonably be deemed consistent with *either* CPI or GDP deflator.[261] Average differences from recent history suggest that the impact on a 31 December 2024 hurdle rate estimate would be in the order of 0.04-0.06%, which is well within the margin of error for this exercise. This is particularly so considering the wide range of evidence that informs judgements on the TMR, meaning that any TMR estimate is itself an approximation of the 'true' value. In this context, we do not consider that seeking to adjust the real TMR starting point for small historical differences between CPI and GDP deflator would be proportionate.

Figure D.8: Comparison of CPI and GDP Deflator (1989 - 2024)



Source: CEPA analysis of ONS data.

Forward-looking

As noted in Appendix D.2.2, because we derive a real RPI risk-free rate from ILG yields, we need forecast values for RPI (to convert to a nominal risk-free rate) in addition to forecasts of CPI and GDP deflator.

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[259] HM Treasury (2024), *GDP deflators at market prices*. Available at: https://www.gov.uk/government/statistics/gdp-deflators-at-market-prices-and-money-gdp-march-2024-quarterly-national-accounts.

[260] Bank of England (2016), *A millennium of macroeconomic data*. Available at: https://www.bankofengland.co.uk/statistics/research-datasets.

[261] Indeed, CEPA's evaluation of the ex-post evidence to inform Ofwat's PR24 decision aimed to develop a real TMR estimate that was not anchored to any single view of historical inflation, recognising that investor views on the past are difficult to determine. See CEPA (2024), *PR24 Cost of Equity*, report for Ofwat, 11 July 2024, p.59. Available at: https://www.ofwat.gov.uk/wp-content/uploads/2024/07/CEPA_PR24-cost-of-equity-1.pdf.

Deriving a forward-looking estimate of expected inflation requires two decisions:

- A decision on the relevant term / investment horizon.
- A way of estimating inflation expectations for that term.

We have considered a 15-year investment horizon (Appendix D.2.1). This means we require forecast inflation for 15 years.

In relation to the estimation approach, there are two broad options: forecasts and market expectations.

Forecasts

The Office of Budgetary Responsibility (OBR) provides long-term forecasts for RPI, CPI and the GDP deflator which are suitable for use in the context of this project.[262] The availability of the RPI, CPI and GDP deflator series means that it is straightforward to adopt either measure of inflation to convert the risk-free rate and cost of debt to nominal/real terms.

Other sources of forecasts include those produced by professional forecasters and submitted to a HM Treasury monthly survey. There is also the Bank of England's (BOE) 2% target. For the majority of forecasts over the past decade, the OBR has assumed that CPI inflation from the fifth year (Yr5) of the forecast onwards is 2.0%, consistent with the BOE target. Evidence from the HM Treasury survey only covers two years, rather than any long-term data.

Market expectations

Market-based measures include inflation swaps and breakeven inflation at different tenors.

Market-based measures are typically higher than forecasts. However, market approaches will not strip out inflation risk premia, so may be less representative of expected outturn inflation. The Bank of England has noted that the inflation risk premium had increased to a 0.9 percentage points to September 2023, up from 0.2 percentage points in 2014.[263]

To illustrate this difference, we present the difference in RPI inflation estimates between inflation swaps, breakeven inflation and the average OBR forecasts across the five subsequent years. We note that regulators have often adopted the Yr5 inflation measure, rather than the average of the five years, as presented below.

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[262] OBR (2024), *Supplementary forecast information release: Long-term economic determinants – March 2024*. Available at: https://obr.uk/supplementary-forecast-information-release-long-term-economic-determinants-march-2024/.

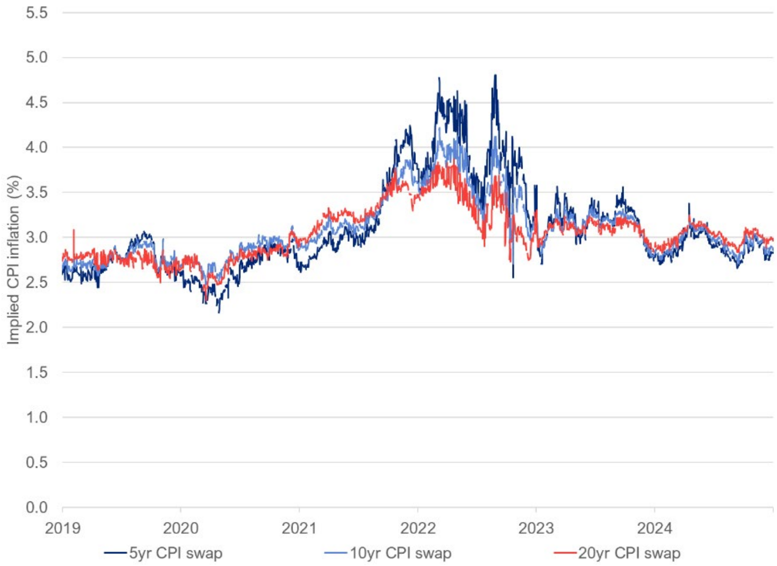
[263] BOE (2023), *Inflation Models and Research: Distilling dynamics for monetary policy decision making - speech by Catherine L. Mann*, 11 September 2023. Available at: inflation-models-and-research-distilling-dynamics-for-monetary-policy-decision-making.pdf.

Figure D.9: Differences in RPI inflation measures

Source: Bloomberg, Bank of England.

Breakeven inflation does not exist for CPI inflation, so CPI swaps is the direct market measure available.

Figure D.10: CPI swap estimates



Source: Bloomberg, Bank of England.

The swap estimates presented were consistently higher than the 2% BOE target for this full period, with recent estimates between 2.7-3.0%.

Investor survey results

The investor survey invited respondents to provide hurdle rates in either real or nominal terms, depending on which type of hurdle rate they used for investments decisions. Respondents were also asked to comment on their underlying assumptions, including in relation to inflation expectations. However, no inflation assumptions were provided through the survey.

Discussion

We note that market-based estimates have been used by UK regulators, and in that context may be the preferred approach.[264] However, in the context of this project we consider it is reasonable to adopt the OBR's long-term forecasts. This is because:

- As noted above, it provides a consistent long-term series of RPI, CPI and GDP deflator, which meets DESNZ's requirements for the hurdle rate estimates.
- We understand that the use of OBR forecasts for inflation (and other economic measures) is consistent with DESNZ's general practice elsewhere.
- It is a simple and practical approach, which will support efficient future updates.

In light of these factors, we have adopted the OBR forecast as the basis for the estimates presented in this report.

D.2.5. Gearing

The weighting of the cost of debt and cost of equity components within the CAPM WACC formula is determined by gearing, the proportion of debt within the overall capital structure. Higher gearing means a higher proportion of debt finance in the capital structure.

Considerations

The impact of differences in gearing on required returns is more complex than simply re-weighting the return on debt and return on equity components of the hurdle rate, because the return on debt and equity themselves are not independent of the capital structure. As gearing increases, so too does the required return on debt and equity, reflecting the greater risk to investors in a more leveraged asset. The higher return on debt and equity offsets the hurdle rate impact of increasing the proportion of debt finance (which is generally lower cost than equity). The Modigliani and Miller theorem states that subject to certain conditions an asset's overall market value is independent of its capital structure – in other words, that the hurdle rate is invariant to gearing.

In practice there are additional considerations that explain why a certain capital structure may be preferable for an investment, in the sense that it maximises its value. For example, increasing the proportion of debt finance can be advantageous because the asset benefits from the tax shield that applies to interest payments. However, this benefit does not continue indefinitely as gearing reaches higher levels, because of the costs of financial distress that arise when leverage is excessive (i.e., when the asset's creditworthiness is in doubt and, in the extreme, the costs associated with bankruptcy). In theory, gearing will increase only to the point where the marginal benefit from the tax shield is equal to the marginal cost of financial distress.

This means that if a particular investment's characteristics points to relatively higher expected cashflows or reduced downside risk, and thus reduces the probability of financial distress, there are two mechanisms through which the overall hurdle rate could fall (in addition to any impact on the return on equity): either through a reduction in the return on debt; or through being able to increase gearing (and benefit from the tax shield) without impacting the credit rating.[265] Similar considerations, in the opposite direction, would apply if the investment's characteristics increased downside risk.

Investor survey

In the investor survey conducted to inform this report, 29 respondents commented on capital structure. Most (20) agreed that capital structure varies across technologies, with others either disagreeing or unsure.

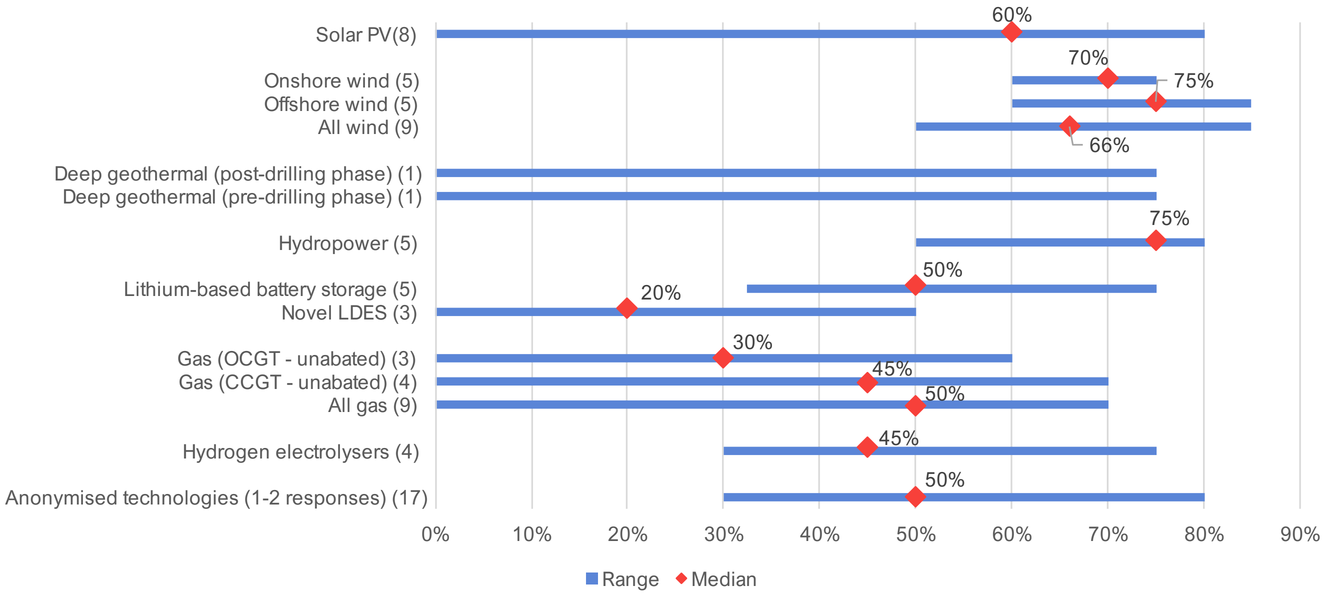
The figure below presents a summary of reported gearing (proportion of debt in the overall capital structure) by technology / technology group. No information was provided for the following technologies: nuclear technologies,

[264] Indeed, in regulatory contexts CEPA's preferred approach has been to adopt a market-based inflation approach.

[265] In other words, the level of gearing at which the benefit of the debt tax shield is offset by the cost of financial distress has shifted upwards.

advanced conversion technology, anaerobic digestion, sewage gas, landfill gas, new compound batteries, OCGT (with CCUS), gas reciprocating engines (with CCUS), and demand response.

Figure D.11: Reported gearing range and median by technology (number of responses in brackets)



Notes: (1) No median is reported for geothermal, as only one response was provided. (2) "All wind" includes onshore wind, offshore wind, remote island wind and floating offshore wind. (3) "All gas" includes OCGT (unabated), CCGT (unabated), CCGT (with CCUS) and reciprocating gas engines (unabated). (4) "Anonymised technologies" includes tidal stream, wave, energy from waste, biomass (unabated / with CCUS), pumped hydro energy storage, hydrogen (CCHT and OCHT) and interconnectors. Gas and wind technologies that received only 1-2 responses have been included under "All gas" and "All wind" respectively.

Our main observations are that:

- For most technologies, the reported range of capital structures is rather wide, indicating that a mix of financing approaches are adopted. When commenting on their responses, 8 participants noted that reported gearing included both senior and junior debt (in varying proportions).
- While still wide, the reported range for wind technologies is narrower than for other technologies and concentrated towards the higher end of the spectrum (a range of 50% to 85%, with a median value of 66%).
- The median of responses for solar PV, wind, and hydropower (falling between 60% and 75%) sits above that of the other technologies. Reported gearing appears to be lower for technologies that are less established (e.g., novel LDES) or for which respondents indicate other financing challenges (e.g., emissions-related concerns in the case of unabated gas generation).
- The reported range for geothermal reflects the minimum and maximum gearing level over the project lifecycle (suggesting a whole-of-life average in the vicinity of ~40%).

Respondents were asked to align reported capital structures to the project lifecycle stage they had selected. Comparing responses for the same technologies, there does not appear to be a link between the project phase and the level of the reported gearing (i.e., gearing is not systematically reported as higher for operational projects compared to those in the development phase). However, this is perhaps more related to the small number of responses and the impact of other considerations on gearing levels. Another potential explanation is that some of the reported gearing values may not in fact reflect the stated project lifecycle phase. For example, some of the higher reported gearing levels for wind projects may reflect the initial financing of a project, but not the capital structure that would apply in later years of merchant operation.

Approach

While observed gearing levels *may* be generally higher or lower for particular technology types, we consider that adopting a common gearing assumption provides an intuitive means of reflecting differences in risk. Under this simple framework, the relationship between the cost of debt/equity and the hurdle rate is very straightforward: if the cost of either debt or equity increases, leaving other things equal, the hurdle rate increases, and vice versa. This approach supports deriving an overall hurdle rate that is consistent with the assessed level of risk for each technology.

This also avoids the complexity of attempting to determine appropriate technology-specific gearing assumptions, noting that capital structures vary materially both across assets of the same technology (e.g., depending on whether a project finance or corporate finance approach is adopted)[266] and over time (e.g., the proportions of debt and equity may be different across the development, construction and operational phases of a project).

We have considered several sources of evidence to determine an appropriate gearing assumption:

- Evidence from the investor survey conducted for this project, which indicated a wide range of capital structures, as described above.
- Evidence from the sample of comparator firms used to derive the asset beta.[267] The range of gearing levels represented in the sample is wide and we identified no relationship between the level of gearing and the primary technology of the comparator. The median value for the sample ranged from 30-33%, and the average between 33-38%.[268]
- NERA's 2015 investor survey produced ranges between 45% - 85%, across the technologies represented in the survey (Figure D.12). While this might appear to contradict the logic for adopting a common gearing assumption, we note that in some cases the evidence is based on very few survey responses. This provides a low level of confidence that the results reflect fundamental differences across technologies.
- Europe Economics' 2018 study reported corporate finance gearing levels of ~35% (based on a similar approach to the comparator sample evidence noted above) and project finance gearing (for wind and solar) of 70-80%.
- Regulatory precedent has reflected a range of assumptions. The CMA's 2015 market investigation adopted a range of 20-40% for a standalone generation business.[269] The SEM Committee (the island of Ireland) adopted a gearing assumption of 40% when estimating the cost of capital for a 'best new entrant' generator.[270]
- CEPA's 2023 survey of Australian investors reported a mix of corporate and project finance approaches across different technologies (Figure D.13).

[266] Corporate finance is where a company raises the capital to construct an asset on its own balance sheet. Under a project finance approach the project is undertaken through a separate special purpose vehicle, with the finance secured against the future cash flows of the project. Project finance typically involves a significantly higher degree of leverage.

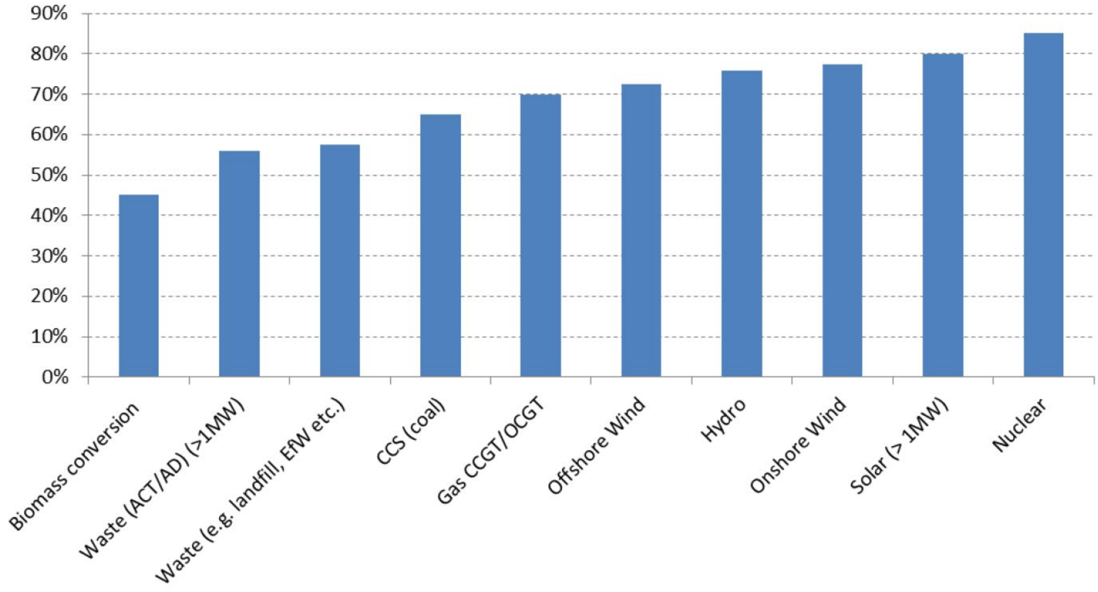
[267] Comparator gearing is measured as net debt / (net debt + market capitalisation).

[268] The ranges represent the different time periods used to estimate asset beta: 2 years, 5 years and 10 years.

[269] CMA (2015), *Energy Market Investigation – Analysis of cost of capital of energy firms,* 25 February 2015. Available at: https://assets.publishing.service.gov.uk/media/54edfe9340f0b6142a000001/Cost_of_capital.pdf.

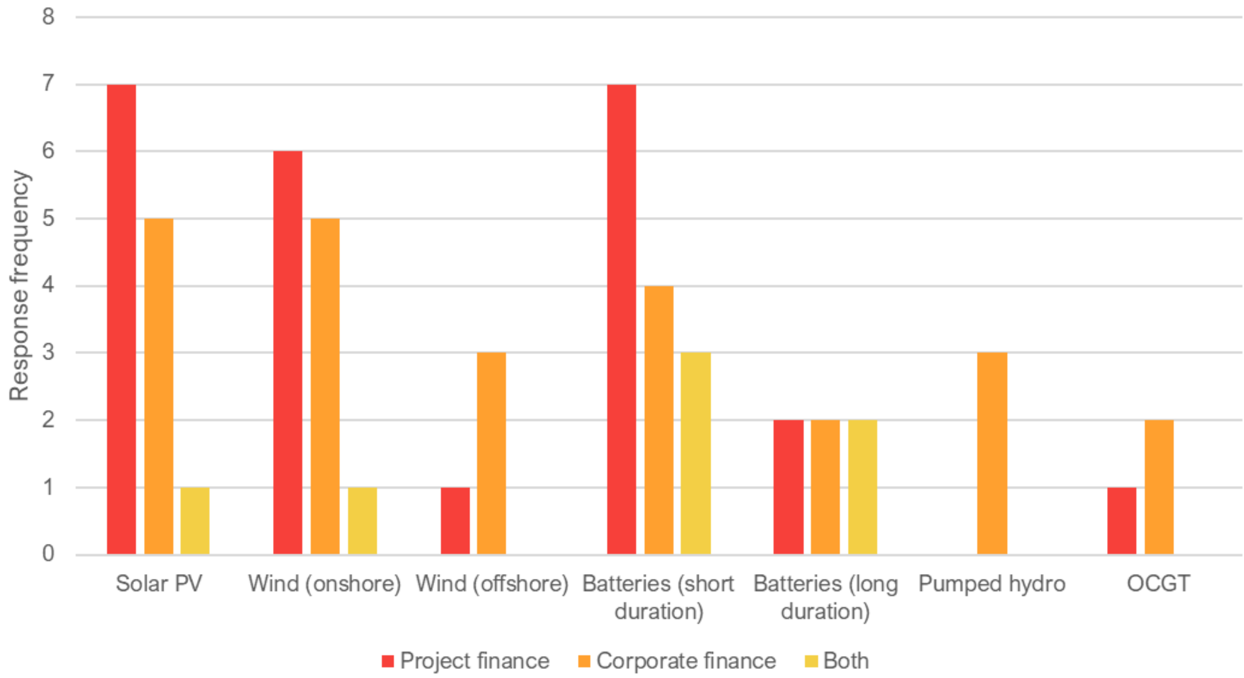
[270] SEM Committee (2023), Capacity Remuneration Mechanism (CRM) - Best New Entrant Net Cost of New Entrant, 2026/27, 31 March 2023. Available at: https://www.semcommittee.com/files/semcommittee/media-files/SEM-23-016%20BNE%20Decision%202023.pdf.

Figure D.12: NERA (2015) - Gearing reported in investor survey



Source: NERA (2015), p.101 and p.31. Number of responses by technology: offshore wind (9), onshore wind (7), waste ACT/AD (5), solar PV (4) responses, all others ('3 or less').

Figure D.13: CEPA (2023) – 'Typical' financing approach reported by Australian investor survey respondents



Source: CEPA (2023).

The range of estimates that could reasonably apply to any given project is clearly wide. Looking across the evidence, if a common gearing assumption is adopted, we suggest that an assumption of 50% strikes a balance between what might be expected under a range of financing approaches. In particular, this reflects that we are seeking to establish an assumption that represents an average level of gearing over the project's life – consistent with a 'whole of life' hurdle rate estimate.

An assumption of 50% gearing is within -/+ 10% of the median reported gearing levels for a wide range of technologies, including solar PV, hydropower, gas (aggregated), lithium batteries, hydrogen electrolysers, geothermal and the anonymised technologies (in aggregate). However:

- 50% is lower than the median survey result for the wind technologies (66%). At the same time, the reported results do not suggest that a whole-of-life average gearing assumption of 50% is implausible. Indeed, some individual responses were consistent with this, even though they were not in the majority.
- 50% is higher than the median survey result for some emerging technologies (e.g., 20% for novel LDES). As for wind, the individual survey responses also suggested that 50% gearing was a plausible assumption for some projects (even though it was not the median response).

Sensitivity to gearing assumption

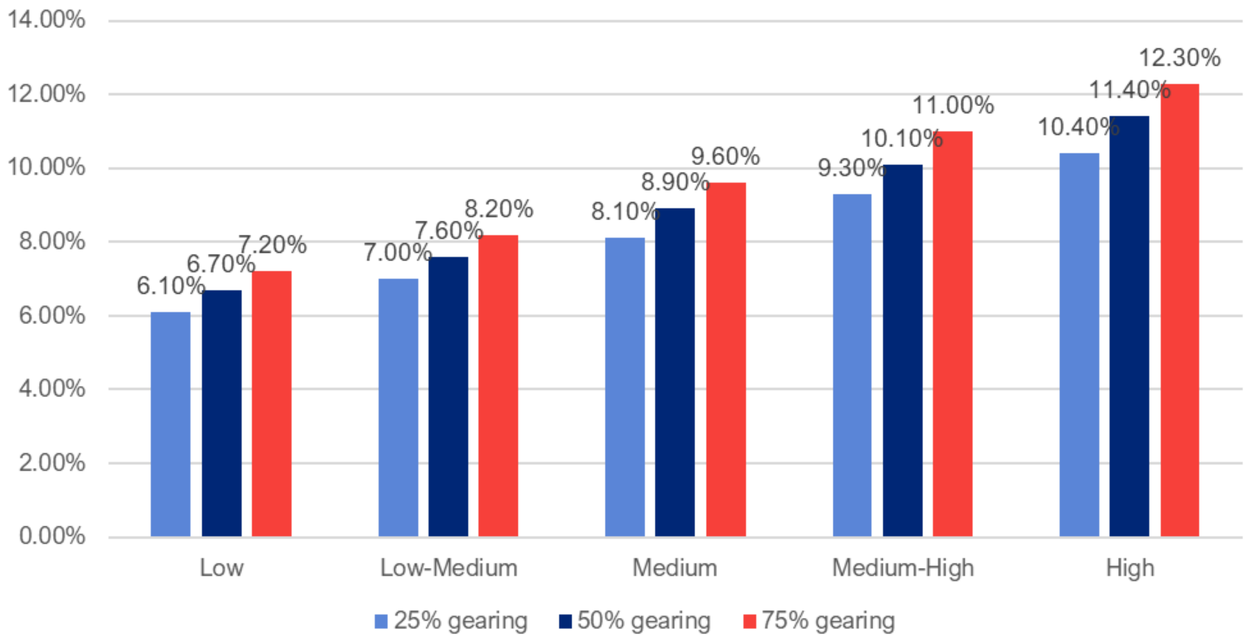
As explained above, changing the gearing assumption has offsetting effects on the overall hurdle rate – i.e., higher gearing increases the cost of debt and equity (increasing the hurdle rate), but at the same time raises the proportion of lower-cost debt finance in the capital structure (reducing the hurdle rate). While this means that changes in the gearing assumption might not alter the hurdle rate as materially as one might expect, the offsetting effect is not necessarily one-for-one and depends on the relationship between the prevailing cost of debt and cost of equity. Accordingly, adopting technology-specific gearing assumptions could drive differences in hurdle rates across technologies.

Given that the range of estimates that could reasonably apply to any given project is wide, we have considered the impact on hurdle rates under three gearing assumptions:

- A "low" gearing assumption of 25%, broadly representing the lower end of the investor survey evidence and the observed comparator sample range.
- A "mid" assumption of 50%, which broadly reflects the mid-point of the different sources of evidence set out above.
- A "high" assumption of 75%, which reflects the upper end of the investor survey results and may be considered broadly representative of a project (non-recourse) financing approach that appears to be relatively common for wind and solar PV developments.

As illustrated in Figure D.14, the impact of the gearing assumption can be quite material, particularly for the hurdle rate assumptions that apply to the "high risk" technologies. In this case, the pre-tax real hurdle rate is 100 basis points higher under the mid gearing assumption compared to the low gearing assumption, and 90 basis points higher for the high gearing assumption compared to the mid gearing assumption.

Figure D.14: Impact of gearing assumptions



Source: CEPA analysis.

This outcome reflects that while required returns on debt are lower than for equity, under the CAPM-based methodology that we have adopted, the return on equity is not invariant to the gearing level. This relates to the calculation of the equity beta. As shown in the formula below, the equity beta (β_e) is the product of the assumed asset beta (β_a) and level of gearing ($D/D{+}E$). As gearing increases, the equity beta also increases to reflect the impact of higher financial leverage on the risks faced by equity investors.

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

This means that Figure D.14 above reflects the combined impact of two offsetting effects: an increase in the equity beta as gearing increases (producing an increase in the return on equity and overall hurdle rate) and the higher weight given to the return on debt in the hurdle rate calculation (producing a decrease in the overall hurdle rate, because the return on debt is lower than the return on equity). In this case, the relative magnitude of the return on equity and return on debt produces hurdle rate estimates that increase as gearing increases. The table below provides an example of the underlying calculations for the 'low risk' hurdle rate.

Table D.12: Impact of gearing assumptions (real CPI pre-tax)

	Low gearing	Mid gearing	High gearing
A – Asset beta	0.50	0.50	0.50
B – Gearing	25%	50%	75%
C – Equity beta *A ÷ (1 - B)*	0.67	1.0	2.0
D – Risk-free rate	1.61%	1.61%	1.61%
E – Equity risk premium	5.22%	5.22%	5.22%
F – Return on equity (post-tax) *D + (E x C)*	5.09%	6.83%	12.05%
G – Return on equity (pre-tax) *F / (1 – tax rate)*	6.78%	9.11%	16.07%
H – Return on debt	4.23%	4.23%	4.23%
I – Hurdle rate (pre-tax)	6.15%	6.67%	7.19%

Source: CEPA analysis.

In part, the sensitivity of the results to the gearing assumption reflects that we have adopted a zero-debt beta assumption (see Section 4.4.8). This impacts the conversion between the equity beta and asset beta (both when the equity betas observed for comparator firms are de-levered to derive asset betas, and when the selected asset beta assumption for each technology is then re-levered to derive the equity beta).

Under the de-levering approach we have adopted for this report (see Section 4.1), the equation to derive the asset beta (β_a) where the debt beta is non-zero is replicated below. The same relationship is applied in reverse to derive an equity beta from the asset beta.

$$\beta_a = \beta_e \times (1 - \frac{D}{D+E}) + \beta_d \times \frac{D}{D+E}$$

Given this equation, assuming a positive debt beta would reduce the sensitivity of the hurdle rate estimates to changes in the assumed gearing level. For instance, using the example set out in Table D.12 above, if we assumed a debt beta of 0.125 the difference between the hurdle rate estimates at 50% and 75% gearing would be 0.3% rather than 0.5%.

The impact of gearing on hurdle rates is also impacted by other factors. These include:

- Under the pre-tax real hurdle rate formulation set out above, the gearing scenarios also do not reflect the changing value of the tax shield at different gearing levels. This means that this offsetting effect is not captured as part of the sensitivity.
- There are different methods for de-levering / re-levering, which will produce different results. For example, there are alternative equations that can be applied depending on how one views the risk of the tax shield. Other approaches make different long-term assumptions about the long-term financial strategy of the firm (e.g., whether to assume a constant level of debt or a constant gearing ratio).
- There are alternative ways to measure gearing (e.g., gross or net debt, whether operating leases are or other debt-like obligations are included, etc.)

More fundamentally, even after accounting for these factors, some sensitivity to the gearing assumption will remain. This reflects that – consistent with common practice in the UK – we have adopted a return on debt assumption that is based on a corporate bond benchmark at an assumed credit rating.[271]

Accordingly, we suggest that it is appropriate to consider the gearing sensitivities presented above as part of the overall uncertainty range associated with the hurdle rate estimates. Given this, we also present in the table below a set of unlevered hurdle rate estimates – i.e., the mid-point hurdle rate assumptions that result from adopting a capital structure that is 100% equity. This is provided as a point of reference that may be more relevant to some users of this report, compared to the levered hurdle rate estimates. However, users of this report should note that due to the factors listed above (e.g., alternative de-levering / re-levering methods), these may not be directly comparable to unlevered hurdle rates estimated under a different approach.

Table D.13: Unlevered hurdle rate sensitivity (pre-tax real CPI, base revenue model)

Risk rating	Lead scenario (mid-point, 50% gearing)	Unlevered scenario (mid-point, 0% gearing)
L	6.70%	5.60%
L-M	7.60%	6.30%
M	8.90%	7.40%
M-H	10.10%	8.40%
H	11.40% (12.90%)[1]	9.50% (11.0%)

Source: CEPA analysis. Notes: (1) Applies to tidal range and new compound batteries. See Section 4.6.

Recommendations

On balance, we consider that there are sound reasons for adopting a common gearing assumption for all technologies. This is because:

- The evidence does not clearly demonstrate that gearing is mainly a technology-specific issue. This reflects that individual projects of the same technology can have widely varying debt service capacities, for example due factors such as the quality of the renewable resource and specific features of the contracting and implementation arrangements that underpin the project.
- There is a degree of arbitrariness in making technology-specific assumptions, due to the lack of clear and robust evidence on which to base these.

[271] In principle, invariance of hurdle rates to gearing could be achieved by estimating a pure 'CAPM' return on debt, calculated as the risk-free rate plus the equity risk premium multiplied by the debt beta.

- A common gearing assumption supports a transparent link between the qualitative risk assessment and the resulting hurdle rates (via technology-specific asset beta and credit rating assumptions). This allows technologies to be compared on a common basis – reflecting that a cost of equity estimated on the basis of 80% gearing is not the same as a cost of equity estimated under a 50% gearing assumption.
- There is a potential concern that other hurdle rate parameters (for example, the return on debt) might not be consistent with a higher gearing assumption. For example, as noted in Section 4.3.2, within the comparator sample, higher gearing levels are associated with weaker credit ratings.

On the other hand, the investor survey indicates that there is some evidence of trends or clustering in a narrower gearing range for certain technologies (e.g., wind, for which reported gearing levels were higher). Accordingly, adopting a common, lower gearing assumption may not be aligned with stakeholder expectations. Even if the overall hurdle rate is not materially affected by gearing, this may impact the credibility of the assumptions. However, with the exception of wind, an assumption of 50% is within -/+10% of the median values reported through the investor survey.

While we consider that a common gearing assumption of 50% is broadly reasonable, we suggest it is reasonable to consider the impact of alternative gearing assumptions a part of the overall uncertainty range for the estimates. Appendix F provides the hurdle rate estimates for each technology under the 25%, 50% and 75% gearing assumptions, should DESNZ wish to use these in its future analysis.

D.2.6. Tax rate

We have adopted the corporate tax rate (25%) as a common assumption across the technologies.[272]

This differs from the approach taken in NERA and Europe Economics past work. NERA adopted 2013 estimates prepared by KPMG of effective tax rates for different technologies. KPMG's estimates were based on an analysis of the main expenditure components for the various technologies, expected operating life and the tax treatment of cash flows for indicative projects.[273] The different estimates for the technologies reflected that:

- for some technologies, the proportion of capital expenditure that qualifies for capital allowances may be different, and
- some technologies have a higher ratio of capital expenditure to operating expenditure – this impacts the effective tax rate because while qualifying capital expenditure may be recovered upfront, tax relief on operating expenditure is recovered over the life of the asset.

In its 2018 report, Europe Economics adjusted the 2013 KPMG estimates to reflect changes in the corporate tax rate (from 20% to 17%).

We appreciate that in practice, the effective tax rates that apply to each technology may differ, for the reasons outlined above. On the other hand, it is likely that there have been changes in the way that capital allowances are applied since the 2013 KPMG report was prepared. Indeed, even at the time of that report, KPMG noted uncertainties for certain technologies – for example, whether capital expenditure for the structures, foundations and moorings of tidal projects would qualify for capital allowances.[274] Accordingly, without conducting a detailed analysis of the type undertaken by KPMG, we do not consider that it is appropriate to adopt technology-specific rates.

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[272] HM Revenue and Customs (2025), *Corporation Tax rates and allowances*. Available at: https://www.gov.uk/government/publications/rates-and-allowances-corporation-tax/rates-and-allowances-corporation-tax.

[273] Specifically, the Corporation Tax main rate. See KPMG (2013), *Electricity Market Reform: Review of effective tax rates for renewable technologies,* July 2013. Available at: https://assets.publishing.service.gov.uk/media/5a7c3034ed915d76e2ebba9b/July_2013_DECC_EMR_ETR_Report_for_Publication_-_FINAL.pdf.

[274] KPMG (2013), p.30.

However, we have considered a sensitivity based on the KPMG assumptions. To derive its assumptions in 2018, Europe Economics multiplied the effective rates estimated by KPMG by the ratio between the new and revised corporate rate (i.e., 17/20). For comparison, we have undertaken the same exercise using the current 25% rate, shown in the table below. This relates only to those technologies for which we have effective tax rate assumptions from the Europe Economics study.

Table D.13: Update of KPMG (2013) effective tax rate estimates

Technology	KPMG 2013	Europe Economics 2018	2025 Update
Solar PV	12.0%	10.2%	15.0%
Onshore wind	11.0%	9.4%	13.8%
Offshore wind	12.0%	10.2%	15.0%
Floating offshore wind	-	-	15.0%
Remote island wind	-	-	13.8%
Geothermal	20.0%	17.0%	25.0%
Hydropower	20.0%	17.0%	25.0%
Advanced conversion technologies	12.0%	10.2%	15.0%
Anaerobic digestion	12.0%	10.2%	15.0%
Biomass – unabated	20.0%	17.0%	25.0%
Biomass – CCUS	20.0%	17.0%	25.0%
Energy from waste	12.0%	10.2%	15.0%
Landfill gas	12.0%	10.2%	15.0%
Sewage gas	20.0%	17.0%	25.0%
Tidal stream	20.0%	17.0%	25.0%
Wave	12.0%	10.2%	15.0%
Gas – unabated	20.0%	17.0%	25.0%
Gas – CCUS	20.0%	17.0%	25.0%

Source: CEPA analysis. This assumes that the effective rates for floating offshore wind and remote island wind will be, respectively, the same as offshore wind and onshore wind.

D.2.7. Transaction costs

Debt issuance costs

We have separately applied an estimate of debt transaction costs to the cost of debt, adopting an assumption of 0.15% (applied as an uplift to the cost of debt).

We have considered the following precedent in making this assumption:

- Ofwat's PR4 final determination proposes a point estimate of 0.15% for its standard debt issuance and liquidity cost allowance, intended to cover non-interest costs associated with borrowing (e.g., credit rating agency fees) and maintaining liquidity.[275]

[275] Ofwat (2024), p.7.

- Ofgem's RIIO-3 methodology noted that it would make a decision based on evidence available at the time of its draft determinations. Previously Ofgem has adopted an allowance of 0.20%.[276]

The NERA and Europe Economics reports did not specifically comment on debt transaction costs.

Equity issuance costs

A related question is whether equity transaction costs should also apply. Ofgem's RIIO-3 methodology assumed an equity issuance allowance of 5%. This was applied as a one-off cost, rather than an ongoing uplift to the allowed rate of return (i.e., the allowance was calculated as 5% multiplied by forecast new equity issuance over the price control period).[277] In the PR24 final determinations Ofwat proposed an allowance of 2% (applied on the same basis as Ofgem's).

The NERA and Europe Economics reports did not specifically comment on equity issuance costs.

DESNZ could consider applying a similar approach – for example, by including an additional item in the cost estimates it uses to determine ASPs for CfD allocation rounds. A value between that proposed by Ofwat and Ofgem may be appropriate (i.e. 3%). The quantity of equity issued could be based on the gearing assumptions set out in this report.

D.2.8. Debt beta

We have adopted a zero-debt beta for our analysis alongside the common gearing assumption.

Regulators have adopted different approaches to the debt beta. In the UK context, it is not uncommon for a positive debt beta to be applied.[278] This is consistent with financial economic theory, which would suggest that the debt beta should typically be positive for regulated businesses.[279]

However, we consider that in the context of this report for DESNZ, the simplicity of a zero-debt beta outweighs the potentially greater precision from using a positive one, given the margin for error that would apply. This is because:

- Debt beta is generally a challenging parameter to estimate in a statistically robust and accurate way. CEPA's 2019 report for the UKRN identified four broad approaches to estimating debt betas. Each method has advantages and disadvantages, and that no one method is demonstrably superior to the others. Accordingly, we recommended that the weight that should be given to a particular approach will vary with the regulatory context and specific details.

- The UKRN's 2023 guidance did not propose the use of a particular methodology for estimating the debt beta.[280] Although UK regulatory precedent could be drawn on, the assumptions applied in those contexts are not necessarily directly relevant to many of the generation and storage technologies considered in this report, which have different characteristics from regulated network utilities.

- The debt beta for a given firm is likely be related to its level of gearing and may also be affected by the credit rating.[281] Although we propose a common gearing assumption, the assumed credit rating is linked to the risk assessment and varies across technologies. Accordingly, adopting a common debt beta assumption may not be consistent with other aspects of the hurdle rate framework we have set out.

- Although in principle different debt betas could be applied for the various technologies (for example, linked to the assumed credit rating or other characteristics), in practice combining different debt beta and gearing

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[276] Ofgem (2023) p.28.

[277] Ofgem (2023), p.123.

[278] See CEPA (2019), *Considerations for UK regulators setting the value of debt beta*, Report for the UK Regulators Network, 2 December 2019, p.19. Available at: https://ukrn.org.uk/app/uploads/2019/12/CEPAReport_UKRN_DebtBeta_Final.pdf.

[279] CEPA (2019), p.6.

[280] UKRN (2023), p.24.

[281] CEPA (2019), p.25.

assumptions could lead to some unintuitive effects.[282] Further, adopting technology-specific debt beta would require a range of assumptions, which are uncertain.

Although on balance we consider this approach to be reasonable in the context, as explained in Appendix D.2.5 a zero-debt beta assumption does have some implications for the gearing sensitivities that we have considered.

[282] Europe Economics' 2018 report for DESNZ proposed debt beta assumptions that varied by technology. These were derived from the debt premium assigned to each technology (based on an assumed credit rating) and common assumptions regarding the probability of default and the loss in the event of default. See Europe Economics (2018), pp.67-70. The 2015 NERA report did not explicitly comment on the issue on debt betas.

Appendix E CROSS CHECKS

This appendix sets out more detail on the cross checks we have considered.

E.1. OTHER SURVEYS

CEPA 2023

In 2023, CEPA conducted a study of generation and storage technologies for AEMO Services Limited, a division of the Australian Energy Market Operator (AEMO).[283] This was informed by similar analysis to that set out in this report, and an investor survey. The most relevant cross-checks from this report for the DESNZ study are that:

- Solar and onshore wind were found to have the same pre-tax real hurdle rate (7.5%), which was primarily based on the survey evidence.
- The hurdle rate for offshore wind was estimated to be 1.0% higher than solar PV/onshore wind, largely reflecting an assumed higher level of construction risk and the technology's relative immaturity in Australia. Offshore wind is far more established in the UK than in Australia. However, construction remains fundamentally more challenging in a marine environment, and supply chain pressures are currently considered to be particularly significant for offshore assets.
- The hurdle rate for PHES was estimated to be 2.5% higher than solar PV / onshore wind, reflecting an assumed higher level of construction risk (+1.5%) and a different (less contracted) revenue model (+1%). However, these assumptions are rather different to the assumed revenue model for PHES that we have adopted for this project.

Oxford Economics 2023

Oxford Economics conducted a survey of Australian investors at around the same time as CEPA's 2023 survey.

Their survey found that found that Australian industry stakeholders considered construction risk to be more prominent for pumped hydro compared to solar PV and wind (onshore/offshore), owing to geological concerns. This was considered to imply a higher cost of capital relative to other technologies.[284] This is consistent with our assumption that PHES has a higher hurdle rate relative to onshore wind.

Oxford Economics also found that a greater number of commercial transactions was considered to reduce hurdle rates, as this provides better planning and construction benchmarks for certain technologies (onshore wind, solar PV) relative to others.[285] This broadly supports our ranking of the technologies, which reflects their level of maturity and development experience in the UK (among other factors).

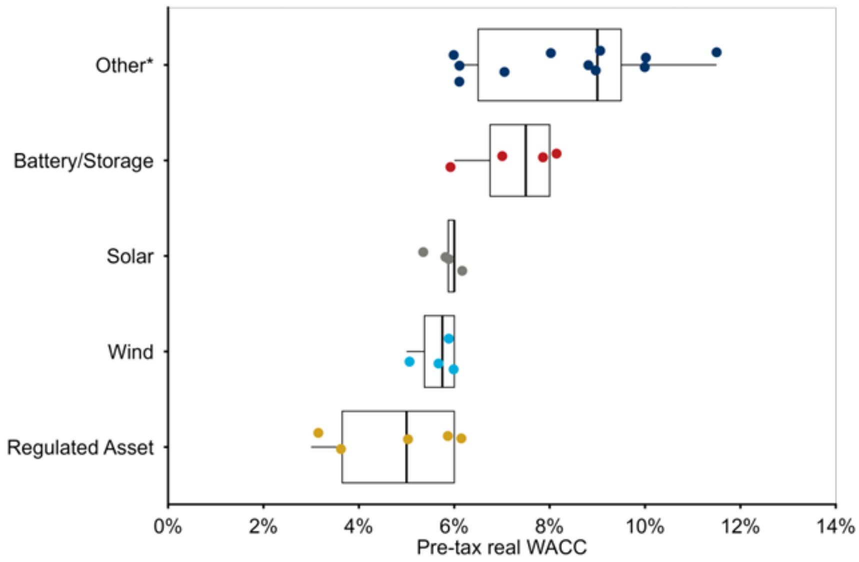
Their findings are summarised in the figure below.

[283] Our report is available here: https://aemoservices.com.au/en/support-and-resources/wacc-report.

[284] Oxford Economics (2023), *Cost of Capital Survey 2023 – Report produced for the Australian Energy Market Operator*, 29 June 2023), p.6.

[285] Ibid., p. 17.

Figure E.1: Oxford Economics - 2023 survey results (Australia)

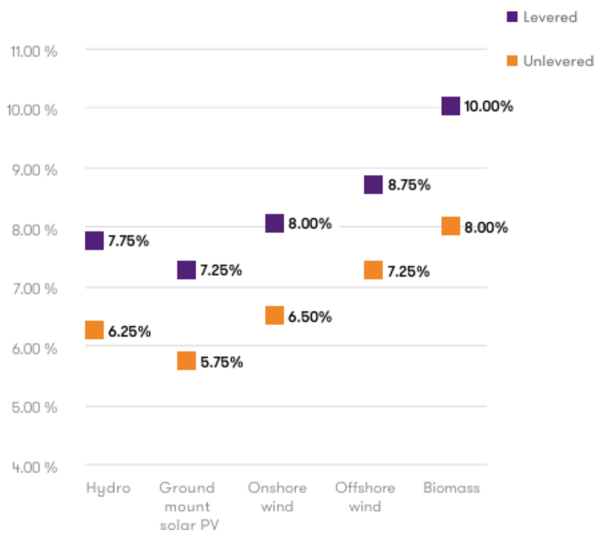


Source: Oxford Economics (2023), p.6.

Grant Thornton 2018

Grant Thornton conducted a survey of hurdle rates for renewable technologies in 2018.[286] Overall, they found an ordering from lowest to highest hurdle rate of: solar PV, hydro, onshore wind, offshore wind, and biomass. The differentials are shown in the figure below.

Figure E.2: Grant Thornton - 2018 survey results - UK



Source: Grant Thornton (2019), p.29.

E.2. Other reports

IRENA 2023

The International Renewable Energy Agency (IRENA)[287] report international WACC ranges for renewable energy technologies, primarily based on survey evidence. For the UK, they report an average WACC of 3.3% for solar PV

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[286] Grant Thornton (2019), *Renewable energy discount rate survey results – 2018*, January 2019.

[287] IRENA (2023), *The cost of financing for renewable power*, pp.11-12.

(for the period 2019-2021), 3.4% for onshore wind (2019-2021), and 4% for offshore wind (2020-2021). The report states that the reported figures are in post-tax nominal terms.

NREL 2020

The US National Renewable Energy Laboratory (NREL)[288] publish financial assumptions as an input into levelised cost of energy estimates. Although their estimates reflect hurdle rates for US-based projects, the relative ranking and differences between technologies provides a relevant cross check for our estimates.

NREL's 2024 parameters are summarised in the table below. The estimates assume that the project has entered into a long-term fixed price take-or-pay power purchase agreement (PPA) for the sale of its output. Although NREL assumes higher gearing than our estimates (~80% compared to 50%), it is consistent across the technologies (except for geothermal in the pre-drilling phase).

Table E.1: NREL (2024) – Cost of capital parameters (nominal)

Technology	Operation		Construction		Leverage
	Post-tax cost of equity	Cost of debt (term debt)	Post-tax cost of equity	Cost of debt (construction debt)	
Utility-scale solar PV (including with battery storage)	8.5%	7.0%	10.5%	6.5%	80%
Onshore wind	9.0%	7.0%	11.0%	6.5%	80%
Hydropower	9.75%	7.0%	11.75%	7.0%	80%
Offshore wind	10.5%	7.0%	12.5%	7.0%	80%
Geothermal	10.5%	7.0%	Pre-drilling: 15% Post-drilling: 10%	7.0%	Pre-drilling: 0% Post-drilling: 75%
Natural gas (quasi-merchant)	10.5%	8.0%	10.5%	6.5%	80%

Source: NREL (2024).

E.3. COMPANY REPORTS

Some companies publish information on hurdle rates in their reporting to investors. The table below summarises the sources that we have identified. Generally, it is challenging to draw conclusions from this evidence considering that the basis of the estimates is not always explicitly stated and the estimates do not necessarily relate only to UK-based projects.

[288] NREL (2024), *Annual Technology Baseline*, available at: https://atb.nrel.gov/electricity/2024/financial_cases_&_methods.

Table E.2: Summary of company reports

Company	Technologies	Reported hurdle rate
Equinor[289]	Wind	Offshore wind: 12-16% nominal equity return (full cycle, not including future farm downs) Offshore wind: 4-8% real base project return (IRR after tax, full cycle, excluding farm downs and the effect of financing).
Iberdrola[290]	Offshore wind, onshore wind, solar	IRR target: 7-12%. Not clear whether nominal / real, pre-/post-tax. Target spread to corporate WACC of > 200bps.
Orsted[291]	All	Target spread to corporate WACC of 150-300bps.
RWE[292]	Offshore wind, onshore wind, solar, batteries, flexible generation and hydrogen	IRR requirements – post-tax, unlevered, nominal. Offshore wind (global): 7-11% Onshore wind, solar, batteries (Europe and USA): 6-10% Flexible generation and hydrogen (Europe): 8-12%
SSE[293]	Offshore wind, onshore wind, future CCS/hydrogen	Offshore wind = post-tax nominal equity returns of at least 11% (excluding developer profits). Onshore wind = 100 – 400 bps spread to corporate WACC. Future CCS/hydrogen = 300 – 500 bps spread to corporate WACC. Spreads to WACC reflect the balance of merchant, technology and construction risk specific to each project, and are on unlevered projects.
Foresight Environmental Infrastructure Limited (FGEN)[294]	Wind, waste & bioenergy, anaerobic digestion, solar, batteries, hydropower	Reports weighted average discount rates (and gearing), used in the valuation of assets. Not clear whether nominal / real, pre-/post-tax. Wind: 8.7% (35%) Waste & bioenergy: 9.8% (9%) Anaerobic digestion: 8.6% (0%) Solar: 7.6% (15%) Batteries: 10.0% (0%) Hydropower: 8.0% (38%)

Sources: See footnotes.

[289] ESG Day presentation, 8 April 2024, pp.21-22. Available at: https://cdn.equinor.com/files/h61q9gi9/global/893718bf0d487152f3e6492beef671afaed4adfa.pdf?esg-day-2024-presentation-equinor.pdf.

[290] Capital Markets & ESG Day presentation, 21 March 2024, p.19. Available at: https://www.iberdrola.com/documents/20125/4005786/CMD24-financial-management.pdf

[291] Capital Market Day presentation, 8 June 2023, p.22. Available at: https://orstedcdn.azureedge.net/-/media/www/docs/corp/capital-markets-day/orsted-cmd-2023.pdf?rev=f7d3ce29cf6d437a9722ff83aa93cb88&hash=237B05B6D748C24B08E73BB57B097CD4

[292] Capital Markets Day presentation, 28 November 2023, p.27. Available at: https://www.rwe.com/-/media/RWE/documents/05-investor-relations/finanzkalendar-und-veroeffentlichungen/2023-cmd/cmd-2023_presentation.pdf

[293] Investment Case factsheet 2024. Available at: https://www.sse.com/media/ehapr4md/sse-fy24-factsheet.pdf

[294] FGEN (2024), *Half-year Report 2024*, p.18. Available at: https://media.umbraco.io/foresight/dxll25ld/final_web_fgen_hy24.pdf.

Appendix F HURDLE RATE ESTIMATES

This appendix sets out hurdle rate estimates under alternative scenarios, namely: real and nominal; pre- and post-tax; with expected inflation defined as both forecast CPI and GDP deflator; under varying gearing assumptions (0%, 25%, 50%, 75%); and under lower-bound / mid-point / upper bound asset beta and credit rating assumptions.

All estimates quoted in this appendix:

- Are as at 31 December 2024.
- Reflect the base case revenue model for all technologies.

Table F.1: Hurdle rates - Pre-tax real CPI, 50% gearing. Mid-point and uncertainty range.

Technology	Lead scenario	Uncertainty range	
Asset beta and credit rating assumption	**Mid**	**Low**	**High**
Solar PV	7.60%	7.00%	8.20%
Onshore wind	7.60%	7.00%	8.20%
Offshore wind	8.90%	7.90%	9.80%
Remote island wind	8.90%	7.90%	9.80%
Floating offshore wind	11.40%	10.50%	12.20%
Hydropower	8.90%	7.90%	9.80%
Advanced conversion technologies (ACT)	10.10%	9.20%	11.00%
Anaerobic digestion (AD)	7.60%	7.00%	8.20%
Sewage gas	7.60%	7.00%	8.20%
Landfill gas	7.60%	7.00%	8.20%
Energy from waste	8.90%	7.90%	9.80%
Biomass – unabated	8.90%	7.90%	9.80%
Deep geothermal	10.10%	9.20%	11.00%
Wave	11.40%	10.50%	12.20%
Tidal stream	11.40%	10.50%	12.20%
Tidal range[1]	12.90%	12.00%	13.70%
Biomass – with CCUS – mature[2]	8.90%	7.90%	9.80%
Biomass – with CCUS – maturing[2]	10.10%	9.20%	11.00%
Large-scale nuclear	7.60%	7.00%	8.20%
Small modular reactors (SMRs)	8.90%	7.90%	9.80%
Advanced modular reactors (AMRs)	8.90%	7.90%	9.80%
Pumped hydro energy storage (PHES)	8.90%	7.90%	9.80%
Novel long duration energy storage (LDES)	10.10%	9.20%	11.00%
Lithium batteries[3]	8.90%	7.90%	9.80%
New compound batteries[1]	12.90%	12.00%	13.70%
Demand response aggregators	8.90%	7.90%	9.80%
Gas generation – unabated	8.90%	7.90%	9.80%
Gas generation – with CCUS – mature[2]	8.90%	7.90%	9.80%
Gas generation – with CCUS – maturing[2]	10.10%	9.20%	11.00%
Hydrogen CCHT / OCHT – mature[2]	8.90%	7.90%	9.80%
Hydrogen CCHT / OCHT – emerging[2]	10.10%	9.20%	11.00%
Hydrogen electrolyser	10.10%	9.20%	11.00%
Interconnectors	7.60%	7.00%	8.20%

Source: CEPA analysis. Notes: (1) Reflects uplift to capture differences between the other 'high risk' technologies – see Section 4.6. (2) Given the uncertainties around nascent CCUS and hydrogen to power (H2P) technologies, we have included a wide indicative range that will be refined at a future date. (3) These results assume that lithium batteries have a CM contract, but no other form of revenue support. However, they may also be eligible for the LDES cap & floor scheme if they meet the relevant criteria – see Section 2.2. This may reduce the assumed risk rating and hurdle rate compared to the level shown in this table.

Table F.2: Hurdle rates - Pre-tax real CPI. Mid-point asset beta and credit rating assumptions. Alternative gearing scenarios.

Technology	Lead scenario	Uncertainty range		Unlevered
Gearing	**50%**	**25%**	**75%**	**0%**
Solar PV	7.60%	7.00%	8.20%	6.30%
Onshore wind	7.60%	7.00%	8.20%	6.30%
Offshore wind	8.90%	8.10%	9.60%	7.40%
Remote island wind	8.90%	8.10%	9.60%	7.40%
Floating offshore wind	11.40%	10.40%	12.30%	9.50%
Hydropower	8.90%	8.10%	9.60%	7.40%
Advanced conversion technologies (ACT)	10.10%	9.30%	11.00%	8.40%
Anaerobic digestion (AD)	7.60%	7.00%	8.20%	6.30%
Sewage gas	7.60%	7.00%	8.20%	6.30%
Landfill gas	7.60%	7.00%	8.20%	6.30%
Energy from waste	8.90%	8.10%	9.60%	7.40%
Biomass – unabated	8.90%	8.10%	9.60%	7.40%
Deep geothermal	10.10%	9.30%	11.00%	8.40%
Wave	11.40%	10.40%	12.30%	9.50%
Tidal stream	11.40%	10.40%	12.30%	9.50%
Tidal range[1]	12.90%	11.90%	13.80%	11.0%
Biomass – with CCUS – mature[2]	8.90%	8.10%	9.60%	7.40%
Biomass – with CCUS – maturing[2]	10.10%	9.30%	11.00%	8.40%
Large-scale nuclear	7.60%	7.00%	8.20%	6.30%
Small modular reactors (SMRs)	8.90%	8.10%	9.60%	7.40%
Advanced modular reactors (AMRs)	8.90%	8.10%	9.60%	7.40%
Pumped hydro energy storage (PHES)	8.90%	8.10%	9.60%	7.40%
Novel long duration energy storage (LDES)	10.10%	9.30%	11.00%	8.40%
Lithium batteries[3]	8.90%	8.10%	9.60%	7.40%
New compound batteries[1]	12.90%	11.90%	13.80%	11.0%
Demand response aggregators	8.90%	8.10%	9.60%	7.40%
Gas generation – unabated	8.90%	8.10%	9.60%	7.40%
Gas generation – with CCUS – mature[2]	8.90%	8.10%	9.60%	7.40%
Gas generation – with CCUS – maturing[2]	10.10%	9.30%	11.00%	8.40%
Hydrogen CCHT / OCHT – mature[2]	8.90%	8.10%	9.60%	7.40%
Hydrogen CCHT / OCHT – emerging[2]	10.10%	9.30%	11.00%	8.40%
Hydrogen electrolyser	10.10%	9.30%	11.00%	8.40%
Interconnectors	7.60%	7.00%	8.20%	6.30%

Source: CEPA analysis. Notes: (1) Reflects uplift to capture differences between the other 'high risk' technologies – see Section 4.6. (2) Given the uncertainties around nascent CCUS and hydrogen to power (H2P) technologies, we have included a wide indicative range that will be refined at a future date. (3) These results assume that lithium batteries have a CM contract, but no other form of revenue support. However, they may also be eligible for the LDES cap & floor scheme if they meet the relevant criteria – see Section 2.2. This may reduce the assumed risk rating and hurdle rate compared to the level shown in this table.

Table F.3: Hurdle rates – Alternative formulations (inflation, tax). 50% gearing, mid-point asset beta and credit rating assumptions.

Technology	Real CPI		Real GDP deflator		Nominal	
Form	Pre-tax	Post-tax	Pre-tax	Post-tax	Pre-tax	Post-tax
Solar PV	7.60%	6.30%	7.40%	6.10%	10.00%	8.30%
Onshore wind	7.60%	6.30%	7.40%	6.10%	10.00%	8.30%
Offshore wind	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Remote island wind	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Floating offshore wind	11.40%	9.30%	11.10%	9.10%	13.90%	11.40%
Hydropower	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Advanced conversion technologies (ACT)	10.10%	8.30%	9.90%	8.10%	12.60%	10.40%
Anaerobic digestion (AD)	7.60%	6.30%	7.40%	6.10%	10.00%	8.30%
Sewage gas	7.60%	6.30%	7.40%	6.10%	10.00%	8.30%
Landfill gas	7.60%	6.30%	7.40%	6.10%	10.00%	8.30%
Energy from waste	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Biomass – unabated	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Deep geothermal	10.10%	8.30%	9.90%	8.10%	12.60%	10.40%
Wave	11.40%	9.30%	11.10%	9.10%	13.90%	11.40%
Tidal stream	11.40%	9.30%	11.10%	9.10%	13.90%	11.40%
Tidal range[1]	12.90%	10.80%	12.60%	10.60%	15.40%	12.90%
Biomass – with CCUS – mature[2]	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Biomass – with CCUS – maturing[2]	10.10%	8.30%	9.90%	8.10%	12.60%	10.40%
Large-scale nuclear	7.60%	6.30%	7.40%	6.10%	10.00%	8.30%
Small modular reactors (SMRs)	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Advanced modular reactors (AMRs)	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Pumped hydro energy storage (PHES)	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%

Technology	Real CPI		Real GDP deflator		Nominal	
Form	**Pre-tax**	**Post-tax**	**Pre-tax**	**Post-tax**	**Pre-tax**	**Post-tax**
Novel long duration energy storage (LDES)	10.10%	8.30%	9.90%	8.10%	12.60%	10.40%
Lithium batteries[3]	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
New compound batteries[1]	12.90%	10.80%	12.60%	10.60%	15.40%	12.90%
Demand response aggregators	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Gas generation – unabated	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Gas generation – with CCUS – mature[2]	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Gas generation – with CCUS – maturing[2]	10.10%	8.30%	9.90%	8.10%	12.60%	10.40%
Hydrogen CCHT / OCHT – mature[2]	8.90%	7.30%	8.60%	7.10%	11.30%	9.40%
Hydrogen CCHT / OCHT – emerging[2]	10.10%	8.30%	9.90%	8.10%	12.60%	10.40%
Hydrogen electrolyser	10.10%	8.30%	9.90%	8.10%	12.60%	10.40%
Interconnectors	7.60%	6.30%	7.40%	6.10%	10.00%	8.30%

Source: CEPA analysis. Notes: (1) Reflects uplift to capture differences between the other 'high risk' technologies – see Section 4.6. (2) Given the uncertainties around nascent CCUS and hydrogen to power (H2P) technologies, we have included a wide indicative range that will be refined at a future date. (3) These results assume that lithium batteries have a CM contract, but no other form of revenue support. However, they may also be eligible for the LDES cap & floor scheme if they meet the relevant criteria – see Section 2.2. This may reduce the assumed risk rating and hurdle rate compared to the level shown in this table.

Table F.4: Low asset beta and credit rating, 50% gearing

Gearing	50%					
				Risk ranking		
Asset beta / credit rating	**Low**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		50%	50%	50%	50%	50%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Equity risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.45	0.55	0.65	0.80	0.95
Equity beta		0.90	1.10	1.30	1.60	1.90
Post-tax return on equity	*Real CPI*	6.31%	7.35%	8.40%	9.96%	11.53%
Credit rating		BBB+	BBB	BBB-	BB+	BB
Return on debt (pre-transaction costs)	*Nominal*	5.97%	6.11%	6.57%	7.03%	7.48%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Hurdle rate						
Post-tax real return on debt	*Real CPI*	4.09%	4.23%	4.68%	5.13%	5.58%
Post-tax real return on equity	*Real CPI*	6.31%	7.35%	8.40%	9.96%	11.53%
Post-tax real hurdle rate	*Real CPI*	5.20%	5.79%	6.54%	7.55%	8.55%
Rounded	***Real CPI***	**5.20%**	**5.80%**	**6.50%**	**7.50%**	**8.60%**
Pre-tax real return on debt	*Real CPI*	4.09%	4.23%	4.68%	5.13%	5.58%
Pre-tax real return on equity	*Real CPI*	8.41%	9.80%	11.20%	13.29%	15.38%
Pre-tax real hurdle rate	*Real CPI*	6.25%	7.02%	7.94%	9.21%	10.48%
Rounded	***Real CPI***	**6.30%**	**7.00%**	**7.90%**	**9.20%**	**10.50%**
Post-tax nominal return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Post-tax nominal return on equity	*Nominal*	8.38%	9.45%	10.51%	12.11%	13.71%
Post-tax nominal hurdle rate	*Nominal*	7.25%	7.86%	8.62%	9.64%	10.67%
Rounded	***Nominal***	**7.30%**	**7.90%**	**8.60%**	**9.60%**	**10.70%**
Pre-tax nominal return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Pre-tax nominal return on equity	*Nominal*	11.17%	12.59%	14.01%	16.15%	18.28%
Pre-tax nominal hurdle rate	*Nominal*	8.65%	9.43%	10.37%	11.66%	12.96%
Rounded	***Nominal***	**8.60%**	**9.40%**	**10.40%**	**11.70%**	**13.00%**
Post-tax real return on debt	*Real GDP deflator*	3.91%	4.05%	4.50%	4.94%	5.39%
Post-tax real return on equity	*Real GDP deflator*	6.12%	7.16%	8.21%	9.77%	11.34%
Post-tax real hurdle rate	*Real GDP deflator*	5.01%	5.61%	6.35%	7.36%	8.36%
Rounded	***Real GDP deflator***	**5.00%**	**5.60%**	**6.40%**	**7.40%**	**8.40%**
Pre-tax real return on debt	*Real GDP deflator*	3.91%	4.05%	4.50%	4.94%	5.39%
Pre-tax real return on equity	*Real GDP deflator*	8.16%	9.55%	10.94%	13.03%	15.11%
Pre-tax real hurdle rate	*Real GDP deflator*	6.03%	6.80%	7.72%	8.99%	10.25%
Rounded	***Real GDP deflator***	**6.00%**	**6.80%**	**7.70%**	**9.00%**	**10.30%**

Source: CEPA analysis.

Table F.5: Mid-point asset beta and credit rating, 50% gearing

Gearing	50%					
				Risk ranking		
Asset beta / credit rating	**Mid**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		50%	50%	50%	50%	50%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Equity risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.50	0.60	0.75	0.90	1.05
Equity beta		1.00	1.20	1.50	1.80	2.10
Post-tax return on equity	*Real CPI*	6.83%	7.87%	9.44%	11.01%	12.58%
Credit rating		BBB	BBB-	BB+	BB	BB-
Return on debt (pre-transaction costs)	*Nominal*	6.11%	6.57%	7.03%	7.48%	7.87%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Hurdle rate						
Post-tax real return on debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Post-tax real return on equity	*Real CPI*	6.83%	7.87%	9.44%	11.01%	12.58%
Post-tax real hurdle rate	*Real CPI*	5.53%	6.28%	7.29%	8.29%	9.26%
Rounded	***Real CPI***	**5.50%**	**6.30%**	**7.30%**	**8.30%**	**9.30%**
Pre-tax real return on debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Pre-tax real return on equity	*Real CPI*	9.11%	10.50%	12.59%	14.68%	16.77%
Pre-tax real hurdle rate	*Real CPI*	6.67%	7.59%	8.86%	10.13%	11.36%
Rounded	***Real CPI***	**6.70%**	**7.60%**	**8.90%**	**10.10%**	**11.40%**
Post-tax nominal return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Post-tax nominal return on equity	*Nominal*	8.91%	9.98%	11.58%	13.17%	14.77%
Post-tax nominal hurdle rate	*Nominal*	7.59%	8.35%	9.38%	10.40%	11.39%
Rounded	***Nominal***	**7.60%**	**8.30%**	**9.40%**	**10.40%**	**11.40%**
Pre-tax nominal return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Pre-tax nominal return on equity	*Nominal*	11.88%	13.30%	15.44%	17.57%	19.70%
Pre-tax nominal hurdle rate	*Nominal*	9.07%	10.01%	11.31%	12.60%	13.86%
Rounded	***Nominal***	**9.10%**	**10.00%**	**11.30%**	**12.60%**	**13.90%**
Post-tax real return on debt	*Real GDP deflator*	4.05%	4.50%	4.94%	5.39%	5.76%
Post-tax real return on equity	*Real GDP deflator*	6.64%	7.68%	9.25%	10.81%	12.38%
Post-tax real hurdle rate	*Real GDP deflator*	5.35%	6.09%	7.10%	8.10%	9.07%
Rounded	***Real GDP deflator***	**5.30%**	**6.10%**	**7.10%**	**8.10%**	**9.10%**
Pre-tax real return on debt	*Real GDP deflator*	4.05%	4.50%	4.94%	5.39%	5.76%
Pre-tax real return on equity	*Real GDP deflator*	8.86%	10.25%	12.33%	14.42%	16.51%
Pre-tax real hurdle rate	*Real GDP deflator*	6.45%	7.37%	8.64%	9.90%	11.13%
Rounded	***Real GDP deflator***	**6.50%**	**7.40%**	**8.60%**	**9.90%**	**11.10%**

Source: CEPA analysis.

Table F.6: High asset beta and credit rating, 50% gearing

Gearing	50%					
				Risk ranking		
Asset beta / credit rating	**High**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		50%	50%	50%	50%	50%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Equity risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.55	0.65	0.85	1.00	1.15
Equity beta		1.10	1.30	1.70	2.00	2.30
Post-tax return on equity	*Real CPI*	7.35%	8.40%	10.49%	12.05%	13.62%
Credit rating		BBB-	BB+	BB	BB-	B+
Return on debt (pre-transaction costs)	*Nominal*	6.57%	7.03%	7.48%	7.87%	8.25%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Hurdle rate						
Post-tax real return on debt	*Real CPI*	4.68%	5.13%	5.58%	5.95%	6.32%
Post-tax real return on equity	*Real CPI*	7.35%	8.40%	10.49%	12.05%	13.62%
Post-tax real hurdle rate	*Real CPI*	6.02%	6.76%	8.03%	9.00%	9.97%
Rounded	***Real CPI***	**6.00%**	**6.80%**	**8.00%**	**9.00%**	**10.00%**
Pre-tax real return on debt	*Real CPI*	4.68%	5.13%	5.58%	5.95%	6.32%
Pre-tax real return on equity	*Real CPI*	9.80%	11.20%	13.98%	16.07%	18.16%
Pre-tax real hurdle rate	*Real CPI*	7.24%	8.16%	9.78%	11.01%	12.24%
Rounded	***Real CPI***	**7.20%**	**8.20%**	**9.80%**	**11.00%**	**12.20%**
Post-tax nominal return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Post-tax nominal return on equity	*Nominal*	9.45%	10.51%	12.64%	14.24%	15.84%
Post-tax nominal hurdle rate	*Nominal*	8.08%	8.84%	10.14%	11.13%	12.12%
Rounded	***Nominal***	**8.10%**	**8.80%**	**10.10%**	**11.10%**	**12.10%**
Pre-tax nominal return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Pre-tax nominal return on equity	*Nominal*	12.59%	14.01%	16.86%	18.99%	21.12%
Pre-tax nominal hurdle rate	*Nominal*	9.66%	10.60%	12.25%	13.50%	14.76%
Rounded	***Nominal***	**9.70%**	**10.60%**	**12.20%**	**13.50%**	**14.80%**
Post-tax real return on debt	*Real GDP deflator*	4.50%	4.94%	5.39%	5.76%	6.14%
Post-tax real return on equity	*Real GDP deflator*	7.16%	8.21%	10.29%	11.86%	13.42%
Post-tax real hurdle rate	*Real GDP deflator*	5.83%	6.57%	7.84%	8.81%	9.78%
Rounded	***Real GDP deflator***	**5.80%**	**6.60%**	**7.80%**	**8.80%**	**9.80%**
Pre-tax real return on debt	*Real GDP deflator*	4.50%	4.94%	5.39%	5.76%	6.14%
Pre-tax real return on equity	*Real GDP deflator*	9.55%	10.94%	13.72%	15.81%	17.90%
Pre-tax real hurdle rate	*Real GDP deflator*	7.02%	7.94%	9.56%	10.79%	12.02%
Rounded	***Real GDP deflator***	**7.00%**	**7.90%**	**9.60%**	**10.80%**	**12.00%**

Source: CEPA analysis.

Table F.7: Low asset beta and credit rating, 25% gearing

Gearing	**25%**					
				Risk ranking		
Asset beta / credit rating		**Low**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**

		Low	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		25%	25%	25%	25%	25%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Equity risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.45	0.55	0.65	0.80	0.95
Equity beta		0.60	0.73	0.87	1.07	1.27
Post-tax return on equity	*Real CPI*	4.74%	5.44%	6.13%	7.18%	8.22%
Credit rating		BBB+	BBB	BBB-	BB+	BB
Return on debt (pre-transaction costs)	*Nominal*	5.97%	6.11%	6.57%	7.03%	7.48%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Hurdle rate						
Post-tax real return on debt	*Real CPI*	4.09%	4.23%	4.68%	5.13%	5.58%
Post-tax real return on equity	*Real CPI*	4.74%	5.44%	6.13%	7.18%	8.22%
Post-tax real hurdle rate	*Real CPI*	4.58%	5.14%	5.77%	6.67%	7.56%
Rounded	***Real CPI***	**4.60%**	**5.10%**	**5.80%**	**6.70%**	**7.60%**
Pre-tax real return on debt	*Real CPI*	4.09%	4.23%	4.68%	5.13%	5.58%
Pre-tax real return on equity	*Real CPI*	6.32%	7.25%	8.18%	9.57%	10.96%
Pre-tax real hurdle rate	*Real CPI*	5.76%	6.49%	7.30%	8.46%	9.62%
Rounded	***Real CPI***	**5.80%**	**6.50%**	**7.30%**	**8.50%**	**9.60%**
Post-tax nominal return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Post-tax nominal return on equity	*Nominal*	6.78%	7.49%	8.20%	9.27%	10.33%
Post-tax nominal hurdle rate	*Nominal*	6.62%	7.19%	7.83%	8.75%	9.66%
Rounded	***Nominal***	**6.60%**	**7.20%**	**7.80%**	**8.70%**	**9.70%**
Pre-tax nominal return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Pre-tax nominal return on equity	*Nominal*	9.04%	9.99%	10.94%	12.36%	13.78%
Pre-tax nominal hurdle rate	*Nominal*	8.31%	9.06%	9.88%	11.06%	12.24%
Rounded	***Nominal***	**8.30%**	**9.10%**	**9.90%**	**11.10%**	**12.20%**
Post-tax real return on debt	*Real GDP deflator*	3.91%	4.05%	4.50%	4.94%	5.39%
Post-tax real return on equity	*Real GDP deflator*	4.56%	5.25%	5.95%	6.99%	8.03%
Post-tax real hurdle rate	*Real GDP deflator*	4.39%	4.95%	5.58%	6.48%	7.37%
Rounded	***Real GDP deflator***	**4.40%**	**5.00%**	**5.60%**	**6.50%**	**7.40%**
Pre-tax real return on debt	*Real GDP deflator*	3.91%	4.05%	4.50%	4.94%	5.39%
Pre-tax real return on equity	*Real GDP deflator*	6.07%	7.00%	7.93%	9.32%	10.71%
Pre-tax real hurdle rate	*Real GDP deflator*	5.53%	6.26%	7.07%	8.23%	9.38%
Rounded	***Real GDP deflator***	**5.50%**	**6.30%**	**7.10%**	**8.20%**	**9.40%**

Source: CEPA analysis.

Table F.8: Mid-point asset beta and credit rating, 25% gearing

Gearing	25%					
				Risk ranking		
Asset beta / credit rating	**Mid**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		25%	25%	25%	25%	25%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Equity risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.50	0.60	0.75	0.90	1.05
Equity beta		0.67	0.80	1.00	1.20	1.40
Post-tax return on equity	*Real CPI*	5.09%	5.79%	6.83%	7.87%	8.92%
Credit rating		BBB	BBB-	BB+	BB	BB-
Return on debt (pre-transaction costs)	*Nominal*	6.11%	6.57%	7.03%	7.48%	7.87%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Hurdle rate						
Post-tax real return on debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Post-tax real return on equity	*Real CPI*	5.09%	5.79%	6.83%	7.87%	8.92%
Post-tax real hurdle rate	*Real CPI*	4.87%	5.51%	6.40%	7.30%	8.18%
Rounded	***Real CPI***	**4.90%**	**5.50%**	**6.40%**	**7.30%**	**8.20%**
Pre-tax real return on debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Pre-tax real return on equity	*Real CPI*	6.78%	7.71%	9.11%	10.50%	11.89%
Pre-tax real hurdle rate	*Real CPI*	6.15%	6.96%	8.11%	9.27%	10.41%
Rounded	***Real CPI***	**6.10%**	**7.00%**	**8.10%**	**9.30%**	**10.40%**
Post-tax nominal return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Post-tax nominal return on equity	*Nominal*	7.14%	7.85%	8.91%	9.98%	11.04%
Post-tax nominal hurdle rate	*Nominal*	6.92%	7.57%	8.48%	9.39%	10.29%
Rounded	***Nominal***	**6.90%**	**7.60%**	**8.50%**	**9.40%**	**10.30%**
Pre-tax nominal return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Pre-tax nominal return on equity	*Nominal*	9.52%	10.46%	11.88%	13.30%	14.73%
Pre-tax nominal hurdle rate	*Nominal*	8.70%	9.53%	10.71%	11.89%	13.05%
Rounded	***Nominal***	**8.70%**	**9.50%**	**10.70%**	**11.90%**	**13.00%**
Post-tax real return on debt	*Real GDP deflator*	4.05%	4.50%	4.94%	5.39%	5.76%
Post-tax real return on equity	*Real GDP deflator*	4.90%	5.60%	6.64%	7.68%	8.73%
Post-tax real hurdle rate	*Real GDP deflator*	4.69%	5.32%	6.22%	7.11%	7.99%
Rounded	***Real GDP deflator***	**4.70%**	**5.30%**	**6.20%**	**7.10%**	**8.00%**
Pre-tax real return on debt	*Real GDP deflator*	4.05%	4.50%	4.94%	5.39%	5.76%
Pre-tax real return on equity	*Real GDP deflator*	6.54%	7.46%	8.86%	10.25%	11.64%
Pre-tax real hurdle rate	*Real GDP deflator*	5.92%	6.72%	7.88%	9.03%	10.17%
Rounded	***Real GDP deflator***	**5.90%**	**6.70%**	**7.90%**	**9.00%**	**10.20%**

Source: CEPA analysis.

Table F.9: High asset beta and credit rating, 25% gearing

Gearing	25%					
				Risk ranking		
Asset beta / credit rating	**High**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		25%	25%	25%	25%	25%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Equity risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.55	0.65	0.85	1.00	1.15
Equity beta		0.73	0.87	1.13	1.33	1.53
Post-tax return on equity	*Real CPI*	5.44%	6.13%	7.53%	8.57%	9.62%
Credit rating		BBB-	BB+	BB	BB-	B+
Return on debt (pre-transaction costs)	*Nominal*	6.57%	7.03%	7.48%	7.87%	8.25%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Hurdle rate						
Post-tax real return on debt	*Real CPI*	4.68%	5.13%	5.58%	5.95%	6.32%
Post-tax real return on equity	*Real CPI*	5.44%	6.13%	7.53%	8.57%	9.62%
Post-tax real hurdle rate	*Real CPI*	5.25%	5.88%	7.04%	7.92%	8.79%
Rounded	***Real CPI***	**5.20%**	**5.90%**	**7.00%**	**7.90%**	**8.80%**
Pre-tax real return on debt	*Real CPI*	4.68%	5.13%	5.58%	5.95%	6.32%
Pre-tax real return on equity	*Real CPI*	7.25%	8.18%	10.04%	11.43%	12.82%
Pre-tax real hurdle rate	*Real CPI*	6.61%	7.42%	8.92%	10.06%	11.20%
Rounded	***Real CPI***	**6.60%**	**7.40%**	**8.90%**	**10.10%**	**11.20%**
Post-tax nominal return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Post-tax nominal return on equity	*Nominal*	7.49%	8.20%	9.62%	10.69%	11.75%
Post-tax nominal hurdle rate	*Nominal*	7.30%	7.95%	9.13%	10.02%	10.91%
Rounded	***Nominal***	**7.30%**	**7.90%**	**9.10%**	**10.00%**	**10.90%**
Pre-tax nominal return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Pre-tax nominal return on equity	*Nominal*	9.99%	10.94%	12.83%	14.25%	15.67%
Pre-tax nominal hurdle rate	*Nominal*	9.17%	10.00%	11.53%	12.69%	13.85%
Rounded	***Nominal***	**9.20%**	**10.00%**	**11.50%**	**12.70%**	**13.90%**
Post-tax real return on debt	*Real GDP deflator*	4.50%	4.94%	5.39%	5.76%	6.14%
Post-tax real return on equity	*Real GDP deflator*	5.25%	5.95%	7.34%	8.38%	9.42%
Post-tax real hurdle rate	*Real GDP deflator*	5.06%	5.70%	6.85%	7.73%	8.60%
Rounded	***Real GDP deflator***	**5.10%**	**5.70%**	**6.90%**	**7.70%**	**8.60%**
Pre-tax real return on debt	*Real GDP deflator*	4.50%	4.94%	5.39%	5.76%	6.14%
Pre-tax real return on equity	*Real GDP deflator*	7.00%	7.93%	9.78%	11.17%	12.56%
Pre-tax real hurdle rate	*Real GDP deflator*	6.37%	7.18%	8.68%	9.82%	10.96%
Rounded	***Real GDP deflator***	**6.40%**	**7.20%**	**8.70%**	**9.80%**	**11.00%**

Source: CEPA analysis.

Table F.10: Low asset beta and credit rating, 75% gearing

Gearing	75%					
				Risk ranking		
Asset beta / credit rating	**Low**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		75%	75%	75%	75%	75%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Equity risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.45	0.55	0.65	0.80	0.95
Equity beta		1.80	2.20	2.60	3.20	3.80
Post-tax return on equity	*Real CPI*	11.01%	13.10%	15.19%	18.32%	21.46%
Credit rating		BBB+	BBB	BBB-	BB+	BB
Return on debt (pre-transaction costs)	*Nominal*	5.97%	6.11%	6.57%	7.03%	7.48%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Hurdle rate						
Post-tax real return on debt	*Real CPI*	4.09%	4.23%	4.68%	5.13%	5.58%
Post-tax real return on equity	*Real CPI*	11.01%	13.10%	15.19%	18.32%	21.46%
Post-tax real hurdle rate	*Real CPI*	5.82%	6.45%	7.31%	8.43%	9.55%
Rounded	***Real CPI***	**5.80%**	**6.40%**	**7.30%**	**8.40%**	**9.50%**
Pre-tax real return on debt	*Real CPI*	4.09%	4.23%	4.68%	5.13%	5.58%
Pre-tax real return on equity	*Real CPI*	14.68%	17.47%	20.25%	24.43%	28.61%
Pre-tax real hurdle rate	*Real CPI*	6.74%	7.54%	8.57%	9.95%	11.34%
Rounded	***Real CPI***	**6.70%**	**7.50%**	**8.60%**	**10.00%**	**11.30%**
Post-tax nominal return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Post-tax nominal return on equity	*Nominal*	13.17%	15.31%	17.44%	20.63%	23.83%
Post-tax nominal hurdle rate	*Nominal*	7.88%	8.52%	9.40%	10.54%	11.68%
Rounded	***Nominal***	**7.90%**	**8.50%**	**9.40%**	**10.50%**	**11.70%**
Pre-tax nominal return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Pre-tax nominal return on equity	*Nominal*	17.57%	20.41%	23.25%	27.51%	31.77%
Pre-tax nominal hurdle rate	*Nominal*	8.98%	9.80%	10.85%	12.26%	13.67%
Rounded	***Nominal***	**9.00%**	**9.80%**	**10.90%**	**12.30%**	**13.70%**
Post-tax real return on debt	*Real GDP deflator*	3.91%	4.05%	4.50%	4.94%	5.39%
Post-tax real return on equity	*Real GDP deflator*	10.81%	12.90%	14.99%	18.12%	21.25%
Post-tax real hurdle rate	*Real GDP deflator*	5.63%	6.26%	7.12%	8.24%	9.35%
Rounded	***Real GDP deflator***	**5.60%**	**6.30%**	**7.10%**	**8.20%**	**9.40%**
Pre-tax real return on debt	*Real GDP deflator*	3.91%	4.05%	4.50%	4.94%	5.39%
Pre-tax real return on equity	*Real GDP deflator*	14.42%	17.20%	19.98%	24.16%	28.33%
Pre-tax real hurdle rate	*Real GDP deflator*	6.54%	7.34%	8.37%	9.75%	11.12%
Rounded	***Real GDP deflator***	**6.50%**	**7.30%**	**8.40%**	**9.70%**	**11.10%**

Source: CEPA analysis.

Table F.11: Mid-point asset beta and credit rating, 75% gearing

Gearing	75%					
				Risk ranking		
Asset beta / credit rating	**Mid**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		75%	75%	75%	75%	75%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Equity risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.50	0.60	0.75	0.90	1.05
Equity beta		2.00	2.40	3.00	3.60	4.20
Post-tax return on equity	*Real CPI*	12.05%	14.14%	17.28%	20.41%	23.55%
Credit rating		BBB	BBB-	BB+	BB	BB-
Return on debt (pre-transaction costs)	*Nominal*	6.11%	6.57%	7.03%	7.48%	7.87%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Hurdle rate						
Post-tax real return on debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Post-tax real return on equity	*Real CPI*	12.05%	14.14%	17.28%	20.41%	23.55%
Post-tax real hurdle rate	*Real CPI*	6.19%	7.05%	8.17%	9.29%	10.35%
Rounded	***Real CPI***	**6.20%**	**7.00%**	**8.20%**	**9.30%**	**10.30%**
Pre-tax real return on debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Pre-tax real return on equity	*Real CPI*	16.07%	18.86%	23.04%	27.22%	31.40%
Pre-tax real hurdle rate	*Real CPI*	7.19%	8.23%	9.61%	10.99%	12.31%
Rounded	***Real CPI***	**7.20%**	**8.20%**	**9.60%**	**11.00%**	**12.30%**
Post-tax nominal return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Post-tax nominal return on equity	*Nominal*	14.24%	16.37%	19.57%	22.76%	25.96%
Post-tax nominal hurdle rate	*Nominal*	8.26%	9.13%	10.28%	11.42%	12.50%
Rounded	***Nominal***	**8.30%**	**9.10%**	**10.30%**	**11.40%**	**12.50%**
Pre-tax nominal return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Pre-tax nominal return on equity	*Nominal*	18.99%	21.83%	26.09%	30.35%	34.61%
Pre-tax nominal hurdle rate	*Nominal*	9.45%	10.50%	11.91%	13.31%	14.66%
Rounded	***Nominal***	**9.40%**	**10.50%**	**11.90%**	**13.30%**	**14.70%**
Post-tax real return on debt	*Real GDP deflator*	4.05%	4.50%	4.94%	5.39%	5.76%
Post-tax real return on equity	*Real GDP deflator*	11.86%	13.94%	17.07%	20.20%	23.33%
Post-tax real hurdle rate	*Real GDP deflator*	6.00%	6.86%	7.98%	9.09%	10.16%
Rounded	***Real GDP deflator***	**6.00%**	**6.90%**	**8.00%**	**9.10%**	**10.20%**
Pre-tax real return on debt	*Real GDP deflator*	4.05%	4.50%	4.94%	5.39%	5.76%
Pre-tax real return on equity	*Real GDP deflator*	15.81%	18.59%	22.76%	26.94%	31.11%
Pre-tax real hurdle rate	*Real GDP deflator*	6.99%	8.02%	9.40%	10.78%	12.10%
Rounded	***Real GDP deflator***	**7.00%**	**8.00%**	**9.40%**	**10.80%**	**12.10%**

Source: CEPA analysis.

Table F.12: High asset beta and credit rating, 75% gearing

Gearing	75%					
				Risk ranking		
Asset beta / credit rating	**High**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		75%	75%	75%	75%	75%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Equity risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.55	0.65	0.85	1.00	1.15
Equity beta		2.20	2.60	3.40	4.00	4.60
Post-tax return on equity	*Real CPI*	13.10%	15.19%	19.37%	22.50%	25.64%
Credit rating		BBB-	BB+	BB	BB-	B+
Return on debt (pre-transaction costs)	*Nominal*	6.57%	7.03%	7.48%	7.87%	8.25%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Hurdle rate						
Post-tax real return on debt	*Real CPI*	4.68%	5.13%	5.58%	5.95%	6.32%
Post-tax real return on equity	*Real CPI*	13.10%	15.19%	19.37%	22.50%	25.64%
Post-tax real hurdle rate	*Real CPI*	6.79%	7.64%	9.02%	10.09%	11.15%
Rounded	***Real CPI***	**6.80%**	**7.60%**	**9.00%**	**10.10%**	**11.20%**
Pre-tax real return on debt	*Real CPI*	4.68%	5.13%	5.58%	5.95%	6.32%
Pre-tax real return on equity	*Real CPI*	17.47%	20.25%	25.83%	30.01%	34.19%
Pre-tax real hurdle rate	*Real CPI*	7.88%	8.91%	10.64%	11.96%	13.29%
Rounded	***Real CPI***	**7.90%**	**8.90%**	**10.60%**	**12.00%**	**13.30%**
Post-tax nominal return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Post-tax nominal return on equity	*Nominal*	15.31%	17.44%	21.70%	24.89%	28.09%
Post-tax nominal hurdle rate	*Nominal*	8.87%	9.74%	11.15%	12.23%	13.32%
Rounded	***Nominal***	**8.90%**	**9.70%**	**11.20%**	**12.20%**	**13.30%**
Pre-tax nominal return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Pre-tax nominal return on equity	*Nominal*	20.41%	23.25%	28.93%	33.19%	37.45%
Pre-tax nominal hurdle rate	*Nominal*	10.14%	11.20%	12.96%	14.31%	15.66%
Rounded	***Nominal***	**10.10%**	**11.20%**	**13.00%**	**14.30%**	**15.70%**
Post-tax real return on debt	*Real GDP deflator*	4.50%	4.94%	5.39%	5.76%	6.14%
Post-tax real return on equity	*Real GDP deflator*	12.90%	14.99%	19.16%	22.29%	25.42%
Post-tax real hurdle rate	*Real GDP deflator*	6.60%	7.45%	8.83%	9.89%	10.96%
Rounded	***Real GDP deflator***	**6.60%**	**7.50%**	**8.80%**	**9.90%**	**11.00%**
Pre-tax real return on debt	*Real GDP deflator*	4.50%	4.94%	5.39%	5.76%	6.14%
Pre-tax real return on equity	*Real GDP deflator*	17.20%	19.98%	25.55%	29.72%	33.89%
Pre-tax real hurdle rate	*Real GDP deflator*	7.67%	8.70%	10.43%	11.75%	13.07%
Rounded	***Real GDP deflator***	**7.70%**	**8.70%**	**10.40%**	**11.80%**	**13.10%**

Source: CEPA analysis.

Table F.13: Low asset beta and credit rating, 0% gearing

Gearing	Unlevered					
				Risk ranking		
Asset beta / credit rating	**Low**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		0%	0%	0%	0%	0%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Market risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.45	0.55	0.65	0.80	0.95
Equity beta		0.45	0.55	0.65	0.80	0.95
Post-tax return on equity	*Real CPI*	3.96%	4.48%	5.00%	5.79%	6.57%
Credit rating		BBB+	BBB	BBB-	BB+	BB
Return on debt (pre-transaction costs)	*Nominal*	5.97%	6.11%	6.57%	7.03%	7.48%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Hurdle rate						
		LowLow	*LowLow-Medium*	*LowMedium*	*LowMedium-High*	*LowHigh*
Post-tax return on debt	*Real CPI*	4.09%	4.23%	4.68%	5.13%	5.58%
Post-tax return on equity	*Real CPI*	3.96%	4.48%	5.00%	5.79%	6.57%
Post-tax hurdle rate	*Real CPI*	3.96%	4.48%	5.00%	5.79%	6.57%
Rounded	***Real CPI***	**4.00%**	**4.50%**	**5.00%**	**5.80%**	**6.60%**
Pre-tax return on debt	*Real CPI*	4.09%	4.23%	4.68%	5.13%	5.58%
Pre-tax return on equity	*Real CPI*	5.28%	5.97%	6.67%	7.71%	8.76%
Pre-tax hurdle rate	*Real CPI*	5.28%	5.97%	6.67%	7.71%	8.76%
Rounded	***Real CPI***	**5.30%**	**6.00%**	**6.70%**	**7.70%**	**8.80%**
Post-tax return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Post-tax return on equity	*Nominal*	5.98%	6.52%	7.05%	7.85%	8.65%
Post-tax hurdle rate	*Nominal*	5.98%	6.52%	7.05%	7.85%	8.65%
Rounded	***Nominal***	**6.00%**	**6.50%**	**7.00%**	**7.80%**	**8.60%**
Pre-tax return on debt	*Nominal*	6.12%	6.26%	6.72%	7.18%	7.63%
Pre-tax return on equity	*Nominal*	7.98%	8.69%	9.40%	10.46%	11.53%
Pre-tax hurdle rate	*Nominal*	7.98%	8.69%	9.40%	10.46%	11.53%
Rounded	***Nominal***	**8.00%**	**8.70%**	**9.40%**	**10.50%**	**11.50%**
Post-tax return on debt	*Real GDP deflator*	3.91%	4.05%	4.50%	4.94%	5.39%
Post-tax return on equity	*Real GDP deflator*	3.77%	4.29%	4.82%	5.60%	6.38%
Post-tax hurdle rate	*Real GDP deflator*	3.77%	4.29%	4.82%	5.60%	6.38%
Rounded	***Real GDP deflator***	**3.80%**	**4.30%**	**4.80%**	**5.60%**	**6.40%**
Pre-tax return on debt	*Real GDP deflator*	3.91%	4.05%	4.50%	4.94%	5.39%
Pre-tax return on equity	*Real GDP deflator*	5.03%	5.73%	6.42%	7.46%	8.51%
Pre-tax hurdle rate	*Real GDP deflator*	5.03%	5.73%	6.42%	7.46%	8.51%
Rounded	***Real GDP deflator***	**5.00%**	**5.70%**	**6.40%**	**7.50%**	**8.50%**

Source: CEPA analysis.

Table F.14: Mid-point asset beta and credit rating, 0% gearing

Gearing	Unlevered					
				Risk ranking		
Asset beta / credit rating	**Mid**	**Low**	**Low-Medium**	**Medium**	**Medium-High**	**High**
Parameters						
Gearing		0%	0%	0%	0%	0%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Market risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.50	0.60	0.75	0.90	1.05
Equity beta		0.50	0.60	0.75	0.90	1.05
Post-tax return on equity	*Real CPI*	4.22%	4.74%	5.52%	6.31%	7.09%
Credit rating		BBB	BBB-	BB+	BB	BB-
Return on debt (pre-transaction costs)	*Nominal*	6.11%	6.57%	7.03%	7.48%	7.87%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Hurdle rate						
		MidLow	*MidLow-Medium*	*MidMedium*	*MidMedium-High*	*MidHigh*
Post-tax return on debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Post-tax return on equity	*Real CPI*	4.22%	4.74%	5.52%	6.31%	7.09%
Post-tax hurdle rate	*Real CPI*	4.22%	4.74%	5.52%	6.31%	7.09%
Rounded	***Real CPI***	**4.20%**	**4.70%**	**5.50%**	**6.30%**	**7.10%**
Pre-tax return on debt	*Real CPI*	4.23%	4.68%	5.13%	5.58%	5.95%
Pre-tax return on equity	*Real CPI*	5.62%	6.32%	7.37%	8.41%	9.45%
Pre-tax hurdle rate	*Real CPI*	5.62%	6.32%	7.37%	8.41%	9.45%
Rounded	***Real CPI***	**5.60%**	**6.30%**	**7.40%**	**8.40%**	**9.50%**
Post-tax return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Post-tax return on equity	*Nominal*	6.25%	6.78%	7.58%	8.38%	9.18%
Post-tax hurdle rate	*Nominal*	6.25%	6.78%	7.58%	8.38%	9.18%
Rounded	***Nominal***	**6.20%**	**6.80%**	**7.60%**	**8.40%**	**9.20%**
Pre-tax return on debt	*Nominal*	6.26%	6.72%	7.18%	7.63%	8.02%
Pre-tax return on equity	*Nominal*	8.33%	9.04%	10.11%	11.17%	12.24%
Pre-tax hurdle rate	*Nominal*	8.33%	9.04%	10.11%	11.17%	12.24%
Rounded	***Nominal***	**8.30%**	**9.00%**	**10.10%**	**11.20%**	**12.20%**
Post-tax return on debt	*Real GDP deflator*	4.05%	4.50%	4.94%	5.39%	5.76%
Post-tax return on equity	*Real GDP deflator*	4.03%	4.56%	5.34%	6.12%	6.90%
Post-tax hurdle rate	*Real GDP deflator*	4.03%	4.56%	5.34%	6.12%	6.90%
Rounded	***Real GDP deflator***	**4.00%**	**4.60%**	**5.30%**	**6.10%**	**6.90%**
Pre-tax return on debt	*Real GDP deflator*	4.05%	4.50%	4.94%	5.39%	5.76%
Pre-tax return on equity	*Real GDP deflator*	5.38%	6.07%	7.12%	8.16%	9.20%
Pre-tax hurdle rate	*Real GDP deflator*	5.38%	6.07%	7.12%	8.16%	9.20%
Rounded	***Real GDP deflator***	**5.40%**	**6.10%**	**7.10%**	**8.20%**	**9.20%**

Source: CEPA analysis.

Table F.15: High asset beta and credit rating, 0% gearing

Gearing	Unlevered					
				Risk ranking		
Asset beta / credit rating	High	Low	Low-Medium	Medium	Medium-High	High
Parameters						
Gearing		0%	0%	0%	0%	0%
Tax rate		25%	25%	25%	25%	25%
Expected inflation (CPI)		1.95%	1.95%	1.95%	1.95%	1.95%
Expected inflation (GDP deflator)		2.13%	2.13%	2.13%	2.13%	2.13%
Risk free rate	*Real CPI*	1.61%	1.61%	1.61%	1.61%	1.61%
Total market returns	*Real CPI*	6.83%	6.83%	6.83%	6.83%	6.83%
Market risk premium	*Real CPI*	5.22%	5.22%	5.22%	5.22%	5.22%
Asset beta		0.55	0.65	0.85	1.00	1.15
Equity beta		0.55	0.65	0.85	1.00	1.15
Post-tax return on equity	*Real CPI*	4.48%	5.00%	6.05%	6.83%	7.61%
Credit rating		BBB-	BB+	BB	BB-	B+
Return on debt (pre-transaction costs)	*Nominal*	6.57%	7.03%	7.48%	7.87%	8.25%
Debt transaction costs	*Nominal*	0.15%	0.15%	0.15%	0.15%	0.15%
Return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Hurdle rate						
		HighLow	*HighLow-Medium*	*HighMedium*	*HighMedium-High*	*HighHigh*
Post-tax return on debt	*Real CPI*	4.68%	5.13%	5.58%	5.95%	6.32%
Post-tax return on equity	*Real CPI*	4.48%	5.00%	6.05%	6.83%	7.61%
Post-tax hurdle rate	*Real CPI*	4.48%	5.00%	6.05%	6.83%	7.61%
Rounded	***Real CPI***	**4.50%**	**5.00%**	**6.00%**	**6.80%**	**7.60%**
Pre-tax return on debt	*Real CPI*	4.68%	5.13%	5.58%	5.95%	6.32%
Pre-tax return on equity	*Real CPI*	5.97%	6.67%	8.06%	9.11%	10.15%
Pre-tax hurdle rate	*Real CPI*	5.97%	6.67%	8.06%	9.11%	10.15%
Rounded	***Real CPI***	**6.00%**	**6.70%**	**8.10%**	**9.10%**	**10.20%**
Post-tax return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Post-tax return on equity	*Nominal*	6.52%	7.05%	8.11%	8.91%	9.71%
Post-tax hurdle rate	*Nominal*	6.52%	7.05%	8.11%	8.91%	9.71%
Rounded	***Nominal***	**6.50%**	**7.00%**	**8.10%**	**8.90%**	**9.70%**
Pre-tax return on debt	*Nominal*	6.72%	7.18%	7.63%	8.02%	8.40%
Pre-tax return on equity	*Nominal*	8.69%	9.40%	10.82%	11.88%	12.95%
Pre-tax hurdle rate	*Nominal*	8.69%	9.40%	10.82%	11.88%	12.95%
Rounded	***Nominal***	**8.70%**	**9.40%**	**10.80%**	**11.90%**	**12.90%**
Post-tax return on debt	*Real GDP deflator*	4.50%	4.94%	5.39%	5.76%	6.14%
Post-tax return on equity	*Real GDP deflator*	4.29%	4.82%	5.86%	6.64%	7.42%
Post-tax hurdle rate	*Real GDP deflator*	4.29%	4.82%	5.86%	6.64%	7.42%
Rounded	***Real GDP deflator***	**4.30%**	**4.80%**	**5.90%**	**6.60%**	**7.40%**
Pre-tax return on debt	*Real GDP deflator*	4.50%	4.94%	5.39%	5.76%	6.14%
Pre-tax return on equity	*Real GDP deflator*	5.73%	6.42%	7.81%	8.86%	9.90%
Pre-tax hurdle rate	*Real GDP deflator*	5.73%	6.42%	7.81%	8.86%	9.90%
Rounded	***Real GDP deflator***	**5.70%**	**6.40%**	**7.80%**	**8.90%**	**9.90%**

Source: CEPA analysis.

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