Economic Parameters for technical work (NCC)

Prepared for Australian Building Construction Board

By **Nicki Hutley, Rovingstone Advisory Pty Ltd**

Updated April 2024 to include Learning Rate Advice

Table of Contents

Acronyms and Abbreviations

ABCB	The Australian Building Codes Board
ACCU	Australian Carbon Credit Unit
ACT	Australian Capital Territory
AEMO	The Australian Energy Market Operator
ANGA	Australian National Greenhouse Accounts
ATO	The Australian Taxation Office
AUD	Australian Dollar
BCA	Building Code of Australia
BCR	Benefit cost ratio
CBA	Cost Benefit Analysis
CCA	The Climate Change Authority
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Use, and Storage
CIE	The Centre for International Economics
CO2	Carbon Dioxide
CO2-e	Carbon Dioxide-equivalent
COVID	Coronavirus disease
CPI	Consumer Price Index
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DICE	Dynamic Integrated Climate Change (IAM model)
DISR	Department of Industry, Science and Resources
EA	Energy Action
EPA	United States Environmental Protection Agency
ERF	Emissions Reduction Fund
ETS	Emissions Trading Scheme
EU	The European Union
EUA	EU Allowance
FUND	Framework for Uncertainty, Negotiation and Distribution (IAM model)

GDP	Gross Domestic Product
GHG	Greenhouse Gas
GJ	Gigajoule
GST	Goods and services tax
IAM	Integrated Assessment Model
IEA	International Energy Agency
IMF	The International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISP	Integrated System Plan
IWG	Interagency Working Group
LCA	Life cycle assessment
LCOE	Levelized Cost of Energy
LED	Light-emitting diode
MAC	Marginal Cost of Abatement
MVA	Megavolt-Amperes
MWh	Megawatt hour
NCC	National Construction Code
NEM	National Electricity Market
NPV	Net Present Value
NSW	New South Wales
NT	Northern Territory of Australia
NUOS	Network Use of Service
OIA	Office of Impact Assessment
pa	per annum
PAGE	Policy Analysis of the Greenhouse Effect (IAM model)
PV	Photovoltaics
QLD	Queensland
RBA	Reserve Bank of Australia
RIS	Regulation Impact Statement
SA	South Australia
SCC	Social Cost of Carbon

SMC	Safeguard Mechanism (Carbon) Credit
SOC	Social Opportunity Cost of Capital
SPR	Strategy.Policy.Research
SRTP	Social Rate of Time Preference
SWIS	South West Interconnected System
TAS	Tasmania
UK	United Kingdom
US	United States
USD	United States Dollar
VA	Volt-ampere
VIC	Victoria
WA	Western Australia

1 Background

This document provides recommendations and rationale for economic parameters to be used by consultants (Regulation Impact Statement (RIS) and technical) in the development of analysis related to National Construction Code (NCC) 2025 energy efficiency changes for commercial buildings. The analysis covers: hotels, office buildings, retail, healthcare, aged care, warehouses, factories, and schools.

The parameters covered, at the request of the Australian Building Codes Board (ABCB), have all been subject to varying levels of debate in the recent past. Some face significant levels of uncertainty for short-, medium-, and long-term projections, particularly in light of current ambiguities surrounding the future of energy markets and net zero pathways in both international and domestical markets.

To ensure inputs to the technical work and RIS are robust and consistent, this document makes recommendations for central case values for parameters, as well as, where indicated, sensitivity values.

This document is informed by both official documentation (e.g. Office of Impact Assessment (OIA) Guidelines) as well as industry literature.

1.1 Structure of report

This document provides detailed recommendations for parameters identified by the ABCB, as follows.

- Building lifecycle
- Discount rate
- Carbon pricing (market, shadow and social cost of carbon)
- Electricity carbon intensity
- Gas carbon intensity
- Network charges: energy consumption charge, augmentation cost, demand charge
- Electricity prices, including feed-in tariff offsets
- Gas prices
- Annual energy price inflation
- Learning rates

For each parameter, a definition, recommended value (central case and sensitivity, where appropriate) and rationale are provided.

2 Building lifecycle

Definition: Life cycle assessment (LCA) is an internationally recognised approach for assessing the environmental impacts of consumption and production.[1] In the case of construction of commercial buildings, LCA allows assessment to consider the environmental impacts of the construction, routine operation and maintenance, and capital renewals phases of a building over its useful life.

Table 2.1 Building lifecycle, NCC 2019 basis and recommendation

Values used for NCC 2019	Recommended values for building level analysis/ RIS central case	RIS sensitivity analysis
40 years	50 years	40 years

Standard Cost Benefit Analysis (CBA) practice, including in OIA guidelines, is for the assessment period to not exceed 30 years, although longer periods may be considered in certain circumstances, particularly in the case where environmental impacts are relevant, as these can last over multiple generations.

This is largely because the discount rate effect reduces the value of long-term benefits calculated in current dollar terms. Using prevailing central case discount rates favoured by many Australian governments, including the Commonwealth Government, of 7%, benefits are typically negligible beyond 30 years, although OIA Guidance allows for declining discount rates over longer time periods (see Section 3 below).

If the analysis is to go beyond the standard 30-year period, the logic for such a decision must be clear.

In previous analysis relating to NCC for commercial buildings, e.g., the Cost Benefit Analysis in the 2018 Decision Regulation Impact Statement for Energy Efficiency of Commercial Buildings, a 40-year lifecycle assumption has been used across all commercial asset classes. This aligns with Australian Taxation Office capital depreciation rates for commercial office and retail buildings (i.e., 2.5% annual depreciation). However, these rates vary depending on the class of building, for example, the depreciation rate for hotels and industrial buildings is 4% per annum, implying a 25-year life.

However, the Australian Taxation Office (ATO) standards do not necessarily align with observed experience. Indeed, NCC 2019 infers a design life of at least 50 years, while the standard life of a commercial building in Australia is commonly estimated to be 60 years or longer.[2,3] One Australian

---

[1] https://acumen.architecture.com.au/environment/materials/life-cycle-assessment/life-cycle-assessment-of-buildings/ accessed 8 February 2022

[2] See, for example, https://www.realcommercial.com.au/news/what-is-the-lifespan-of-a-commercial-building, https://www.rdh.com/blog/long-buildings-last/, or

[3] Ostwald, Clinton [Director, Economics and Property investment, Urbis]. Email communication, received by Nicki Hutley, 14 February 2023

study[4] found a range for useful life of 50 to 250 years (for non-iconic structures), with a mean of 154 years.

A 50-year period could therefore be considered a reasonable assumption.

In the case of commercial buildings, benefits flowing to building owners and tenants through cost savings can be expected to continue to flow throughout the useful life of the building, again supporting a 50-year assessment period.

Community benefits, in the form of avoided Greenhouse Gas (GHG) emissions, will depend on the emissions-intensity of grid energy which is being displaced by new measures in the Code. Government policy envisages 82% renewables by 2030 and a Net Zero system by 2050. For the National Electricity Market (NEM), the Australian Energy Market Operator (AEMO) 2022 Integrated System Plan (ISP) offers a range of scenarios aligned to this policy target (see section 5). This will reduce public benefits over time but is not a reason to shorten the time horizon for the assessment period. WA and the NT, which are not covered by the NEM have 2050 Net Zero targets, but less clear timelines.

Given the above, it is not unreasonable to suggest that a central case of 50 years should be used, which is likely to have more than incremental impacts on the benefit cost ratio (BCR) using the lower bound sensitivity for the discount rate (discussed below).

Sensitivity at the 40-year level could be undertaken to allow for comparison with previous assessments.

[4] Langston, C. A., 2011, Estimating the Useful Life of Buildings In Proceedings of the 36th Annual conference for Australasian Building Educators Association (AUBEA) (pp. 418-432). AUBEA. P. 428

3 Discount Rate

Definition: The social discount rate (discount rate) is used in Cost Benefit Analysis (CBA) to adjust future dollar values of benefits and costs into current dollar terms, reflecting the higher value placed on a dollar today over a dollar in the future.

Table 3.1 Discount rate for CBA, NCC 2019 basis and recommendation

Values used for NCC 2019	Recommended values for building level analysis/ RIS central case	RIS sensitivity analysis
7% (Sensitivity at 3% and 10%)	5.0%	2% and 7%

There is perhaps no area in CBA practice and guidelines subject to greater controversy and there is no consensus on an appropriate value. A 2010 Productivity Commission research paper[5] showed varying approaches over the previous decades had produced rates of between 1% and 15%. There is no consistency between approaches across governments and government entities such as industry regulators, either within Australia or internationally in comparable developed economies.

It is not within the scope of this document to reproduce all the arguments that lead to these different rate choices. Rather, it is to test the merits of earlier practice and make recommendations on whether to maintain or update these values.

There are two key methods for calculating a social discount rate for use in policy analysis.

- Social Rate of Time Preference (SRTP) – this represents a measure of an individual's willingness to postpone private consumption now in order to consume later. An indicator of SRTP is the earnings rate on their savings (i.e., the rate at which individuals will choose to save rather than to consume). SRTP is typically between 1% and 5%.[6]
- Social Opportunity Cost of Capital (SOC) – this reflects the marginal earnings rate for private business (market) investments. It is higher than SRTP, but rates of estimation vary widely (historically, between 5% and 15%).[7]

Current practice in Australia more commonly relies on using the SOC methodology although this does not guarantee a single discount rate will be adopted. As an example, the Victorian Department of Treasury and Finance recommends a central case rate of 4% for a RIS, but 7% for projects such as public transport.[8] In contrast, the UK government uses a 3.5% SRTP-based rate.

The OIA (formerly, Office of Best Practice Regulation) standard advice suggests the calculation of Net Present Values (NPVs) can be undertaken using an annual real discount rate of 7%, with sensitivity

---

[5] Harrison, M., 2010, *Valuing the Future: The Social Discount Rate in Cost-Benefit Analysis*, Productivity Commission
[6] Ibid
[7] Ibid
[8] Department of Treasury and Finance, Victoria, 2013, *Economic evaluation for Business Cases – Technical Guidelines*

analysis conducted at 3% and 10%. A 7% rate is used in a number of jurisdictions, although Victoria and NSW are exceptions.

Importantly, the updated edition of the NSW Treasury CBA Guidelines[9] released in February 2023 recommends a 5% central case rate, with sensitivity testing at 3% and 7%. The change in NSW practice is based on the NSW Treasury's observation that "discount rates have fallen over time" (TPG23-08, P93).

For global examples of research suggesting a permanent decline in global real interest rates, see also, for example, Bauer and Rudebusch[10] and recent work by the International Monetary Fund (IMF).[11] This research argues that, despite recent upward movements in interest rate markets in response to post-Pandemic inflation, the downward shift in real discount rates over the past three or so decades is a permanent trend.

Additionally, OIA notes that "Where there is a research-related reason for using a different discount rate, the analysis can be presented at that discount rate in addition to [prescribed rates]."

Indeed, the Guidance Note for Environmental valuations[12] recommends use of a declining discount rate, as shown in Table 3.2 below, for both environmental and other policy assessments.

Table 3.2 OIA recommended declining long-term discount rates

Period of years	**1-30**	**31-75**	**76-125**	**126-200**	**201-300**	**301+**
Discount rate	7.0%	5.4%	4.8%	4.3%	4.0%	3.7%

Source: Department of Prime Minister and Cabinet

However, these rates are significantly higher than those adopted by, for example, the US Interagency Working Group (IWG) (see Section 4.4), which are based on SRTP, but they acknowledge the issue of longer-term forecasting into uncertainty.

Given these significant changes in observation and practice, and to better align with practice in NSW and Victoria, it is recommended that a central case discount rate of 5% is used, with sensitivity at 2% and 7%.

The lower bound sensitivity at 2% is recommended to align with the central case for the Social Cost of Carbon (SCC), discussed in detail in Section 4.4 below.

---

[9] NSW Treasury, 2023, TPG23-08 NSW Government Guide to Cost-Benefit Analysis

[10] Bauer, M. and Rudebusch, D.G., 2021, The Rising Cost of Climate Change: Evidence from the Bond Market.

[11] International Monetary Fund. 2023. World Economic Outlook: A Rocky Recovery. Washington, DC. April, Ch 2

[12] Department of Prime Minister and Cabinet

4 Carbon pricing options

There is currently no consistent practice among Australian commonwealth, state or territory governments in determining an appropriate carbon (and other GHGs) price for use in economic analysis; in fact, most jurisdictions provide no formal guidance at all. However, economists typically use one or both of two options for determining a carbon price for use in economic analyses: a **market price**, or a **social cost of carbon** (SCC). Variations on these values will typically be used for sensitivity testing.

International best practice, including in jurisdictions such as the US, Canada, France and Germany, mandate using a SCC in policy analysis. Even in Australia, sensitivity testing, at least, will typically include some value for a SCC.

4.1 Market pricing

While Australia no longer has a carbon trading scheme, the World Bank notes that "Some 40 countries and more than 20 cities, states and provinces already use carbon pricing mechanisms."[13] However, the price of carbon in these schemes varies enormously, according to their design.

In theory, a market price for carbon, as reflected in units traded under an Emissions Trading Scheme (ETS) or carbon tax (fixed price), should reflect the cost of containing emissions to a specified pathway. However, the United Nations Intergovernmental Panel on Climate Change (IPCC) states that a carbon concentration no higher than 430 parts per million (ppm) is consistent with 1.5°C warming[14], which would require higher prices than are currently seen on average in international markets.[15]

The most frequently cited carbon (permit) price, because of its size and longevity, is that associated with the European Union (EU) ETS. A permit is known as an EU Allowance (EUA). This is the benchmark recommended by the NSW Government for mining and coal seam gas appraisals.[16] As of 19 December 2022, the price of an EUA was €84.11 (or approximately A$130). Over time, prices can be expected to rise further, as deeper emissions cuts are required so that futures prices or forecasts need to be used in a CBA. Typically, these do not go beyond a five- to ten-year period at most so a "best guess" inflator needs to be used.

Clearly, there are significant limitations associated with "market" pricing of carbon, the most important being that market design currently likely makes these a substantial underestimate of the cost of carbon.

---

[13] https://www.worldbank.org/en/programs/pricing-carbon

[14] IPCC, 2014, Summary for Policymakers in: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

[15] IPCC, 2018, Global Warming of 1.5°C – Special Report chapter 2 at https://www.ipcc.ch/sr15/chapter/chapter-2/

[16] NSW Department of Planning and Environment, 2018, Technical Notes supporting the Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals

Recently updated NSW Treasury CBA Guidelines[17] – currently the only jurisdiction to provide explicit advice on this issue – state that "a carbon emissions value based on market price should be used in the absence of a comprehensive Australian emissions market or modelled target-consistent marginal abatement cost." Previously (2017 Guidelines), in the absence of robust market pricing, NSW Treasury has recommended using estimates of damages (as represented by a SCC).

The new 2023 Guidelines, however, recommend use of the EU ETS price, with the average 2022 market price as the base year, escalated by 2.25% per annum. Recommended values are only provided for a 10-year period, however. While sensitivity testing could be done using the EUA values, to align with some jurisdictional practices, providing longer term forecasts would involve rough estimation given the absence of longer-term futures prices.

Sensitivity testing is recommended based on high and low spot prices in the 2022 calendar year as well as the IPCC estimate of the global average Marginal Cost of Abatement (MAC) to limit warming to 2°C [Note, this is above the Paris Agreement target], escalated by 4.3% per annum.

Table 4.1 below provides NSW Treasury recommended values for use in CBAs.

Table 4.1 NSW Recommended 2030 Carbon Prices for use in CBA ($/t$CO_2$-e)

Central case	Sensitivity		
	High spot	Low spot	IPCC MAC
$144	$149	$88	$163

Source: NSW Treasury (2023)

As noted above, there are limitations in using the EU market price, given design factors are still leading to lower-than-otherwise prices. This is demonstrated by the differential between the December €84/tCO_2 spot price, and at least one recent estimate of the MAC for Europe[18] of €140 /tCO_2 (real 2020 Euros) by 2030, or €170 /tCO_2 in nominal terms.

4.2 Shadow Carbon Price

Definition: Where a market carbon-pricing mechanism does not exist, as in Australia, a so-called "shadow" carbon price may be used, which allows investments to model returns reflecting the externality cost of GHGs.

A shadow price may be observed or theoretical; typically, the shadow price will reflect a relevant benchmark such as a market prices in another jurisdiction, an alternate domestic carbon pricing mechanism, or theoretical economic modelling.

[17] NSW Treasury, 2023, Technical note to NSW Government Guide to Cost-Benefit Analysis TPG23-08 Carbon value in cost-benefit analysis

[18] https://sustainability.crugroup.com/article/eu-2030-emission-targets-need-carbon-price-euro140-tco2

The latter approach is now adopted in the UK, which moved away from an SCC in 2009 due to concerns about emissions pathway choices of other countries and the impact on SCC estimates). The UK applies separate shadow prices for its emissions-traded and non-traded sectors although these converge by 2050.

Unfortunately, there is no publicly available, up-to-date economic modelling of an Australian carbon price consistent with emissions reduction policies published by Commonwealth Treasury. As and when such modelling becomes available, this should be incorporated into future analysis as a sensitivity test.

Australia has a number of carbon instruments which have published prices, namely:

- Australian Carbon Credit Units (ACCUs), generated under a voluntary scheme
- Emissions Reduction Fund (ERF) auction prices, with auctions typically held annually
- Legislation is also underway to update the Safeguard Mechanism which is expected to create Safeguard Mechanism (Carbon) Credits (SMCs).

These can be used as a “shadow” carbon price in analysis.

Table 4.2 Shadow carbon price, NCC 2019 basis and recommendation

Values used for NCC 2019 (Delta Q analysis)	Recommended values
ERF ($12.25, in 2015 plus annual CPI) $36.67 in 2025, $44.61 in 2030, $56.45 in 2036	Not recommended. Instead use SCC values (see Section 4.3 below)

Shadow carbon prices used in the 2018 RIS were based on a 2016 report[19] which in turn used now well out-of-date reference points:

- Emissions Reduction Fund (ERF) auction outcomes for November 2015 ($12.25), assumed to increase in line with the Consumer Price Index (CPI)[20]
- the medium scenario from the Climate Change Authority (CCA) 2014 Targets and Progress Review.

Scheme design, including integrity of offsets and frequency of ERF auctions, means neither ERF auction prices, nor ACCUs, nor SMCs (which will be capped at $75/tons of CO_2-e) are an accurate reflection of the cost of economy-wide abatement required to meet Net Zero and are therefore a poor choice for analysis.

Until such time as an economy-wide scheme or more accurate modelling is available, the EUA is likely the most realistic choice for a shadow carbon price. However, it is more reasonable to use a damages

[19] Pitt and Sherry, 2016, Final Report – Pathway to 2020 for Increased Stringency in New Building Energy Efficiency Standards: Benefit Cost Analysis: Commercial Buildings: 2016 Update

[20] Using the CPI as an inflator would imply a 2022 price some 16% below the actual 14th auction price recorded, of $17.35

approach (SCC), as recommended by NSW Treasury and as adopted in many other developed economies.

4.3 Social Cost of Carbon

Definition: The SCC, sometimes referred to as the 'damage cost' estimate, is the net present value (NPV) of net climate-related impacts as a result of one additional tonne of CO_2 or CO_2-equivalent (CO_2-e) gasses emitted to the atmosphere today.

Table 4.3 Social Cost of Carbon, NCC 2019 basis and recommendation

Values used for NCC 2019	Recommended values for building level analysis/ RIS
US EPA 2017 values	US EPA 2022 values (see Table 4.3)

A SCC is considered perhaps "the single-most important economic concept in the economics of climate change."[21] In the US alone, regulations have been adopted with more than US$1 trillion in benefits, based on economic analysis that uses a SCC.[22]

Modelling a SCC is complex. Integrated Assessment Models (IAMs) incorporate scientific and economic models, which reflect expectations around emissions pathways, climate-related damages, abatement costs, and socio-demographic and economic parameters. IAMs allow us to understand the net total cost of climate change along different pathways. The assumptions underpinning these models, however, are subject to debate, reflecting both uncertainty in climate risk outcomes as well as debate over economic theory and practice.

Indeed, in the US alone, Environmental Protection Agency (EPA) estimates for the SCC draw on three separate IAMs, using a range of assumptions about core parameters such as social discount rate (discussed below), economic and population growth and climate impacts. Core impacts measured (which cover both positive and negative impacts) include physical damages (property, infrastructure, coastal erosion, etc.), changes in net labour and agricultural productivity, human health and mortality, and energy markets.

Despite the inherent uncertainty and debate surrounding IAMs, current SCC estimates are still more likely to be the most accurate and conservative measure of benefits (avoided costs) related to GHG emissions. They are conservative as, at this time, they exclude many dimensions of climate impacts such as forced migration, crime, national security, biodiversity loss, and some dimensions of human health impacts.

For a number of advanced economies, therefore, it is still the preferred measure of carbon price for cost benefit analysis because it provides a best available estimate of benefits (avoided costs) of the

[21] Nordhaus, W., 2017, PNAS February 14, 2017 114 (7) 1518-1523; at https://doi.org/10.1073/pnas.1609244114 accessed 15 February 2021
[22] Ibid.

impact of unchecked emissions growth. Advanced economies that also use an SCC use some variation of the US SCC or the output from at least one of the three models.

One of the most critical variables to impact the SCC values modelled is the discount rate used.[23] Because estimates of damages in IAMs are projected out to 2300, the rate chosen has a very significant effect on modelled values. This is discussed in more detail in Section 4.4 below. However, the latest iteration of US EPA estimates uses 1.5%, 2.0% and 2.5% for SCC estimates (previously 2.5%, 3% and 5%), moving in line with the majority view of economists. It is recommended that these values (shown in Table 4.4 Recommended SCC values ($A) below) be used.[24]

Table 4.4 Recommended SCC values ($A)

Emission year	Discount Rate		
	2.5%	**2.0%**	**1.5%**
2020	161	255	456
2030	188	308	509
2040	228	362	576
2050	268	415	643
2060	308	469	710
2070	348	509	764
2080	375	549	804

Source: US EPA (2022), using USD/AUD 10-year average exchange rate to February 2023, taken from RBA (Table F11Hist.xls)

4.4 Discount Rates for a Social Cost of Carbon

Definition: The discount rate used in estimating a SCC has the same definition and function as the discount rate used for the CBA. However, the extended time periods involved in SCC modelling warrant a different approach.

[23] Weitzman, M. L., 2012, The Ramsey Discounting Formula for a Hidden-State Stochastic Growth Process, Environ Resource Econ (2012) 53:309–321 accessed at Environ Resource Econ (2012) 53:309–321

[24] Annual values for years between those shown can be estimated by calculating the compound annual growth between years shown and applying on an annual basis.

Table 4.5 Discount rate for SCC, NCC 2019 basis and recommendation

Values used for NCC 2019	Recommended values for building level analysis/ RIS central case	RIS sensitivity analysis
Central case: 3%, sensitivity at 2.5%, 5% and 95th percentile impact	2%	1.5% and 2.5%

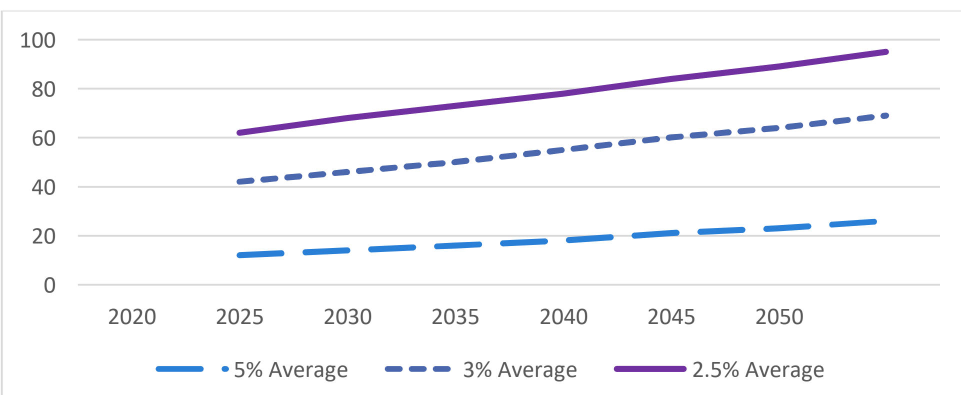
Estimates used in the 2019 RIS CBA relied on earlier US EPA estimates, including a 3% central case with sensitivity at 2.5%, 5%, and the high impact (95th percentile) damages estimate (at a 3% discount rate).

IAMs estimate the impacts of climate change over almost three centuries to 2300, and so the impact of discounting on SCC values chosen will be profound.

Further, estimates for the SCC increase over time because future emissions are expected to produce larger incremental damages, as physical and economic systems become more stressed in response to greater climatic change, and because GDP and populations – and therefore the potential for damages – are also expected to increase over time.

Discounting assumptions are therefore one of the biggest determinants of differences between estimations of the SCC and are subject to the greatest amount of debate. The effect is also demonstrated in Figure 4-1 below.

Figure 4-1: US [2017] SCC forecasts – impact of discount rate choice



Source: Carbon Brief

The majority of economists agree that a SRTP (refer to Section 3) is most appropriate for calculating the SCC, but do not agree on the rate itself. While some argue for prevailing market interest rates as the most relevant proxy, others state that such rates fail to accurately account for societal views about how we view the "value" of future generations themselves and therefore are potentially too high.[25] Leading global climate economist, Professor Nicholas Stern – who favours a discount rate close to zero – states that current interest rates are not valid because these rates do not tell us "how do we, acting together, evaluate our responsibilities to future generations."[26] Future generations cannot retrospectively alter current practices. He suggests a declining long-term rate is preferable.

Nobel Laureate William Nordhaus specifies a SRTP discount rate of 3%, based on actual capital market returns.[27] Nordhaus has famously made the argument that future generations will be better-off economically and technologically than past generations and therefore better equipped to deal with climate change impacts. This is a highly disputed concept.

In a survey of 197 expert climate economists, the average long-term discount rate preferred was 2.25%. The survey found that the vast majority of survey participants accepted a rate of between 1% and 3%, with only a few favouring higher rates.[28] After a review of relevant scientific literature, the IPCC stated that there is no justification for applying discount rates as high as 5% p.a. for climate change analysis.[29]

Both early and most recent US Government guidance suggests a lower rate is appropriate for estimating multi-generational values, given the "special ethical values" attached.[30] Indeed, the same survey showed 46% of respondents recommended using a declining discount rate for intergenerational effects.

The most recent US EPA estimates use the so-called Ramsey discount rate, which reflects less certain future growth rates and seeks to address the issue of intergenerational equity.

There is scope to undertake more study in this area, although the ultimate choice of discount rate comes down to moral, rather than economic, considerations. This is one reason why several estimates are produced by the EPA.

Given the weight of economic sentiment across many governments and academics favours a lower discount rate, the RIS should use most recent US EPA SCC estimates based on a central case of 2% and with sensitivity testing at 1.5% and 2.5% values for this analysis.

---

[25] Kelleher, J.P. (2012), Energy Policy and the Social Discount Rate, Ethics, Policy and Environment 15(1)

[26] Stern. N. (2010), The Economics of Climate Change, in: Gardiner, S., Caney, S., Jamieson, D., Shue, H., & Pachauri, R. K. (eds.), Climate Ethics: Essential Readings, (Oxford: Oxford University Press)

[27] William D. Nordhaus PNAS February 14, 2017 114 (7) 1518-1523; first published January 31, 2017; https://doi.org/10.1073/pnas.1609244114 accessed 21 February 2021

[28] Howard, P. and Sylvan, D (2015), Expert Consensus on the economics of climate change, Institute for Policy Integrity, New York University School of Law

[29] Kolstad, C. et al (2014), Social, economic and ethical concepts and methods. IPCC 5th Assessment report, Working Group III, Chapter 3

[30] US e Office of Management and Budget (2003), Regulatory Analysis, Circular A-4 at https://www.transportation.gov/sites/dot.gov/files/docs/OMB%20Circular%20No.%20A-4.pdf accessed 20 February 2021.

5 Emissions intensity of energy

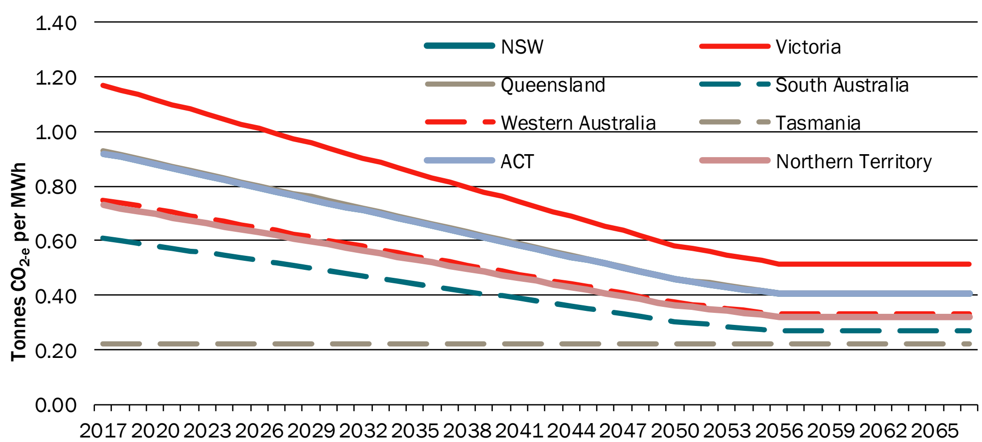
5.1 Electricity Carbon Intensity

Definition: Tonnes of CO2-e emitted per MWh consumed

Table 5.1 Electricity Carbon intensity, NCC 2019 basis and recommendation

Values used for NCC 2019	Recommended values for building level analysis/ RIS
See Figure 5-1	See Table 5.2 and Table 5.3

Figure 5-1 Electricity emissions factors for NCC 2019



Source: CIE, 2019

Emissions intensity factors used as the basis for the 2019 NCC have been impacted by changing state and federal policies and updated assumptions from the AEMO since the analytical work was undertaken. Emissions intensity was assumed to be unchanged after 2056. This is inconsistent with state targets and policies, most notably for Victoria, NSW and the ACT. Updated values are therefore provided.

The Department of Climate Change, Energy, the Environment and Water (DCCEEW) published updated emissions projections in December 2022,[31] which take account of changes in policy since 2021 estimates were issued.

[31] DCCEEW 2022, Australia's emissions projections 2022, Department of Climate Change, Energy, the Environment and Water, Canberra, December. CC BY 4.0.

Table 5.2 Indirect scope 2 and 3 combined emissions factors, baseline scenario, tonnes CO_2-e per MWh

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
NSW/ACT	0.78	0.75	0.64	0.53	0.42	0.36	0.25	0.22	0.13	0.12	0.11	0.13	0.02	0.02
QLD	0.88	0.81	0.77	0.61	0.58	0.54	0.54	0.50	0.46	0.42	0.36	0.29	0.26	0.24
SA	0.33	0.31	0.26	0.23	0.15	0.16	0.11	0.08	0.02	0.02	0.02	0.02	0.10	0.11
VIC	0.92	0.82	0.78	0.72	0.72	0.67	0.59	0.44	0.40	0.38	0.35	0.37	0.41	0.39
TAS	0.18	0.03	0.06	0.02	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02
WA (SWIS)	0.55	0.52	0.50	0.44	0.41	0.38	0.34	0.31	0.26	0.25	0.24	0.24	0.23	0.22
NT	0.61	0.57	0.53	0.50	0.48	0.47	0.45	0.42	0.38	0.38	0.36	0.35	0.32	0.23
Australia - all grid connected	0.77	0.71	0.65	0.56	0.51	0.47	0.41	0.35	0.29	0.27	0.25	0.24	0.21	0.2

Source: DCCEEW, 2022

These projections are consistent with starting point factors for end-users of electricity published in the 2022 *National Greenhouse Accounts Factors*, Australian National Greenhouse Accounts (ANGA), noting the 2018 version was used for the NCC 2019 analysis. Starting point factors for all states and territories are marginally lower than previously used estimates.

DCCEEW notes that: "From 2020 to 2030, most of the decline in emissions is projected to come from the electricity sector due to strong uptake of renewables." The Baseline projection includes a reduction of 93 Mt CO_2-e in the electricity sector between 2020 and 2030, and a further 12 Mt CO_2-e between 2030 and 2035.

Most, but not all, current commitments of states to achieving Net Zero, and investments being undertaken across the electricity grid in renewable energy,[32] are also considered.

[32] For example: Queensland Energy and Jobs Plan, Victoria Offshore Wind Plan, and NSW Electricity Infrastructure Roadmap

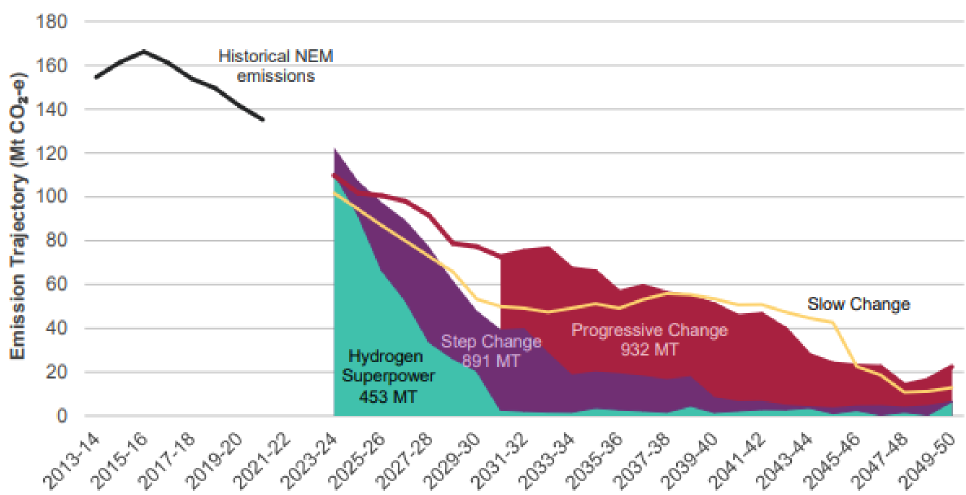
It is possible that the uptake of renewables is either more rapid than forecast by DCCEEW, and/or goes further, as these projections do not include all new policy announcements by different governments. For example, the Federal Government's 82% renewable energy target is not included in this scenario. Additionally, the Victorian Government's renewable energy targets of 65% by 2030 and 95% by 2035, announced in October 2022 as part of its election campaign, have not yet been included.

Further, the AEMO's 2022 ISP, which includes four scenarios for emissions to 2050, notes that:

By 2025, the availability of renewable generation will exceed customer demand at times. This underscores AEMO's priority to develop power systems that are capable of running at up to 100% instantaneous renewable penetration by 2025 to deliver reliable and affordable energy to consumers. The share of potential resource that is actually dispatched depends on a range of market factors.[33]

AEMO's Step Change scenario sees a further drop in systems emissions from both 2030-31 and 2040-41, when compared with the Progressive Change or Slow Change scenarios.

Figure 5-2 NEM Carbon budgets and emissions trajectories



Source: AEMO, 2022

The above trends have been taken into account in recommended projections beyond 2035. These are forecast to continue to decline by 10% per annum at a national average level (consistent with the average 10% rate of decline projected to 2035) to levels broadly consistent with Net Zero. There are variations in performance by state and territory, dependent on current renewable penetration and ambition, as shown in Table 5.3 below.

[33] AEMO ISP 2022 https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en

Table 5.3 Indirect scope 2 and 3 combined emissions factors, projected, tonnes CO_2-e per MWh

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050+
NSW/ACT	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
QLD	0.22	0.20	0.19	0.17	0.16	0.15	0.13	0.12	0.11	0.10	0.10	0.09	0.08	0.07	0.07
SA	0.10	0.09	0.09	0.08	0.07	0.07	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.03	0.03
VIC	0.35	0.32	0.29	0.27	0.24	0.22	0.20	0.18	0.17	0.15	0.14	0.13	0.11	0.10	0.09
TAS	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
WA (SWIS)	0.20	0.19	0.17	0.16	0.14	0.13	0.12	0.11	0.10	0.10	0.09	0.08	0.07	0.07	0.06
NT	0.21	0.19	0.18	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.08	0.07	0.07
Australia -all grid connected	0.18	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.06	0.05	0.05	0.04

Source: Rovingstone Projections

Given the ambition for Australia is to achieve Net Zero emissions by 2050, a sensitivity test with a zero value from 2050 could be undertaken, but it is anticipated that any impact on the BCA would be negligible, and this is not therefore considered useful.

5.2 Gas Carbon Intensity

Definition: Kg of CO2-e emitted per GJ consumed

Table 5.4 Gas Carbon intensity, NCC 2019 basis and recommendation

Values used for NCC 2019	Recommended values for building level analysis/ RIS
See Table 5.5	See Table 5.6

As with electricity emissions intensity, DCCEEW emissions factors published in the ANGA for (pipeline) gas are used for this analysis. Only modest changes have been made since the previous analysis. These factors are expected to remain constant over the forecast period. It is possible that some form of Carbon Capture and Storage (CCS) could become technically and financially feasible in the future, thereby lowering emissions intensity. However, given highly limited progress to date as well as storage constraints, no sensitivity testing is recommended at this point in time.

Table 5.5 Natural Gas Emissions Factors NCC2019 (Kg CO_2-e per GJ)

	NSW	Vic	Qld	SA	WA	Tas	ACT	NT	Aust
Scope 1 emissions	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	n/a
Scope 3 emissions	12.8	3.9	8.7	10.4	4.0	3.9	12.8	4.0c	n/a
Total	**64.2**	**55.3**	**60.1**	**61.8**	**55.4**	**55.3**	**64.2**	**55.4**	**n/a**

Source: CIE, 2018

Table 5.6 Natural Gas Emissions Factors – recommended values (Kg CO_2-e per GJ)

	NSW	Vic	Qld	SA	WA	Tas	ACT	NT	Aust[34]
Scope 1 emissions	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5
Scope 3 emissions	12.8	4.0	8.8	10.7	4.1	4.0	12.8	4.1	6.2
Total	**64.2**	**55.3**	**60.1**	**61.8**	**55.4**	**55.3**	**64.2**	**55.4**	**57.7**

Source: DCCEEW (2022)

As per the previous analysis, Scope 3 emissions are based on metro areas. Emissions for Tasmania and the NT are not provided in the ANGA, and so factors for Victoria and WA have been applied.

[34] Nation al average is weighted using states' percentage of gas consumption (AEMO, 2019)

6 Electricity Cost methodology

NCC 2019 and work by Delta Q in 2022 have shed light on the challenges associated with determining appropriate methods and values for determining electricity costs in the CBA. This section is therefore a summary of those issues and Delta Q's findings, and recommendations based on these.

Energy cost savings are the major component of the benefits derived from energy efficiency measures. Reduced costs result from lower consumption as well as the potential for reduced network augmentation requirements (as both energy demand and consumption are lower). Unfortunately, the complexity in electricity tariff determination makes it difficult to separate out these effects.

As noted in the 2018 RIS undertaken by the CIE for NCC 2019,[35] there are two main forms of energy benefits: approaches to valuing energy savings benefits:

1. Private benefit savings: these can be measured through (1) a market pricing approach – this assumes that market prices reflect all retailers' costs to supply energy, including any changes to network demand costs, or (2) a capacity and energy approach, which separates capex and opex for power plants on one side (typically represented by the Long-Run Marginal Cost) and other supply costs on the other.
2. Whole of society benefits (externalities), measured through avoided network costs due to lower peak demand and consumption.

6.1 Private benefits

As noted in the 2019 RIS, a number of different approaches to estimating private benefits have been used in a range of energy efficiency analyses across and within Australian jurisdictions, but each has its own drawbacks and is subject to considerable uncertainty.

The CIE used the retail price approach for the 2018 RIS, based on AEMO's 2016 National Electricity Forecasting Report provided by Energy Action (EA). Prices are held constant beyond 2030, the end of the forecast period at that time. EA developed a single national average price, while CIE used individual state and territory values, which is more appropriate, given significant differentials in both regional climate and pricing.

Some economists[36] have argued that any benefit in the form of lower retail expenditure by beneficiaries of energy efficiency upgrades will be transferred as costs to other system users. That is, that all costs are fixed and cannot be commuted. While this may be true for some elements of pricing (e.g., smart metering), others argue that an efficient provider should be able to lower costs for a number of operational charges, such as call centres. While there is currently little research to

[35] CIE, 2018, Decision Regulation Impact Statement Energy Efficiency of Commercial Buildings

[36] See, for example, ACIL Allen analysis for 2019 NCC Residential RIS

understand the degree to which this happens, it is not reasonable to suggest that there is no net benefit from reduced energy demand.[37]

An important element of any CBA must be pragmatism. To the extent that market pricing reflects the savings to users, and comprises some element of network costs, and that this method is widely used in CBAs at present, makes this a reasonable approach for determining private savings due to energy efficiency improvements. It is important not to let the perfect be the enemy of the good. It is therefore recommended that this practice continue for estimating private benefits until further research is available to provide greater clarity on pricing components. The network component of pricing is discussed below, and values provided in Table 6.1

It is also noted that there has been a significant amount of volatility and elevation of retail electricity prices over 2022 and 2023 due to the Russian invasion of Ukraine. This makes forecasting over the short term more difficult. However, medium to long-term benefits should look through this volatility and incorporate assumptions of lower average energy prices that can be expected due to greater lower-cost renewable penetration of the grid over time.

6.2 Societal benefits

Wider societal benefits (externalities) are also gained by deferred capital investment in generation, transmission and distribution networks, as a result of lower peak demand and consumption.

Since the 2018 RIS and NCC 2019, and to better understand price-setting practices and the degree to which network costs can be separated out, the (then) Department of Industry, Science-and Resources (DISR) commissioned Delta Q to "*examine the extent to which the diverse structures of electricity network tariffs allow building owners and users to capture the benefits of [] Code reforms*."[38]

Delta Q confirmed that "The extent to which costs associated with network infrastructure can be avoided is not straightforward to understand" and called for further work to be undertaken that might allow greater consistency and transparency in the treatment of network costs in future CBAs.

Further, the CIE notes that "*there is limited information available on peak load profiles for commercial buildings and these may vary significantly across different buildings and Climate Zones*"[39], making it difficult to determine network capacity impacts, even given greater transparency in cost determination.

For network savings, there is a greater degree of complexity and opaqueness in price setting and, specifically, the percentage of costs allocated to network augmentation.

---

[37] SPR, 2021, Review of the Consultation Regulation Impact Statement, NCC 2022, Energy Efficiency of Residential Buildings (commissioned by ASBEC)
[38] Delta Q, 2022, Electricity Network Tariff Review
[39] CIE, 2018, Decision Regulation Impact Statement Energy Efficiency of Commercial Buildings

Until further research can be undertaken Delta Q's analysis of average network pricing can be used in the analysis for retail and societal benefits, as shown in Table 6.1, which should be used in conjunction with the full report.[40]

Table 6.1 Average 2021-2022 network tariff prices* (NUOS – Network Use of Service)

State	Business Size	Supply Charge	Energy Consumption Charge	Demand Charge	
		($/day)	(c/kWh)	($/kW/month)	($/kVA/month)
NSW	**Business (All)**	7.50	7.25	3.81	7.24
	Business-Small/Medium (<160 MWh pa)	1.73	8.12	3.81	6.68
	Business-Large (160 - 750 MWh pa)	16.64	6.01	-	7.86
	Business-Very Large (>750 MWh pa)	27.43	3.75	-	5.67
VIC	**Business (All)**	5.89	7.78	6.58	10.42
	Business-Small/Medium (<160 MWh pa)	0.77	9.73	6.58	0.00
	Business-Large (160 MWh - 750 MWh pa, or > 120kVA)	4.39	7.13	-	10.18
	Business-Very Large (> 750 MWh pa)	23.55	2.68	-	10.68
SA	**Business (All)**	112.54	7.98	-	7.91
	Business-Small (< 160 MWh pa)	0.56	11.41	-	5.50
	Business-Large (> 160MWh pa)	142.01	6.65	-	8.22
QLD	**Business (All)**	89.15	9.03	22.48	24.71
	Business-Small Business (<100 MWh pa)	1.44	13.91	4.52	2.90
	Business-Large Business (>100 MWh pa)	176.86	3.96	31.94	26.96
TAS	**Business (All)**	1.77	6.35	10.63	8.75
	Business-	1.77	6.35	10.63	8.75
ACT	**Business (All)**	0.54	12.14	-	14.56
	Business-	0.54	12.14	-	14.56
NT	**Business (All)**	24.72	4.03	13.00	-
	Business-Small/ Medium (< 750 MWh pa)	1.49	5.10	16.00	-

[40] Delta Q, 2022, Electricity Network Tariff Review

	Business-Large (>750 MWh pa)	71.20	1.90	10.00	-
WA	**Business (All)**	103.74	10.53	-	10.64
	Business-	48.38	10.53	-	11.72
	Business-V Large Business (> 1 MVA)	546.65	-	-	8.48

*Source: Delta Q *Prices include GST*

Table 6.2 Electricity costs, NCC 2019 basis and recommendation

Values used for NCC 2019	Recommended values for building level analysis/ RIS
Market pricing approach, based on EA modelling	Private benefits - market pricing (retail cost) approach – commissioned forecasts required from energy market specialist Societal benefits – deferred network costs due to lower peak demand – based on Delta Q's average network tariff prices[41]

[41] Delta Q, 2022, Electricity Network Tariff Review, Table 1 Average, minimum, and maximum 2021-2022 network tariff prices (NUOS – Network Use of Service). Prices include GST

7 Gas Cost methodology

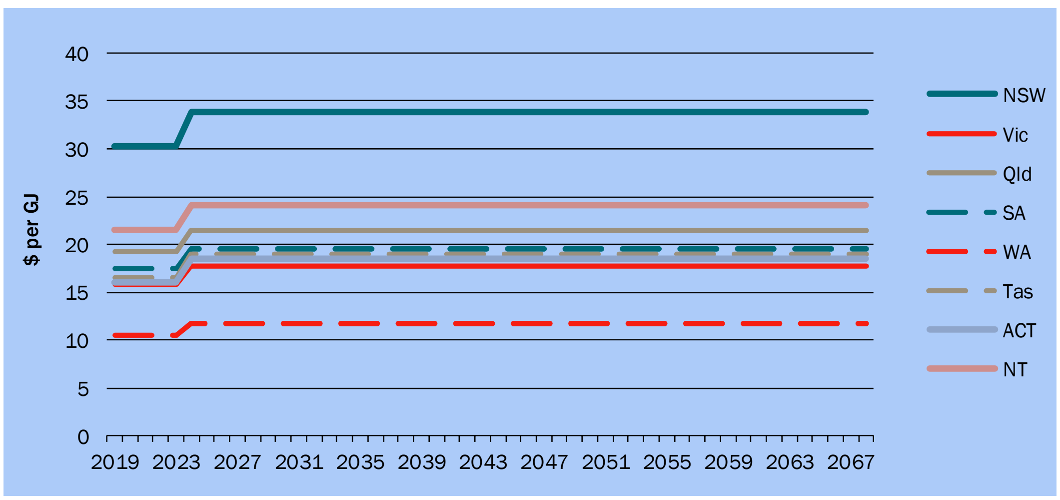
Definition:

Table 7.1 Gas costs, NCC 2019 basis and recommendation

Values used for NCC 2019	Recommended values for building level analysis/ RIS
See Figure 7-1	Use 2021 contract prices adjusted by Lewis Grey Projection factors

In the 2019 NCC analysis, gas prices were projected based on “gas prices achieved in recent tenders conducted by Energy Action (EA) in various locations”, which were then inflated based on AEMO wholesale gas cost projections to 2030 and held steady beyond that period. Certain adjustments to Tasmanian, ACT and NT prices were made by the CIE for the RIS, as these were not provided by EA (See Figure 7-1).

Figure 7-1 Gas price projections (NCC 2019)



Source: CIE, 2018

While the approach taken for NCC 2019 is not unreasonable, it is not possible to replicate this for NCC 2025, given current market volatility (as shown in Figure 7-2 below) – due to the Russian invasion on Ukraine and ensuing boycotts – would likely lead to significant overstating of gas prices. Further, EA notes in its latest commentary on the East Coast Gas market that the wholesale price cap imposed by the Australian Government (at $12/GJ) has “resulted in retailers not being able to secure wholesale gas contracts from producers and forced to withdraw from offering retail contracts to consumers.”[42]

[42] https://energyaction.com.au/energy-market-wrap-1-feb-2023/ accessed 24 February 2024

In any event, the outlook for both wholesale and retail gas prices remains highly uncertain in both the short-term and over the longer-term period of the NCC analysis (2025-2075).

Figure 7-2 East Coast spot gas market prices

Source: Energy Action, 2023

For the purpose of the NCC 2025 analysis, the question is: will “normal” market pricing return once the war is over, and what might the timing of that be?

Longer term considerations (post-2030) involve the pathway of the transition to Net Zero by different countries and the potential for a technological breakthrough in Carbon Capture, Use, and Storage (CCUS).

It is beyond the scope of this work to assess all geopolitical and global gas market trends, and there would be no way to avoid all uncertainties, even if such analysis were done. Instead, a reasonable and defensible approach to projections is taken, which looks through current volatility and assumes a return to more usual market conditions by 2025. Given these inherent uncertainties, sensitivity analysis should be undertaken.

To achieve the projections, the actual average outcomes for 2021 auctions in each market should be taken (to be provided by EA), which can then be adjusted forward to provide hypothetical outcomes for 2021-2023, and an assumed starting point for 2025, through to 2050 using AEMO projected price change factors for the wholesale market, using the Central 2021 case as the base case, with sensitivity using a region-weighted average of the average Compound Annual Growth rates for the Slow Change and Low Gas Price Scenarios. Prices are held steady beyond 2050, (in some instances, AEMO holds prices steady over most of the forecast period). A national-weighted average price should then also be provided for the technical analysis.

8 Annual Inflation Rate

Definition: Rate of price increases, used to determined real price increases in energy, based on the Consumer Price Index (CPI)

Table 8.1 Annual inflation rate, NCC 2019 basis and recommendation

Values used for NCC 2019	Recommended values for building level analysis/ RIS
2.0%	2.5%

Standard economic practice uses a long-term rate of inflation of 2.5%. This is the mid-point of the Reserve Bank of Australia's (RBA) target range. Specifically:

> *Australia's inflation target is to keep annual consumer price inflation between 2 and 3 per cent, on average, over time.*[43]

From the start of formal inflation-targeting by the RBA in 1996 up until the end of 2022, the CPI has averaged exactly 2.5%.[44]

Notwithstanding currently elevated inflation rates, due to the impact of COVID-19 and the Russian invasion of Ukraine, the RBA and central banks around the world are actively seeking to return inflation to target bands. Over the forecast period, it is reasonable to expect that the RBA will be successful at maintaining the CPI within the target range of 2% to 3%, and that the target is unlikely to change.

[43] https://www.rba.gov.au/education/resources/explainers/australias-inflation-target.html

[44] Australian Bureau of Statistics, 6401.0 Consumer Price Index, Australia, Table 2, December 2022

9 Learning Rates

Definition: The learning rate refers to the price reduction in a product that results from economies of scale, and is presented as the per cent change in cost for every doubling of capacity installed. In the case of building energy efficiency products, learning rates may be influenced by production efficiencies, worker productivity (efficiency in installation), and/or design enhancements.

When discussing learning rates relevant to building energy efficiency, it is important to note that individual components will have different learning rates: for more mature products, rate will be approaching, or at, zero. For newer, technologies, they are often seen as being as high as 10% to 20%, as discussed below.

Learning rates are not without critics, not least because it is not always clear at what point a learning rate becomes mature and begins to decline.

Table 9.1 Learning rate, NCC 2025 technical basis and recommendation

Values used for technical modelling in NCC 2025	Recommended sensitivity analysis for consultation discussion
0%	Heat pumps – 10% Solar PV – 20% (10% lower bound option)

It is clear that there is currently insufficient Australian data to provide specific learning rates for all products/design features affected by proposed changes to NCC 2025. There is, however, some evidence available in both Australia and overseas that supports adoption of learning rates for, at a minimum, heat pumps and Solar PV.

Australia is a relatively small market that imports many building products including from large markets such as China. Overseas learning rates are therefore relevant to expected price performance in Australian commercial building components.

Research undertaken by Strategy.Policy.Research (SPR) on behalf of the then Department of the Environment and Energy (now the Department of Climate Change, Energy Efficiency and Water, or DCCEEW)[45] attempts to quantify learning rates for a range of commercial building products. The authors note that:

> *"No single learning rate number can adequately reflect the complex mix of design, specification and elemental cost changes that occur in reality. The range of outcomes*

[45] SPR, 2017, Quantifying Commercial Building Learning Rates in Australia,

varies in sign and magnitude depending upon the particulars of the building form and climate zone modelled."

SPR estimate that the chosen basket of energy-related products (which excluded solar PV) fell by 0.2% per annum over a 12-year period, which they assert improved Benefit Cost Ratios "materially". However, this estimate is not a learning rate per se, as it does not relate to changes in stringency and installed capacity. The SPR report refers to other (international) research that demonstrates learning rates of:

- 4% for insulation and glazing
- 18% for LED lighting in the US residential market, and a forecast 12% rate from 2015 to 2035
- Up to 15% (per annum) for heat pump technology.

Some relatively recent overseas evidence on learning rates includes:

- Air source heat pumps (residential) – 5% to 18%[46]; and, 10%[47]
- Solar PV – 18.6-21.4% depending on type [48]; and 24% (US, based on LCOE at grid scale)[49]
- Mature technologies such as gas and electric heating for residential buildings have an average annual decline in cost of 0.5%[50]

There are likely incremental learning benefits for a large range of energy efficient products used in commercial buildings, however the evidence is not robust at this point. There is, however, sufficient evidence to justify implementing learning rates for heat pumps and solar PV at 10% and 20% respectively. While there are questions about the sustainability of the Solar PV learning rate, increased manufacturing capacity in countries such as India suggest there is reason to believe this rate will be sustained for the period of analysis. However, it may be worth sensitivity testing at 10%.

Given initial analysis suggests BCRs well above 1 are being derived even with a 0% learning rate, it would be reasonable not to undertake sensitivity testing, but to make a qualitative note in the final RIS. Further decisions can be made on the approach following the consultation process and input from stakeholders.

---

46 Currie & Brown, 2019, The costs and benefits of tighter standards for new buildings, Report for the Committee on Climate Change (UK)

[47] Danish Energy Agency, 2023, "Data sheets for Individual Heating Plants" Update version 20-01-2021 accessed at https://ens.dk/en/our-services/projections-and-models/technology-data/technology-data-individual-
://ens.dk/sites/ens.dk/files/Analyser/technology_data_catalogue_for_individual_heating_installations.pdf

[48] Ibid.

[49] Office of energy efficiency and renewable Energy, 2022, Learning a Better Way To Forecast Wind and Solar Energy Costs accessed at https://www.energy.gov/eere/wind/articles/learning-better-way-forecast-wind-and-solar-energy-costs

[50] Danish Energy Agency, 2021, "Technology Catalogue for Individual Heating" accessed at https://ens.dk/en/our-services/projections-and-models/technology-data/technology-data-individual-heating-plants