AEMO Transmission Cost Database, Building Blocks Costs and Risks Factors Update

Final Report

26 April 2023

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Issue and Revision Record

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Glossary of terms

Adjustment factors	Percentages used to increase or decrease the cost components of each building block based on attributes, such as: the jurisdiction where the project will be built, possible constraints to the delivery timetable, etc.
Akaike Information Criterion (AIC).	A statistical measure of the goodness of fit of a regression model that is commonly used to compare models (e.g., A statistical measure of the goodness of fit of a regression model that is commonly used to choose between alternative models (e.g., to determine the optimum number of lags in an ARDL model),
Autoregressive distributed lag (ARDL) model	An ARDL model is a standard least squares regression that includes lags of both the dependent variable and independent variables as regressors.
Basket of indices	The products (goods and services) priced for the purpose of compiling a price index.
Building block	Group of equipment (e.g., transformers), materials (e.g., underground cables) or services (e.g., Gas-insulated high-voltage switchgear - GIS building) that are connected to other building blocks to operate and function as intended.
Building block cost components	The building block costs are divided in the following components: plant, civil and structural works, electrical works, secondary systems, design and survey, testing and commissioning, project management and overheads, easement and property costs, and environmental offset costs.
Escalation factor	Number used to increase or decrease the building block cost components over the time.
HVAC transmission line	Transmission line that operates at high voltage alternating current.
HVAC HTLS transmission line	Transmission line that operates at high voltage alternating current and uses conductors, also known as high-temperature low-sag, able to carry more electric current and at higher temperatures than the traditional conductors.

HVDC transmission line	Transmission line that operates at high voltage direct current transmission line
Known risks	General social and economic condition, such as market activity, project complexity, environmental offset costs, etc.
Parametric formula	Aggregation of different variables to describe one function (e.g., cost).
Risk costs	Known and unknown risk allowances which increase or decrease the project cost
Unknown risks	Also known as contingency. Used to improve cost accuracy of early-stage project cost estimates.
XLPE conductor	Conductor that has an insulation made of cross-linked polyethylene. Used on underground cables, including subsea.

Acknowledgements

Mott MacDonald would like to acknowledge the Australian Energy Market Operator (AEMO) for the opportunity to develop this study and for the full collaboration of its Team dedicated to this project, led by Samantha Christie — Manager Strategic Planning; and Christopher du Plessis — Senior Engineer Strategic Planning.

We acknowledge the Transmission Network Service Providers who shared data from their recent projects with AEMO, which was later anonymised by AEMO before they were made available to Mott MacDonald.

We also acknowledge the contribution provided by stakeholders during the two webinars hosted by AEMO and delivered by AEMO and Mott MacDonald.

Finally, we would like to acknowledge the Mott MacDonald's Team that worked on this project: Dr Stephen Hinchliffe — Energy Advisory Leader Asia Pacific New Zealand and Australia; Marco Aurelio Lenzi Castro — Technical Director; Patrick Ross-Taylor — Senior Infrastructure Advisor; and Richard Hickling — Principal Energy Economist.

Executive summary

Mott MacDonald has updated and expanded the Australian Energy Market Operator's (AEMO's) Transmission Cost Database, expressed using building block costs, adjustment factors, indirect costs, and risk costs. The updated Transmission Cost Database will be used by AEMO to develop transmission expansion option cost estimates for its 2024 Integrated System Plan (ISP).

To update these costs, we developed a method based on publicly available economic indices to build nine parametric formulas, addressing the influence of each index on the price of each equipment type, materials and services associated with transmission projects (e.g., overhead lines, sub-stations, and underground cables and associated equipment). The parametric formulas describe the composition of each basket of indices.

We used anonymised data provided by AEMO from recent projects developed by transmission network service providers (TNSPs) as a benchmark to access and validate our results.

We have added 280 new building blocks to the 2020 Transmission Cost Database, including overhead lines, underground cables, transformers, reactive plants, and HVDC converters. For overhead lines, we calculated the ratings for different ambient temperatures.

We reviewed and updated the ratings for all transmission lines from the original building blocks and the differences between the old and new ratings are presented in this report.

We increased the number of attributes used to adjust the easement and property costs to address regional differences and reviewed the list and adjustment factors applied as known and unknown risks.

We took part in two webinars with AEMO attended by key stakeholders, such as TNSPs and consumer advocates (160 attendees). The first webinar was held on 21 October 2022, and the second was held on 25 November 2022.

In addition, a workshop session with representatives from the ISP Consumers Panel, AEMO and Mott MacDonald was held on 5 December 2022. We considered all feedback received from stakeholders in writing this report.

Overall, our method has the following advantages to that employed in the method used to develop the 2020 Transmission Cost Database:

- It considers the factors that most influence the cost of equipment, materials, and services
- The costs can be updated at any time, enabling a reliable estimate of market prices at a given point in time
- It balances the weight of different indices inside each basket
- It uses publicly available economic data for transparency.

We have developed baskets of weighted commodities prices and labour indices to enable the forecasting of future building block costs. This report provides a procedure to estimate the building block cost components from 2023 to 2040 and to bring them to the present value, that is in 30th June 2022 Australian dollar terms.

1 Introduction

This report presents the method used to update the existing AEMO Transmission Cost Database developed in an Excel® workbook with tabs expressing the building block costs, adjustment factors, indirect costs, and risk costs. It also provides a list of new building blocks added to the Transmission Cost Database.

In both cases, we used anonymised data provided by AEMO from recent projects developed by transmission network service providers (TNSPs) to benchmark, access and validate our developed building block costs.

We expanded the number of building blocks over the number contained in the 2020 Transmission Cost Database, inserted new attributes to address regional differences on easement and property costs and updated the known and unknown risks cost multiplier factors. A full review of all transmission lines ratings is also presented in this report.

We also set out a method for forecasting future costs based on commodity prices and labour indices.

This report should be read in conjunction with the updated version of AEMO's Transmission Cost Database Excel Workbook where we set out the cost of individual equipment, material, and service items for transmission network infrastructure[1].

1.1 Scope

Our scope of work included the following:

- Updating the existing building block costs from 31 December 2020 to 30 June 2022 for the individual subcomponents that were combined to create the building blocks in the 2020 Transmission Cost Database project using updated transmission network project cost information
- Reviewing and updating existing adjustment factors, indirect costs, contingency, and risk costs
- Expanding the current building block descriptions to specify what is and is not included within each building block's costs using appropriate indices to maintain the currency of the information
- Developing new building blocks by using Mott MacDonald's data (domestic and international), and information from TNSPs and economic regulators in Australia and other jurisdictions
- Applying appropriate escalation indices to available cost data to express the cost on 30 June 2022 Australian dollar terms
- Forecasting future costs based on commodity prices and labour indices to address supply constraints and demand pressures
- Reviewing cost estimates and strategic commentary on uplifting factors that have been applied to the 2020 Transmission Cost Database
- Taking part in and presenting at two public webinars to share the key updates to the cost and risk data with stakeholders, including comparison with previous building block estimates, collecting feedback, and answering questions.

[1] Mott MacDonald Transmission Cost Database update_20230326

1.2 Limitations

This report has been prepared by Mott MacDonald for AEMO and may only be used and relied on by AEMO for the purpose agreed between AEMO and Mott MacDonald.

Mott MacDonald otherwise disclaims responsibility to any person other than AEMO arising in connection with this report, including with respect to any reliance placed on the contents of this report and its accompanying spreadsheet. Mott MacDonald also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by Mott MacDonald in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions existing and information reviewed at the date of preparation of the report. Mott MacDonald has no responsibility or obligation to update this report to account for events or changes occurring subsequent the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by Mott MacDonald based on third party data and as described in this report. Mott MacDonald disclaims liability arising from any of the assumptions derived from that third party data being incorrect.

1.3 Assumptions

Assumptions made by Mott MacDonald in undertaking this work are detailed throughout the report. However, key assumptions that underpin this report are listed below:

- The method developed to update the 2020 Transmission Cost Database considers the factors that most influence the costs of equipment, materials, and services. This includes the influence on costs of the material planned expansion of the transmission system in the National Electricity Market (NEM)
- Each basket of economic indices comprises an approximation of the indices of commodities used in the market for equipment, materials, and services and which are publicly available or available via subscription
- Use of historic price trends for transmission infrastructure, say over the last two decades is not appropriate to transmission infrastructure cost increases out to 2040 given that the projected scale of projected transmission infrastructure build has not been observed since the 1980s
- Futures market commodity prices and projections of future labour costs are considered by us as suitable proxies for long term price forecasts
- To develop our forecasting basket of weighted indices, we have made informed assumptions as to the impact of supply chain challenges, global economic trends and forecasts, Australia's economic activity and projected transmission project build-out.

2 Updating the existing transmission cost database

Mott MacDonald developed a method to update the costs for equipment, materials, and services for each building block from the original estimates used for the 2020 Transmission Cost Database (31st December 2020) to the new reference day (30th June 2022 Australian dollar terms). This method utilises data from the 2020 Transmission Cost Database; international benchmarks; anonymised data from projects provided by AEMO and our in-house database of recent Australian and international transmission infrastructure costs; publicly available economic and transmission component cost data; and the experience of our consultants. This is illustrated in Figure 2.1.

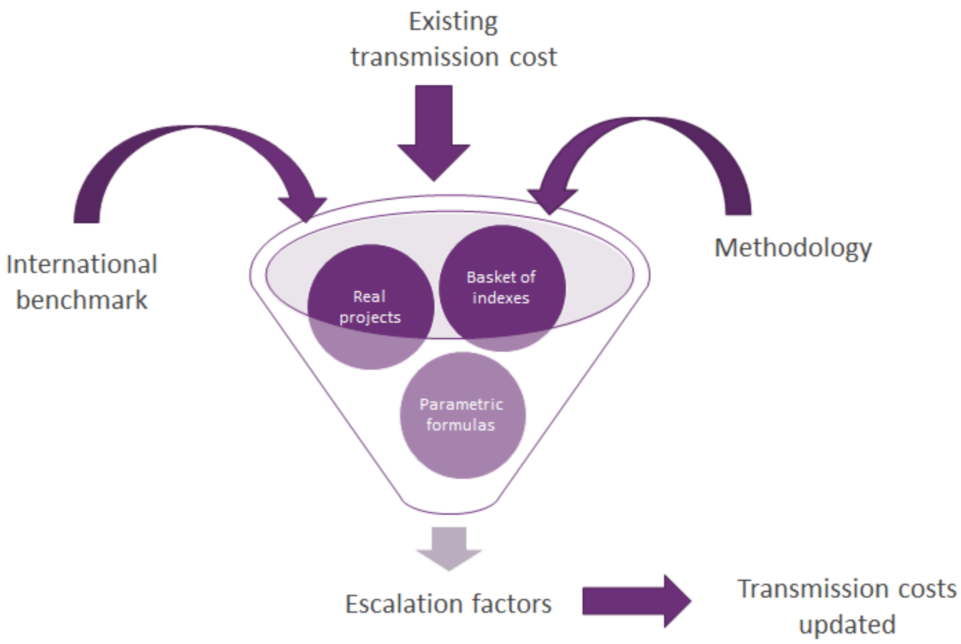

Figure 2.1: Escalation factors

2.1 General approach

We identified the economic indices that most influence the costs of equipment, materials, and services needed to implement electricity transmission facilities. As an example, items such as steel, copper and oil are known to contribute to the formation of the price of a transformer. Thus, to estimate the cost of this equipment over time, we have used a parametric formula accommodating the influence of these elements in its composition.

Based on this information, we selected twelve relevant and publicly available economic indices that we applied to the 2020 Transmission Cost Database to escalate the costs in the 2020 Transmission Cost Database to 30th June 2022 Australian dollar terms. These indices include data and information from the Australian Bureau of Statistics (ABS[2]), the Reserve Bank of Australia and Rural Bank, as presented in Table 2.1.

Table 2.1: Selected economic indices

Index	Description	Application
Consumer Price Index - CPI	Measures household inflation and includes statistics about price change for categories of household expenditure.	Equipment and Materials
Iron smelting and steel manufacturing	Bar, iron, or steel manufacturing. Steel alloy manufacturing. Structural steel shape manufacturing.	Equipment and Materials
Basic non-ferrous metal manufacturing	Alumina production, aluminium smelting, and copper.	Equipment and Materials
Other electrical equipment manufacturing	Batteries, electric motors, generators, electricity transmission or distribution equipment, switchgear, switchboards, transformers or other electrical machinery, equipment, supplies or components not elsewhere classified.	Equipment
Electric cable and wire manufacturing	Co-axial cable, fuse wire, non-ferrous cable, optical fibre cable, telecommunications cable, and wire or electric cable.	Materials
Petroleum refining and petroleum fuel manufacturing	Refining heavy and light component crude oil, manufacturing and/or blending materials into petroleum fuels, and manufacturing fuels from the liquefication of petroleum gases.	Equipment
Other heavy and civil engineering construction Australia	Construction of transmission and distribution electricity lines, electrical machinery, heavy, installation (on-site assembly) and electricity power plant (except buildings).	Services
Engineering design and engineering consulting services	Specialised engineering services: electrical, mechanical, civil, construction, geotechnical, and others.	Services
The Australian dollar trade-weighted index (TWI)	The price of the Australian dollar in terms of a group (or ‘basket’) of foreign currencies based on their share of trade with Australia. TWI provides a broader measure of whether the Australian dollar is appreciating or depreciating against the currencies of its trading partners.	Equipment and Materials
Australian farmland values	The Farmland Values Reports track the Australian farmland sales over the past 24 years for each state.	Easement/property costs
Legal services	Providing legal representation and advice and the preparation of legal documents. Also included are units mainly engaged in establishing the legal ownership of a property such as title-searching services.	Services
Real estate services	Valuing, purchasing, selling, managing, or renting real estate for others.	Services

Table 2.2 presents the economic indices that we used to update the cost of equipment, materials, and services inside each basket of indices[3].

Table 2.2: Components of each basket of indices

Baskets of Indices	Equipment/Materials/Services	Economic Indices
Basket 1	• Switch bay	• Consumer Price Index

[2] All ABS data was retrieved from the Australian Bureau of Statistics website, https://www.abs.gov.au/statistics.

[3] A commonly used term for the products (goods and services) priced for the purpose of compiling a price index.

Baskets of Indices	Equipment/Materials/Services	Economic Indices
	• Property site work and building • Secondary system building	• Iron smelting and steel manufacturing
Basket 2	• Underground cables (HVAC[4]/HVDC[5])	• Consumer Price Index • Iron smelting and steel manufacturing • Electric cable and wire manufacturing • The Australian dollar trade-weighted index
Basket 3	• Secondary system	• Consumer Price Index • Other electrical equipment manufacturing • The Australian dollar trade-weighted index
Basket 4	• Civil and structural works • Electrical works • Testing & Commissioning	• Other heavy and civil engineering construction
Basket 5	• CB (circuit breaker) • CVT (current-voltage transformer) • SA (surge arrestor) • CT (current transformer) • ES (earth switch) • ROI (outdoor insulator) • HVDC converters • Modular power flow controller	• Consumer Price Index • Iron smelting and steel manufacturing • Basic non-ferrous metal manufacturing • Other electrical equipment manufacturing • The Australian dollar trade-weighted index
Basket 6	• Phase shifting transformer • SVC (Static Var Compensators) • Reactor • Capacitor • Statcom (Static synchronous compensator) • Synchronous Condenser • Transformer	• Consumer Price Index • Iron smelting and steel manufacturing • Basic non-ferrous metal manufacturing • Other electrical equipment manufacturing • Petroleum refining and petroleum fuel manufacturing • The Australian dollar trade-weighted index
Basket 7	• Design & Survey • Contractor Project Management & Overheads	• Engineering design and engineering consulting services
Basket 8	• Overhead line (HVAC and HVDC)	• Consumer Price Index • Iron smelting and steel manufacturing • Electric cable and wire manufacturing • The Australian dollar trade-weighted index
Basket 9	• Easement and property costs	• Land value per State • Legal services • Real estate services

[4] High Voltage Alternating Current
[5] High Voltage Direct Current

To assign appropriate weights for each economic index inside each escalation basket, as described in Table 2.2, we considered:

- the Australian economic indices that explain the cost variation of equipment, materials, and services used in transmission systems.
- international benchmarking methods applied to update transmission cost databases
- the experience of our consultants working on transmission projects in Australia and overseas
- anonymised data provided by AEMO from recent projects developed by TNSPs
- anonymised data from transmission projects that Mott MacDonald has previously developed.

Table 2.3 shows the weight of each economic index within each basket.

Table 2.3: Weights for each economic index

Indices/Baskets		B1	B2	B3	B4	B5	B6	B7	B8	B9
W1	CPI	20%	10%	20%		10%	10%		10%	
W2	Iron smelting and steel manufacturing	80%	10%			15%	25%		40%	
W3	Basic non-ferrous metal manufacturing					5%	10%			
W4	Other electrical equipment manufacturing			40%		30%	40%			
W5	Electric cable and wire manufacturing		70%						40%	
W6	Petroleum refining and petroleum fuel manufacturing						5%			
W7	Other heavy and civil engineering construction				100%					
W8	Engineering design and engineering consulting services							100%		
W9	The Australian dollar trade-weighted index (TWI)		10%	40%		40%	10%		10%	
W10	Real estate services									5%
W11	Legal services									15%
W12	Land value per State									80%

Different data sources publish updates at different times. The Australian Bureau of Statistics publishes quarterly updates[6] for each index listed in**Table 2.1**, while the Reserve Bank of Australia publishes daily updates[7] and the Rural Bank issues reports annually[8]**.** Table 2.4 shows the indices for 31 December 2020[9] and for 30 June 22, and the variation between them, calculated by formula 1:

$$Variation = \left(\frac{Index_{mi}}{Index_{mo}}\right) \qquad (1)$$

[6] Available at: https://www.abs.gov.au/

[7] For the Australian dollar trade-weighted index, available at: https://www.rba.gov.au/statistics/historical-data.html#exchange-rates

[8] Available at: https://www.ruralbank.com.au/

[9] The current Transmission Cost Database was updated in September 2021 with the costs referred to 31 December 2020.

Where:

- $Index_{mi}$ is the selected index value in the target date, to which the date that the cost will be updated
- $Index_{mo}$ is the selected index value in the initial date, which is the date that the current costs were last updated.

Table 2.4: Indices variation

Indices		Initial date	Target date	Variation
		Dec-20	Jun-22	Dec-20 to Jun-22
V1	CPI	117.20	126.10	1.0759
V2	Iron smelting and steel manufacturing	111.00	148.10	1.3342
V3	Basic non-ferrous metal manufacturing	143.50	178.20	1.2418
V4	Other electrical equipment manufacturing	109.60	119.90	1.0940
V5	Electric cable and wire manufacturing	100.10	135.50	1.3536
V6	Petroleum refining and petroleum fuel manufacturing	62.10	170.40	2.7440
V7	Other heavy and civil engineering construction Australia	117.80	131.20	1.1138
V8	Engineering design and engineering consulting services	111.90	122.90	1.0983
V9	The Australian dollar trade-weighted index (TWI)	63.40	61.80	0.9748
V10	Real estate services	127.10	149.40	1.1755
V11	Legal services	128.10	132.40	1.0336
V12	Land value NSW ($/ha)	5,855.00	6,766.00	1.1556
	Land value VIC ($/ha)	8,114.00	11,330.00	
	Land value QLD ($/ha)	5,200.00	7,223.00	
	Land value SA ($/ha)	5,482.00	6,307.00	
	Land value TAS ($/ha)	13,691.00	15,797.00	

We calculated the escalation factor (EF) for each basket by applying the appropriate parametric formula, as presented below, which uses the weights of each index (Table 2.3), and the variation for each index between the initial date and the target date (Table 2.4).

$$EF\ (Basket\ 1) = W1_{B1} \times V1 + W2_{B1} \times V2 \quad (2)$$

$$EF\ (Basket\ 2) = W1_{B2} \times V1 + W2_{B2} \times V2 + W5_{B2} \times V5 + W9_{B2} \times V9 \quad (3)$$

$$EF\ (Basket\ 3) = W1_{B3} \times V1 + W4_{B3} \times V4 + W9_{B3} \times V9 \quad (4)$$

$$EF\ (Basket\ 4) = W7_{B4} \times V7 \quad (5)$$

$$EF\ (Basket\ 5) = W1_{B5} \times V1 + W2_{B5} \times V2 + W3_{B5} \times V3 + W4_{B5} \times V4 + W9_{B5} \times V9 \quad (6)$$

$$EF\ (Basket\ 6) = W1_{B6} \times V1 + W2_{B6} \times V2 + W3_{B6} \times V3 + W4_{B6} \times V4 + W6_{B6} \times V6 + W9_{B6} \times V9 \quad (7)$$

$$EF\ (Basket\ 7) = W8_{B7} \times V8 \quad (8)$$

$$EF\ (Basket\ 8) = W1_{B8} \times V1 + W2_{B8} \times V2 + W5_{B8} \times V5 + W9_{B8} \times V9 \quad (9)$$

$$EF\ (Basket\ 9) = W10_{B9} \times V10 + W11_{B9} \times V11 + W12_{B9} \times V12 \quad (10)$$

Table 2.5 presents the numbers used in the formulas 2 to 10 to calculate the escalation factors for each basket of indices.

Table 2.5: Parametric formulas values

$W1_{B1} = 20\%$	$W1_{B5} = 10\%$	$W9_{B6} = 10\%$	$V2 = 1.3342$	$V12 = 1.1556$
$W2_{B1} = 80\%$	$W2_{B5} = 15\%$	$W8_{B7} = 100\%$	$V3 = 1.2418$	
$W1_{B2} = 10\%$	$W3_{B5} = 5\%$	$W1_{B8} = 10\%$	$V4 = 1.0940$	
$W2_{B2} = 10\%$	$W4_{B5} = 30\%$	$W2_{B8} = 40\%$	$V5 = 1.3536$	
$W5_{B2} = 70\%$	$W9_{B5} = 40\%$	$W5_{B8} = 40\%$	$V6 = 2.7440$	
$W9_{B2} = 10\%$	$W1_{B6} = 10\%$	$W9_{B8} = 10\%$	$V7 = 1.1138$	
$W1_{B3} = 20\%$	$W2_{B6} = 25\%$	$W10_{B9} = 5\%$	$V8 = 1.0983$	
$W4_{B3} = 40\%$	$W3_{B6} = 10\%$	$W11_{B9} = 15\%$	$V9 = 0.9748$	
$W9_{B3} = 40\%$	$W4_{B6} = 40\%$	$W12_{B9} = 80\%$	$V10 = 1.1755$	
$W7_{B4} = 100\%$	$W6_{B6} = 5\%$	$V1 = 1.0759$	$V11 = 1.0336$	

We applied the escalation factors calculated by formulas 2 to 10 to update the costs of equipment, materials and services included in each building block, as presented in Table 2.6.

Table 2.6: Escalation factors per basket of indices

	Escalation factors
Basked of indices	**Dec/20 to Jun/22**
Basket 1	1.2826
Basket 2	1.2860
Basket 3	1.0427
Basket 4	1.1138
Basket 5	1.0879
Basket 6	1.2376
Basket 7	1.0983
Basket 8	1.2802
Basket 9	1.1383

Table 2.7 presents the escalation factors for each building block and cost components.

Table 2.7: Escalation factors per cost components

Cost Components	Building Blocks				
	Switch bay Property site work and building Secondary system building	Underground cables	CB (circuit breaker) CVT (current-voltage transformer) SA (surge arrestor) CT (current transformer) ES (earth switch) ROI (outdoor insulator) HVDC converters Modular power flow controller	Phase shifting transformer SVC (Static Var Compensators) Reactor Capacitor Statcom (Static synchronous compensator) Synchronous condenser Transformer	Overhead lines
Plant	1.2826	1.2860	1.0879	1.2376	1.2802
Civil	1.1138	1.1138	1.1138	1.1138	1.1138
Electrical	1.1138	1.1138	1.1138	1.1138	1.1138
Secondary systems	1.0427	1.0427	1.0427	1.0427	1.0427
Design	1.0983	1.0983	1.0983	1.0983	1.0983
Testing	1.1138	1.1138	1.1138	1.1138	1.1138
Project management	1.0983	1.0983	1.0983	1.0983	1.0983
Easement	1.1383	1.1383	1.1383	1.1383	1.1383

The cost components of the building blocks are as follows:

- Plant (supply of primary material assets such as steel towers, equipment, conductors, switchgear, cables etc.)
- Civil and structural works (supply of civil infrastructure assets and installation works such as earthworks, buildings, foundation, busbar, gantry, clearing, access tracks etc.)
- Electrical works (supply of electrical installation works such as stringing, fitting, termination, jointing, lighting etc.)
- Secondary systems (supply of secondary system material assets such as relays, control panels, protection panels, SCADA, station batteries etc.)
- Design and survey (supply of engineering and environmental design and survey works towards the front end of the project life cycle phase)
- Testing and commissioning (supply of electrical, civil, and structural assurance works towards the back end of the project life cycle prior to operational approval of the constructed assets)
- Contractor project management and overheads (supply of the site supervision, resource mobilisation, site set-up, project management and related expenses by the hired contractors)
- Easement and property acquisition costs (procurement of easement right of way and land acquisition by the project proponents)
- Environmental offset costs (costs to compensate for unavoidable environmental and biodiversity impacts due to the project works).

We updated all building blocks cost components using the escalation factors calculated as above, except for Environment offset costs, as presented in item 2.3.

We used the anonymised data provided by AEMO from TNSP projects and information from our in-house database to benchmark and validate the costs estimated by our method, but we did not directly incorporate any cost component derived specifically from TNSPs projects.

2.2 Easement and Property costs

The cost of land is the main part of the easement and property cost building block. Based on data from TNSPs recent projects, and our experience in Australian transmission projects, we understand it represents about 80% of the compensation values paid to landholders.

According to the Rural Bank report,[10] the Australian farmland median price per hectare has increased 20% in 2021 when compared to 2020, reaching up to $7,087 per hectare. Figure 2.2 shows the historical rural median prices in Australia based on more than 270,000 transactions recorded by the Rural Bank since 1995.

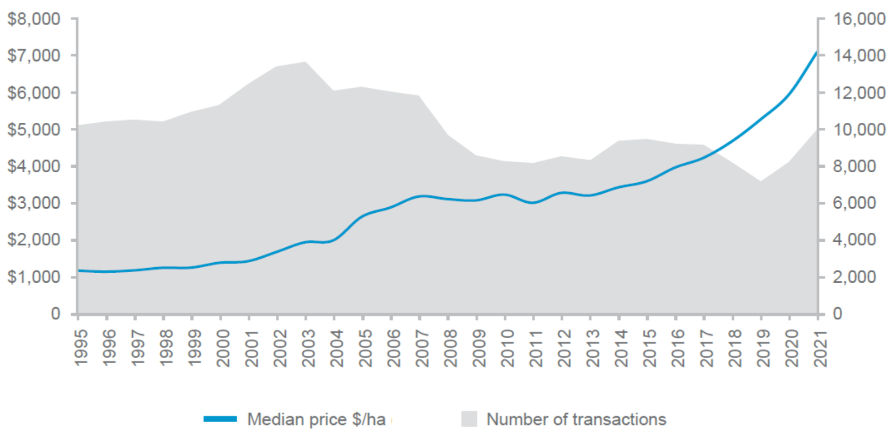

Figure 2.2: Evolution of the farmland median prices in Australia[11]

In developing this building block, we recognised that the variation of the median price in each state must be considered when assessing the easement and property costs, as presented in Figure 2.3.

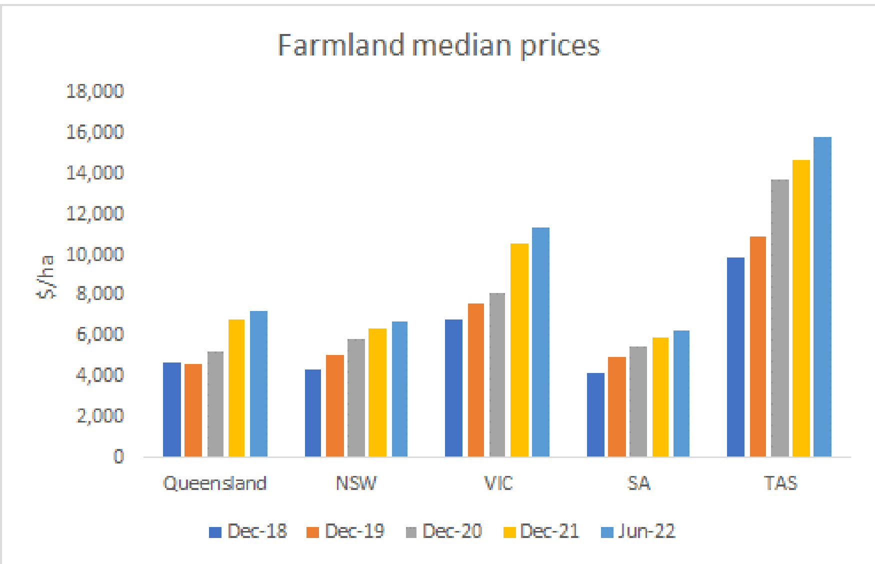

Figure 2.3: Farmland median prices per state

[10] Australian Farmland Values 2022

[11] Source: Australian Farmland Values 2022

Each state's region has its own characteristics that impacts the prices of rural land. Figures 2.3 to 2.8 compare the median prices of each region with their state's median prices (Queensland, New South Wales, Victoria, South Australia and Tasmania).

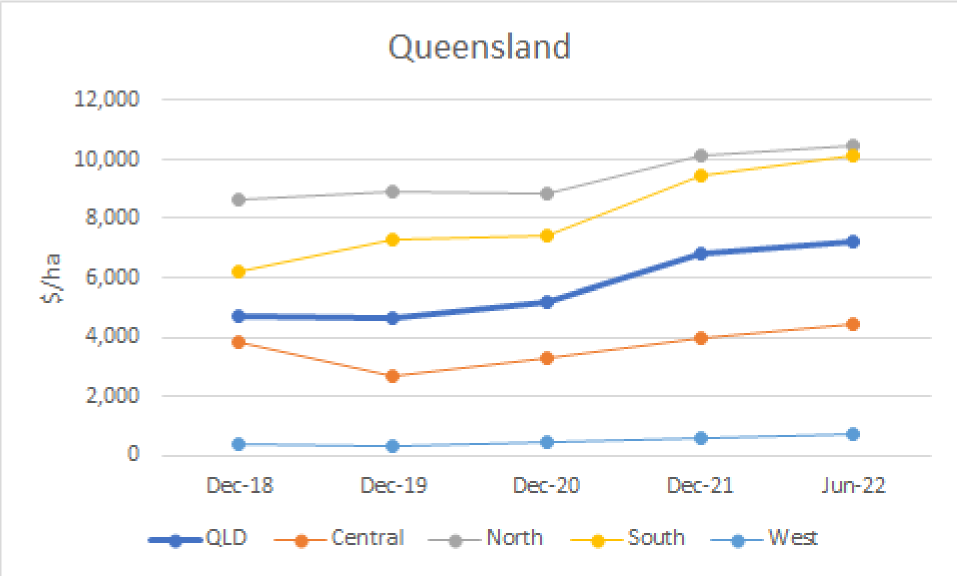

Figure 2.4: Farmland median prices in Queensland regions

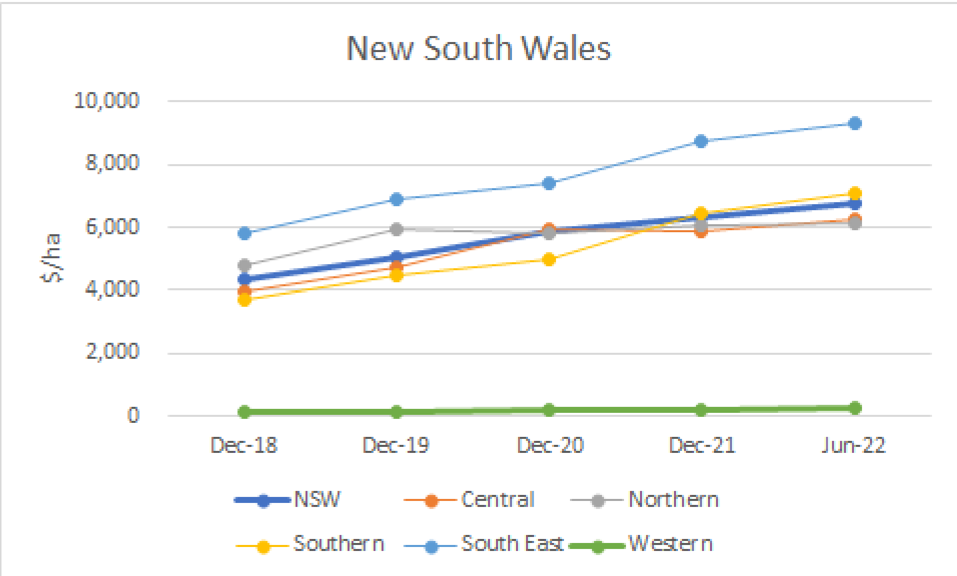

Figure 2.5: Farmland median prices in New South Wales regions

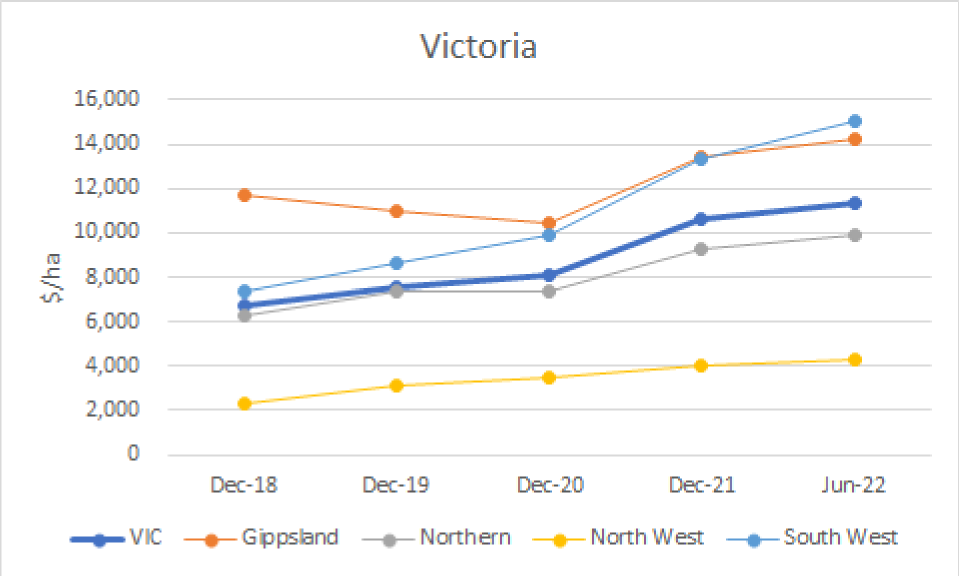

Figure 2.6: Farmland median prices in Victoria regions

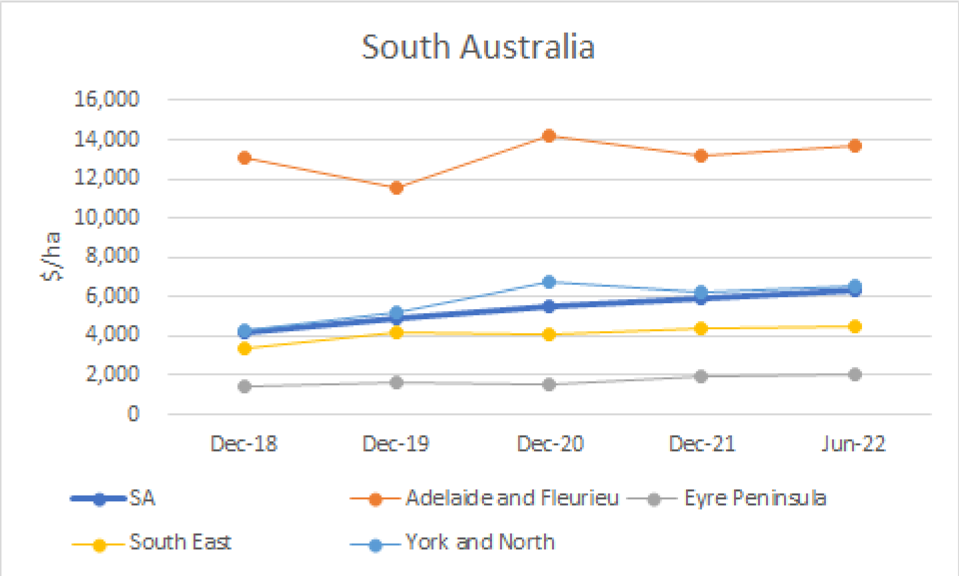

Figure 2.7: Farmland median prices in South Australia regions

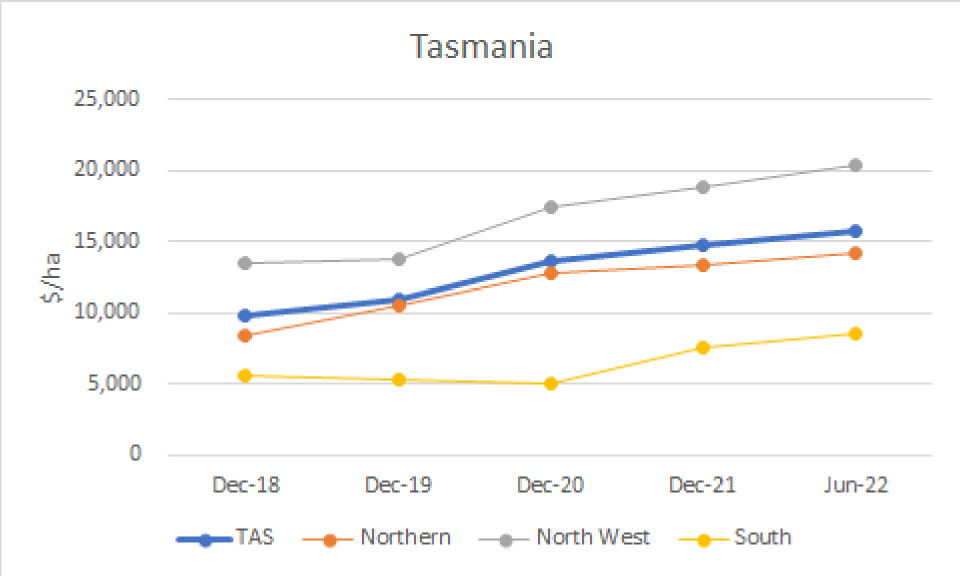

Figure 2.8: Farmland median prices in Tasmania regions

In keeping with the approach used in the 2020 Database, we used the rural land value in New South Wales as the reference for updating the 2022 Database.

However, to accommodate the significant variation of rural land cost in each region, we have provided a function to adjust the easement and property costs by state region in the Excel Workbook tab "dataAdjustment" by selecting the appropriate jurisdiction, as detailed in section 2.5.

The median values of rural land ($/ha) in New South Wales, Victoria, South Australia, Queensland, and Tasmania (only states within the NEM) are also presented in Table 2.4. The adjustment factors that should be applied for projects in each State region are presented in Table 2.8, which takes New South Wales as the reference.

Once the jurisdiction is chosen in the Excel workbook, its adjustment factor is automatically added to the appropriate land use attribute (“Grazing”, “Desert”, “Scrub” or “Developed area”) to increase or decrease the easement and property costs for a specific building block.

In addition, there are services associated with the land valuation and legal compliance that must be included to ensure the indices reflect the true cost of transmission infrastructure components. We selected the Australian Bureau of Statistics (ABS) indices “real estate services” and “legal services” to represent those costs and we applied weights of 5% and 15%, respectively. These weights are in line with data from recent Mott MacDonald and TNSP projects and the experience of our consultants in working on Australian transmission projects.

We also assessed the Strategic Benefit Payments Scheme[12] released by the New South Wales Government in October 2022. Under this scheme, private landowners in New South Wales can receive $200,000 per kilometre of transmission line hosted (in real 2022 dollars), paid out in annual instalments over 20 years. The Strategic Benefit Payments Scheme Policy Paper also highlights that “these benefit sharing payments will be made separately, and in addition to, the

[12] Strategic Benefit Payments Scheme | EnergyCo (nsw.gov.au)

existing requirement to pay compensation to landowners for transmission easements under the Land Acquisition (Just Terms Compensation) Act 1991."[13]

This new compensation scheme imposes ongoing operating expenses (opex) on the operator of transmission infrastructure within a New South Wales Renewable Energy Zone. It does not affect capital expenditure (capex) costs — which is the focus the Transmission Cost Database. We have therefore excluded the cost of the New South Wales Strategic Benefit Payments Scheme and other similar local government incentives in our updated easement and property costs.

We understand that AEMO can address such government incentives, in case of additional interest, after preparing the cost estimate for each project through the updated Transmission Cost Database, since they would only impact TNSPs' OPEX.

2.3 Environment offset costs

We applied the same ratio (environmental offset costs/total direct costs) from the original values in the 2020 Database to the updated costs in the 2022 Database. Our main reasons for doing this are as follows:

- There is a high level of uncertainty in forecasting environmental offset costs for substation and transmission lines
- We did not find an economic index that could be used to accurately represent the different impacts and costs that each project might cause
- The anonymous cost data from TNSPs were not sufficient to build an economic model to represent the environmental offset costs.

Therefore, we applied appropriate escalation factors to update the environmental offset costs to 30 June 2022 by keeping the same ratio (environmental offset costs/total direct costs) from the original values referred to 31 December 2020, as presented in Table 2.8.

The column "Ratios (environmental offset costs/total direct costs)" in Table 2.8 presents the range of the ratios calculated for each building block category and subcategory, and for each one, we applied a specific escalation factor.

To capture the known risks that might impact projects with different levels of complexity, the Excel workbook tab "dataRisk" contains five classifications available for Environmental offset costs: low (+20%), BAU (+ 50%), high (+ 100%), very high (+ 400%), and observed maximum (+2000%). These changes were proposed by AEMO to reflect hypothetical projects with extremely high environmental risks.

In such cases, the environmental offset costs from the TCD will be increased by the respective percentage (known risks), ranging from 20% for projects in areas with low environmental risks up to 2000% for extreme situations.

Table 2.8: Escalation factors for environmental offset costs

Category	Subcategory		Ratios (environmental offset costs/total direct costs)	Escalation factors
Station	Property site work		From 1.00% to 1.23%	1.1015
	Property site work and building		From 0.14% to 0.26%	1.1078
	HVAC	132 kV	From 8.61% to 15.04%	1.1640

[13] New South Wales Government, 2022, *Strategic Benefit Payments Scheme policy paper*, October 2022, p. 5. Accessed at: https://www.energyco.nsw.gov.au/sites/default/files/2022-10/policy-paper-strategic-benefit-payments-scheme.pdf

Category	Subcategory		Ratios (environmental offset costs/total direct costs)	Escalation factors
Overhead line		220 kV	From 8.99% to 14.41%	1.1674
		275 kV	From 9.47% to 15.06%	1.1705
		330 kV	From 9.92% to 14.03%	1.1722
		500 kV	From 6.63% to 10.63%	1.1696
	HVAC line diversion	132 kV	From 4.91% to 17.32%	1.1659
		220 kV	From 5.10% to 17.60%	1.1684
		275 kV	From 5.35% to 18.48%	1.1723
		330 kV	From 5.59% to 19.30%	1.1730
		500 kV	From 4.13% to 15.32%	1.1681
	HVAC with HTLS conductor	132 kV	From 7.44% to 14.37%	1.1650
		220 kV	From 7.90% to 13.77%	1.1691
		275 kV	From 8.35% to 14.41%	1.1724
		330 kV	From 8.78% to 13.02%	1.1734
	HVDC - LCC	± 320 kV	From 6.78% to 8.57%	1.1235
		± 500 kV	From 7.08% to 9.79%	1.1235
		± 600 kV	6.97%	1.1235
	HVDC - VSC	± 320 kV	From 6.27% to 8.57%	1.1235
		± 500 kV	From 6.44% to 9.79%	1.1235
	HVDC built in two stages - LCC	± 500 kV	6.44%	1.1235
		± 600 kV	6.34%	1.1235
	HVDC built in two stages - VSC	± 500 kV	From 5.85% to 6.44%	1.1235

2.4 Total costs

We calculated the total cost by summing the following values:

i. total direct cost
ii. easement/property costs
iii. environmental offset costs.

We calculated the total cost by summing the following costs:

i. plant
ii. civil and structural works
iii. electrical works
iv. secondary systems
v. design & survey
vi. testing & commissioning
vii. contractor project management & overheads.

2.5 Updating adjustment factors, indirect costs, contingency, and risk costs

The 2020 Transmission Cost Database was originally designed to produce early stage (Class 5[14]) project cost estimates, accuracy range of ± 30%. With the Transmission Cost Database unknown risk factors, which are intended to be used by AEMO to review advanced stage cost estimates provided by the project proponents, the accuracy of the estimates may be assumed to be Class 3 (± 15%) given that they have been benchmarked against actual and recent transmission infrstructure build out cost data.

The escalation factor method used for this 2022 Transmission Cost Database maintains the same class 5 accuracy level of the original 2020 Transmission Cost Database and moves to class 3 when adding the unknown risk factors.

We have revised and updated the “jurisdiction” percentages for station and overhead lines in the Excel workbook tab "dataAdjustment" applied to the easement and property costs. As mentioned in section2.2, we have assumed the rural land value in New South Wales as the reference for updating the Database. By selecting the appropriate jurisdiction, the value of the land (which represents 80% of the easement and property costs) can be adjusted to the median local market price. The remaining 20% of costs are due to real estate (15%) and legal services (5%).

Therefore, the state median value for Queensland, Victoria, and Tasmania for easement and property costs respectively are 5%, 55% and 105% higher than the state median value for New South Wales, and in South Australia these costs are 5% lower than for New South Wales. We inserted new adjustment factors to address the regional difference in rural land prices, when compared to the state median value for New South Wales (reference), as presented in Table 2.9

Table 2.9: Easement and property costs adjustment factors

Jurisdiction	Adjustment factor
QLD - State median value	5%
QLD - Central	-30%
QLD - North	45%
QLD - South	40%
QLD - West	-70%
NSW - State median value	0%
NSW - Central	-5%
NSW - Northern	-10%
NSW - Southern	5%
NSW - South East	30%
NSW - Western	-75%
VIC - State median value	55%
VIC - Gippsland	90%
VIC - Northern	35%
VIC - North West	-30%
VIC - South West	100%
SA - State median value	-5%
SA - Adelaide and Fleurieu	80%
SA - Eyre Peninsula	-55%
SA - South East	-25%

[14] Association for the Advancement of Cost Engineering International Recommended Practice cost classification system.

Jurisdiction	Adjustment factor
SA - York and North	-5%
TAS - State median value	105%
TAS - Northern	90%
TAS - North West	160%
TAS - South	20%

For the Excel Workbook tab “dataRisk”, we revised all attributes, updating the text under the headings “Detail”, “Description” and “Notes”, and “Percentages”. We also inserted new attributes for environmental offset risks. Below, we present the changes aggregated into three groups.

- Group 1: Table 2.10 presents the attributes where we have changed the numbers under the heading “Percentages” but keeping the other columns unchanged
- Group 2: Table 2.11 presents the attributes where we have changed the texts under those respective headings but keeping the information of the other columns as original
- Group 3: Table 2.12 presents the new options we included for Environmental offset risks, and changes for the headings “Notes” and “Percentages”.

Table 2.10: Updates to “Percentages”

Category	Subcategory	Detail	Description	Notes	Percentages
Station known risk	Market activity	Excess capacity	Not changed	Not changed	Updated
Station known risk	Market activity	Tight	Not changed	Not changed	Updated
Overhead line known risk	Market activity	Excess capacity	Not changed	Not changed	Updated
Overhead line known risk	Market activity	Tight	Not changed	Not changed	Updated

For the percentages provided in Table 2.10, we updated the percentages applied to the cost of materials, equipment, and services to provide a more current and representative estimate for possible changes in market conditions and hence price. In the case of excess supply capacity over demand, we expect that those prices will decrease, while in tight conditions, those costs will increase. We also decided to keep the other columns as the original because they express adequate information for each attribute.

- Group 2: Table 2.11 presents the attributes where we have changed the texts under those respective headings but keeping the information of the other columns as original. It is also highlighted that we did not change the percentages.

Table 2.11: Updates to “Description” and “Notes”

Category	Subcategory	Detail	Description	Notes	Percentages
Station unknown risk	Productivity and labour cost risks	Class 5b	Updated	Updated	Not changed
Station unknown risk	Productivity and labour cost risks	Class 5a	Updated	Updated	Not changed
Station unknown risk	Productivity and labour cost risks	Class 4	Updated	Updated	Not changed
Station unknown risk	Productivity and labour cost risks	Class 3	Updated	Updated	Not changed
Station unknown risk	Productivity and labour cost risks	Class 1/2	Updated	Updated	Not changed
Station unknown risk	Plant procurement cost risks	Class 5b	Updated	Updated	Not changed
Station unknown risk	Plant procurement cost risks	Class 5a	Updated	Updated	Not changed

Category	Subcategory	Detail	Description	Notes	Percentages
Station unknown risk	Plant procurement cost risks	Class 4	Updated	Updated	Not changed
Station unknown risk	Plant procurement cost risks	Class 3	Updated	Updated	Not changed
Station unknown risk	Plant procurement cost risks	Class 1/2	Updated	Updated	Not changed
Station unknown risk	Project overhead risks	Class 5b	Updated	Updated	Not changed
Station unknown risk	Project overhead risks	Class 5a	Updated	Updated	Not changed
Station unknown risk	Project overhead risks	Class 4	Updated	Updated	Not changed
Station unknown risk	Project overhead risks	Class 3	Updated	Updated	Not changed
Station unknown risk	Project overhead risks	Class 1/2	Updated	Updated	Not changed

For the data in Table 2.11, we updated the information under the headings “Description” and “Notes” with the aim to improve the understanding of the application of each classification. We also decided to keep the other columns the same as the original because they express adequate information for each attribute.

- Group 3: Table 2.12 presents the new options we included for Environmental offset risks, and changes for the headings “Notes” and “Percentages”.

Table 2.12: New attributes and updates

Category	Subcategory	Detail	Description	Notes	Percentages
Station known risk	Environmental offset risks	Low	Not changed	Updated	Updated
Station known risk	Environmental offset risks	BAU	Not changed	Updated	Updated
Station known risk	Environmental offset risks	High	Not changed	Updated	Updated
Station known risk	Environmental offset risks	Very high	New	New	New
Station known risk	Environmental offset risks	Observed maximum	New	New	New
Overhead line known risk	Environmental offset risks	Low	Not changed	Updated	Updated
Overhead line known risk	Environmental offset risks	BAU	Not changed	Updated	Updated
Overhead line known risk	Environmental offset risks	High	Not changed	Updated	Updated
Overhead line known risk	Environmental offset risks	Very high	New	New	New
Overhead line known risk	Environmental offset risks	Observed maximum	New	New	New
Underground cable known risk	Environmental offset risks	Low	Not changed	Updated	Updated
Underground cable known risk	Environmental offset risks	BAU	Not changed	Updated	Updated
Underground cable known risk	Environmental offset risks	High	Not changed	Updated	Updated
Underground cable known risk	Environmental offset risks	Very high	New	New	New
Underground cable known risk	Environmental offset risks	Observed maximum	New	New	New

For the data in Table 2.12, we added new options for environmental offset risks to provide a broader assessment of the impacts that each transmission project might cause due to specific levels of complexity.

We have also reviewed the Excel Workbook Tab “dataIndirectCost” and decided to keep the current description and percentages as the original for all indirect costs, because we did not find strong evidence for a need for them to be updated.

2.6 Updating of HVAC transmission lines ratings

We reviewed and updated the ratings for all HVAC transmission lines from the original building blocks in the 2020 Transmission Cost Database. The ratings were calculated for summer day, 1 m/s wind speed, and air temperature of 35ºC. The purpose of this update was to have a common interpretation of the conductor line ratings and to provide a clear line rating for different temperature assumptions.

Table 2.13 presents a comparison between the original ratings and the updated ratings for each HVAC overhead line previously included in the 2020 Transmission Cost Database.

Table 2.13: Updated ratings for HVAC overhead lines – original building blocks

Voltage (kV)	Conductor type	Number of circuits	Number of conductors/phase (each circuit)	Original TCD rating (MVA)	Mott MacDonald rating (MVA)	Difference (%)
500	Olive	Double	2	2,000	3,350	67.5%
500	Mango	Double	3	4,000	4,167	4.2%
500	Orange	Double	4	6,080	6,124	0.7%
500	Olive	Double	4	6,500	6,699	3.1%
500	Orange	Single	4	2,900	3,062	5.6%
500	Orange	Single	4	3,200	3,062	-4.3%
500	Olive	Single	4	3,400	3,350	-1.5%
330	Mango	Double	2	1,886	1,834	-2.8%
330	Mango	Double	3	2,400	2,750	14.6%
330	Lychee	Single	2	700	736	5.1%
330	Mango	Single	2	900	917	1.9%
330	Orange	Single	2	1,000	1,011	1.1%
330	Mango	Single	3	1,200	1,375	14.6%
275	Mango	Double	1	520	764	46.9%
275	Olive	Double	1	900	921	2.3%
275	Lemon	Double	2	1,073	1,115	3.9%
275	Mango	Double	2	1,400	1,528	9.1%
275	Orange	Double	2	1700	1,684	-0.9%
275	Olive	Double	2	1,900	1,842	-3.1%
275	Mango	Double	3	2,145	2,292	6.9%
275	Orange	Single	1	400	421	5.3%
275	Lemon	Single	2	536	557	3.9%
275	Mango	Single	2	700	764	9.1%
275	Orange	Single	2	800	842	5.3%
275	Orange	Single	3	1,200	1,263	5.3%
220	Mango	Double	1	520	611	17.5%

Voltage (kV)	Conductor type	Number of circuits	Number of conductors/phase (each circuit)	Original TCD rating (MVA)	Mott MacDonald rating (MVA)	Difference (%)
220	Lemon	Double	2	800	892	11.5%
220	Lychee	Double	2	1,000	982	-1.8%
220	Mango	Double	2	1,200	1,222	1.8%
220	Orange	Double	2	1,400	1,347	-3.8%
220	Mango	Double	3	1,600	1,834	14.6%
220	Mango	Single	1	286	306	7.0%
220	Olive	Single	1	373	368	-1.3%
220	Lemon	Single	2	429	446	4.0%
220	Lychee	Single	2	488	491	0.6%
220	Mango	Single	3	800	917	14.6%
220	Paw Paw	Double	2	1,500	1,594	6.3%
132	Grape	Double	1	100	214	114.0%
132	Grape	Double	1	150	214	42.7%
132	Lemon	Double	1	250	267	6.8%
132	Mango	Double	1	338	367	8.6%
132	Lemon	Double	2	500	535	7.0%
132	Mango	Double	3	1,000	1,100	10.0%
132	Grape	Single	1	75	107	42.7%
132	Lychee	Single	1	150	147	-2.0%
132	Mango	Single	1	169	183	8.3%

We also reviewed and updated the ratings for all HTLS[15] transmission lines for the original building blocks. The ratings were calculated for summer day, 1 m/s wind speed, and air temperature of 35^{o}C.

Table 2.14 presents a comparison between the original ratings and the updated ratings for each HVAC HTLS overhead line previously included in the 2020 Transmission Cost Database.

Table 2.14: Updated ratings for HVAC HTLS overhead lines – original building blocks

Voltage (kV)	Conductor type	Number of circuits	Number of conductors/phase (each circuit)	Original TCD rating (MVA)	Mott MacDonald rating (MVA)	Difference (%)
330	Stockholm 3L	double	2	1,886	1,955	3.7%
330	Olso	double	3	2,400	2,342	-2.4%
330	Amsterdam	single	2	800	855	6.9%
330	Stockholm 3L	single	2	943	977	3.6%
330	Amsterdam	single	3	1,200	1,283	6.9%
275	Reykjavik	double	1	520	525	1.0%
275	Amsterdam	double	2	1,400	1,425	1.8%
275	Amsterdam	double	3	2,145	2,138	-0.3%
275	Warsaw	single	1	400	435	8.8%
275	Amsterdam	single	2	700	713	1.9%

[15] Hight-temperature low-sag

Voltage (kV)	Conductor type	Number of circuits	Number of conductors/phase (each circuit)	Original TCD rating (MVA)	Mott MacDonald rating (MVA)	Difference (%)
275	Stockholm 3L	single	3	1,200	1,222	1.8%
220	Oslo	double	1	520	521	0.2%
220	Oslo	double	2	1,000	1,041	4.1%
220	Oslo	double	3	1,600	1,562	-2.4%
220	Milan	single	1	373	372	-0.3%
220	Oslo	single	2	488	521	6.8%
220	Oslo	single	3	800	781	-2.4%
132	Silvassa	double	1	150	174	16.0%
132	Reykjavik	double	2	500	504	0.8%
132	Amsterdam	double	3	1,000	1,026	2.6%
132	Reykjavik	single	1	100	126	26.0%

2.7 Updating of HVAC underground cables ratings

We reviewed and updated the ratings for all HVAC underground cables for the original building blocks. The ratings were calculated for ground temperature of 20°C and trefoil formation.

Table 2.15 presents a comparison between the original ratings and the updated ratings for each HVAC underground cable type included in the 2020 Transmission Cost Database.

We considered the full capacity of the cables to calculate the ratings for double circuits. This is different to the approach taken for the 2020 Transmission Cost Database for underground cables: the 2020 Transmission Cost Database used the second circuit only as a backup and did not add its capacity to inform ratings.

However, for the Transmission Cost Database update AEMO requested that we apply for underground cables the same criteria as for overhead lines to avoid confusion and to ensure like for like comparisons.

Table 2.15: Updated ratings for HVAC underground cables – original building blocks

Voltage (kV)	Conductor cross section (mm^2)	Number of circuits	Buried/ Tunnel	Number conductors/ phase (each circuit)	Current TCD (MVA)	Mott MacDonald (MVA)	Difference (%)
500	1000	single	buried	2	1,820	1,559	-14.3%
500	2000	single	buried	2	2,500	2,061	-17.6%
500	3000	single	buried	2	3,000	2,546	-15.1%
500	2000	double	buried	2	2,500	4,122	64.9%
500	3000	double	tunnel	2	3,000	5,092	69.7%
500	2000	double	tunnel	2	2,500	4,122	64.9%
330	1000	single	buried	2	1,230	1,029	-16.3%
330	1600	single	buried	2	1,600	1,252	-21.8%
330	2500	single	buried	2	1,910	1,524	-20.2%
330	1600	double	buried	2	1,600	2,503	56.4%
330	1600	double	tunnel	2	1,600	2,503	56.4%
275	500	single	buried	2	500	590	18.0%
275	1000	single	buried	2	700	858	22.6%

Voltage (kV)	Conductor cross section (mm^2)	Number of circuits	Buried/ Tunnel	Number conductors/ phase (each circuit)	Current TCD (MVA)	Mott MacDonald (MVA)	Difference (%)
275	2500	single	buried	2	1,080	1,270	17.6%
275	1000	double	buried	2	700	1,716	145.1%
275	1000	double	tunnel	2	700	1,716	145.1%
220	500	single	buried	2	400	472	18.0%
220	870	single	buried	2	550	636	15.6%
220	2500	single	buried	2	870	1,016	16.8%
220	870	double	buried	2	550	1,272	131.3%
220	870	double	tunnel	2	550	1,272	131.3%

2.8 New building blocks

Table 2.16 summarises the new building blocks in the new category “Station” which we have added to the 2022 Transmission Cost Database. We have included the complete cost information in the Excel Workbook tab “Data Building Block escalated”.

Table 2.16: Station new building blocks

Category	Subcategory	Detail	Voltage (kV)
Station	Reactive Plant	SVC ±150 MVAr	500
Station	Reactive Plant	SVC ±250 MVAr	500
Station	Reactive Plant	SVC ±350 MVAr	500
Station	Reactive Plant	SVC ±450 MVAr	500
Station	Reactive Plant	SVC ±150 MVAr	330
Station	Reactive Plant	SVC ±250 MVAr	330
Station	Reactive Plant	SVC ±350 MVAr	330
Station	Reactive Plant	SVC ±450 MVAr	330
Station	Reactive Plant	SVC ±150 MVAr	275
Station	Reactive Plant	SVC ±250 MVAr	275
Station	Reactive Plant	SVC ±350 MVAr	275
Station	Reactive Plant	SVC ±450 MVAr	275
Station	Reactive Plant	Reactor 150 MVAr	500
Station	Reactive Plant	Reactor 250 MVAr	500
Station	Reactive Plant	Reactor 350MVAr	500
Station	Reactive Plant	Reactor 450 MVAr	500
Station	Reactive Plant	Reactor 150 MVAr	330
Station	Reactive Plant	Reactor 250 MVAr	330
Station	Reactive Plant	Reactor 350 MVAr	330
Station	Reactive Plant	Reactor 150 MVAr	275
Station	Reactive Plant	Reactor 250 MVAr	275
Station	Reactive Plant	Reactor 350 MVAr	275
Station	Reactive Plant	Reactor 150 MVAr	220
Station	Reactive Plant	Reactor 250 MVAr	220
Station	Reactive Plant	Reactor 350 MVAr	220
Station	Reactive Plant	Reactor 150 MVAr	132

Category	Subcategory	Detail	Voltage (kV)
Station	Reactive Plant	Reactor 250 MVAr	132
Station	Reactive Plant	Reactor 350 MVAr	132
Station	Reactive Plant	Capacitor 150 MVAr	330
Station	Reactive Plant	Capacitor 250 MVAr	330
Station	Reactive Plant	Capacitor 350 MVAr	330
Station	Reactive Plant	Capacitor 150 MVAr	275
Station	Reactive Plant	Capacitor 250MVAr	275
Station	Reactive Plant	Capacitor 350 MVAr	275
Station	Reactive Plant	Capacitor 150 MVAr	220
Station	Reactive Plant	Capacitor 250 MVAr	220
Station	Reactive Plant	Capacitor 350 MVAr	220
Station	Reactive Plant	Synchronous Condenser 2 × 200 MVA	330
Station	HVDC converters - VSC	2 × Asymmetrical Monopole (Bipole), 2 × 2,000 MW	±500
Station	HVDC converters built in two stages - VSC	2 × Asymmetrical Monopole (Bipole), 2 × 2,000 MW	±500
Station	HVDC converters built in two stages - LCC	2 × Asymmetrical Monopole (Bipole), 2 × 2,000 MW	±600
Station	Transformer	2 winding Tx (3ph) 30 MVA	220/22
Station	Transformer	2 winding Tx (3ph) 100 MVA	220/22
Station	Transformer	2 winding Tx (3ph) 150 MVA	220/22
Station	Transformer	2 winding Tx (3ph) 375 MVA	275/110
Station	Transformer	2 winding Tx (3ph) 375 MVA	275/132
Station	Transformer	2 winding Tx (3ph) 250 MVA	275/132
Station	Transformer	2 winding Tx (3ph) 200 MVA	330/132
Station	Transformer	2 winding Tx (3ph) 375 MVA	330/132
Station	Transformer	2 winding Tx (3ph) 200MVA	330/220
Station	Transformer	2 winding Tx (3ph) 700 MVA	330/220
Station	Transformer	2 winding Tx (3 banks of 1ph) 700 MVA	330/220
Station	Transformer	2 winding Tx (3ph) 700 MVA	330/275
Station	Transformer	2 winding Tx (3 banks of 1ph) 700 MVA	330/275
Station	Transformer	2 winding Tx (3ph) 250 MVA	330/66
Station	Transformer	2 winding Tx (3 banks of 1ph) 1,200 MVA	500/220
Station	Transformer	2 winding Tx (3ph) 700 MVA	500/220
Station	Transformer	2 winding Tx (3ph) 700 MVA	500/275
Station	Transformer	2 winding Tx (3 banks of 1ph) 1,200 MVA	500/330

Table 2.17 summarises the new building blocks in the category “Overhead lines”, subcategory “HVDC” which we added to the Transmission Cost Database in this update. We have incorporated the complete cost information in the Excel Workbook tab “Data Building Block escalated”.

Table 2.17: HVDC overhead lines – new building blocks

Category	Subcategory	Detail	Voltage (kV)
Overhead line	HVDC – VSC	Asymmetrical Monopole, 1,000 MW	500 (<750km)
Overhead line	HVDC - VSC	Symmetrical Monopole, 1,000MW	±500
Overhead line	HVDC - VSC	Symmetrical Monopole, 1,500MW	±500
Overhead line	HVDC - VSC	Symmetrical Monopole, 2,500MW	±500
Overhead line	HVDC - VSC	2 × Asymmetrical Monopole (Bipole metallic return), 2 × 2,000 MW	±500
Overhead line	HVDC - LCC	2 × Asymmetrical Monopole (Bipole metallic return), 2 × 3,000 MW	±600
Overhead line	HVDC built in two stages - VSC	First Asymmetrical Monopole and then Second Asymmetrical Monopole, 2 × 2,000 MW	±500
Overhead line	HVDC built in two stages - LCC	First Asymmetrical Monopole and then Second Asymmetrical Monopole, 2 × 3,000 MW	±600

Table 2.18 summarises the new building blocks in the category “Underground cable”, subcategory “HVAC”, which we added to the transmission cost database in this update. We incorporated the full cost information in the Excel workbook tab “Data Building Block escalated”.

Table 2.18: HVAC underground cables – new building blocks

Category	Subcategory	Detail	Voltage (kV)
Underground Cable	HVAC tunnel installed cable	2,061 MVA – 1,000 mm^2 single circuit direct installed in a tunnel	500
Underground Cable	HVAC tunnel installed cable	2,061 MVA – 2,000 mm^2 single circuit direct installed in a tunnel	500
Underground Cable	HVAC tunnel installed cable	2,546 MVA – 3,000 mm^2 single circuit direct installed in a tunnel	500
Underground Cable	HVAC tunnel installed cable	1,029 MVA – 1,000 mm^2 single circuit direct installed in a tunnel	330
Underground Cable	HVAC tunnel installed cable	1,252 MVA – 1,600 mm^2 single circuit direct installed in a tunnel	330
Underground Cable	HVAC tunnel installed cable	1,524 MVA – 2,500 mm^2 single circuit direct installed in a tunnel	330
Underground Cable	HVAC tunnel installed cable	2,058 MVA – 1,000 mm^2 per circuit double circuit installed in a tunnel	330
Underground Cable	HVAC tunnel installed cable	590 MVA – 500 mm^2 single circuit direct installed in a tunnel	275
Underground Cable	HVAC tunnel installed cable	858 MVA – 1,000 mm^2 single circuit direct installed in a tunnel	275
Underground Cable	HVAC tunnel installed cable	1,044 MVA – 1,600 mm^2 single circuit direct installed in a tunnel	275
Underground Cable	HVAC tunnel installed cable	1,270 MVA – 2,500 mm^2 single circuit direct installed in a tunnel	275
Underground Cable	HVAC tunnel installed cable	2,086 MVA – 1,600 mm^2 per circuit double circuit installed in a tunnel	275
Underground Cable	HVAC tunnel installed cable	2,032 MVA – 2,500 mm^2 per circuit double circuit installed in a tunnel	220

Category	Subcategory	Detail	Voltage (kV)
Underground Cable	HVAC underground direct buried cable	1,044 MVA – 1,600 mm^2 single circuit direct buried	275
Underground Cable	HVAC tunnel installed cable	636 MVA – 870 mm^2 single circuit installed in a tunnel	220
Underground Cable	HVAC tunnel installed cable	1,016 MVA – 2,500 mm^2 single circuit installed in a tunnel	220
Underground Cable	HVAC tunnel installed cable	472 MVA – 500 mm^2 single circuit installed in a tunnel	220

Table 2.19 summarises the new building blocks in the category “Underground cable”, subcategory “HVDC” added to the transmission cost database in this update. We have incorporated the full cost information in the Excel workbook tab “Data Building Block escalated”.

Table 2.19: HVDC underground cables – new building blocks

Category	Subcategory	Detail	Voltage (kV)
Underground Cable	HVDC underground direct buried cable	1,000 MW - Direct buried cable - twin 500 MW symmetrical monopole circuits	500
Underground Cable	HVDC underground direct buried cable	2,000 MW - Direct buried cable - twin 1,000 MW symmetrical monopole circuits	500
Underground Cable	HVDC underground direct buried cable	2,500 MW - Direct buried cable - twin 1,250 MW symmetrical monopole circuits	500
Underground Cable	HVDC underground direct buried cable	1,500 MW - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x750 MW	±500
Underground Cable	HVDC underground direct buried cable	2,000 MW - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x1,000 MW	±500
Underground Cable	HVDC underground direct buried cable	3,000 MW - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x1,500 MW	±500
Underground Cable	HVDC underground direct buried cable	4,000 MW - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x2,000 MW	±500
Underground Cable	HVDC underground direct buried cable	6,000 MW - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x3,000 MW	±600
Underground Cable	HVDC underground direct buried cable - built in two stages	2 × Asymmetrical Monopole (Bipole), 2 × 1,000 MW - First Stage 1,000 MW, Second stage 1,000 MW	500
Underground Cable	HVDC underground direct buried cable - built in two stages	2 × Asymmetrical Monopole (Bipole), 2 × 1,500MW - First Stage 1,500 MW, Second Stage 1,500 MW	500
Underground Cable	HVDC underground direct buried cable - built in two stages	2 × Asymmetrical Monopole (Bipole), 2 × 2,000MW - First Stage 2,000 MW, Second Stage 2,000 MW	500
Underground Cable	HVDC underground direct buried cable - built in two stages	2 × Asymmetrical Monopole (Bipole), 2 × 3,000MW - First Stage 3,000 MW, Second Stage 3,000 MW	600
Underground Cable	HVDC subsea cable	1000 MW - Subsea Cable - twin 500 MW symmetrical monopole circuits	500
Underground Cable	HVDC subsea cable	2,000 MW - Subsea Cable - twin 1,000 MW symmetrical monopole circuits	500

Category	Subcategory	Detail	Voltage (kV)
Underground Cable	HVDC subsea cable	2,500 MW - Subsea Cable - twin 1,250 MW symmetrical monopole circuits	500
Underground Cable	HVDC subsea cable	1,500 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x750 MW	±500
Underground Cable	HVDC subsea cable	2,000 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x1,000 MW	±500
Underground Cable	HVDC subsea cable	3,000 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x1,500 MW	±500
Underground Cable	HVDC subsea cable	4,000 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x2,000 MW	±500
Underground Cable	HVDC subsea cable	6,000 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x3,000 MW	±600
Underground Cable	HVDC subsea cable - built in two stages	2 × Asymmetrical Monopole (Bipole), 2 × 1,000MW - First Stage 1,000 MW, Second stage 1,000 MW	500
Underground Cable	HVDC subsea cable - built in two stages	2 × Asymmetrical Monopole (Bipole), 2 × 1,500MW - First Stage 1,500 MW, Second Stage 1,500 MW	500
Underground Cable	HVDC subsea cable - built in two stages	2 × Asymmetrical Monopole (Bipole), 2 × 2,000MW - First Stage 2,000 MW, Second Stage 2,000 MW	500
Underground Cable	HVDC subsea cable - built in two stages	2 × Asymmetrical Monopole (Bipole), 2 × 3,000MW - First Stage 3,000 MW, Second Stage 3,000 MW	600

Table 2.20 summarises of the new building blocks in the category “Overhead lines”, subcategory “HVAC” which we added to the Transmission Cost Database in this update. We have incorporated the complete cost information in the Excel Workbook tab “Data Building Block escalated”.

The ratings were calculated for 1 m/s wind speed and for a summer day with the following air temperatures: 30ºC, 35ºC (standard adopted), 40ºC, and 45ºC.

Table 2.20: HVAC overhead lines – new building blocks

Category	Subcategory	Detail	Voltage (kV)	Rating (MVA)			
				30ºC	35ºC	40ºC	45ºC
Overhead line	HVAC	2 x Paw Paw SCST 1,196 MVA	330	1,241	1,196	1,149	1,100
Overhead line	HVAC	2 x Paw Paw DCST 2,392 MVA	330	2,482	2,392	2,298	2,200
Overhead line	HVAC	Stage 1 development: 2 x Paw Paw DCST 2392 MVA	330	2,482	2,392	2,298	2,200
Overhead line	HVAC	Stage 2 development: 2 x Paw Paw DCST 2,392 MVA	330	2,482	2,392	2,298	2,200
Overhead line	HVAC	2 x Olive SCST 1,106MVA	330	1,146	1,106	1,064	1,020
Overhead line	HVAC	2 x Olive DCST 2,212 MVA	330	2,292	2,212	2,127	2,040

Category	Subcategory	Detail	Voltage (kV)	Rating (MVA)			
				30ºC	35ºC	40ºC	45ºC
Overhead line	HVAC	Stage 1 development: 2 x Olive DCST 2,212 MVA	330	2,292	2,212	2,127	2,040
Overhead line	HVAC	Stage 2 development: 2 x Olive DCST 2,212 MVA	330	2,292	2,212	2,127	2,040
Overhead line	HVAC	2 x Sulphur SCST 1,293 MVA	330	1,342	1,293	1,242	1,189
Overhead line	HVAC	2 x Sulphur DCST 2,586 MVA	330	2,684	2,586	2,484	2,378
Overhead line	HVAC	Stage 1 development: 2 x Sulphur DCST 2,586 MVA	330	2,684	2,586	2,484	2,378
Overhead line	HVAC	Stage 2 development: 2 x Sulphur DCST 2,586 MVA	330	2,684	2,586	2,484	2,378
Overhead line	HVAC	2 x Phosphorous DCST 15,93 MVA	275	1,647	1,593	1,537	1,479
Overhead line	HVAC	Stage 1 development: 2 x Phosphorous DCST 1,593 MVA	275	1,647	1,593	1,537	1,479
Overhead line	HVAC	Stage 2 development: 2 x Phosphorous DCST 1,593 MVA	275	1,647	1,593	1,537	1,479
Overhead line	HVAC	2 x Sulphur DCST 2,155 MVA	275	2,236	2,155	2,070	1,982
Overhead line	HVAC	Stage 1 development: 2 x Sulphur DCST 2,155 MVA	275	2,236	2,155	2,070	1,982
Overhead line	HVAC	Stage 2 development: 2 x Sulphur DCST 2,155 MVA	275	2,236	2,155	2,070	1,982
Overhead line	HVAC	2 x Phosphorus SCST 796 MVA	275	823	796	768	739
Overhead line	HVAC	2 x Olive SCST 920 MVA	275	955	920	886	850
Overhead line	HVAC	1 x Olive SCST 460 MVA	275	477	460	443	425
Overhead line	HVAC	2 x Sulphur SCST 1,077 MVA	275	1,118	1,077	1,035	991
Overhead line	HVAC	2 x Olive SCST 737 MVA	220	764	737	709	680
Overhead line	HVAC	2 x Olive DCST 1,474 MVA	220	1,528	1,474	1,418	1,360
Overhead line	HVAC	Stage 1 development: 2 x Olive DCST 1,474 MVA	220	1,528	1,474	1,418	1,360
Overhead line	HVAC	Stage 2 development: 2 x Olive DCST 1,474 MVA	220	1,528	1,474	1,418	1,360
Overhead line	HVAC	2 x Sulphur SCST 862 MVA	220	894	862	828	792
Overhead line	HVAC	2 x Sulphur DCST 1,724 MVA	220	1,788	1,724	1,656	1,584
Overhead line	HVAC	Stage 1 development: 2 x Sulphur DCST 1,724 MVA	220	1,788	1,724	1,656	1,584
Overhead line	HVAC	Stage 2 development: 2 x Sulphur DCST 1,724 MVA	220	1,788	1,724	1,656	1,584
Overhead line	HVAC	1 x Sulphur SCST 431 MVA	220	447	431	414	396

Category	Subcategory	Detail	Voltage (kV)	Rating (MVA)			
				30ºC	35ºC	40ºC	45ºC
Overhead line	HVAC	1 x Sulphur DCST 862 MVA	220	894	862	828	792
Overhead line	HVAC	Stage 1 development: 1 x Sulphur DCST 862 MVA	220	894	862	828	792
Overhead line	HVAC	Stage 2 development: 1 x Sulphur DCST 862 MVA	220	894	862	828	792
Overhead line	HVAC	6 x Phosphorus SCCT 1,911 MVA	220	1,976	1,911	1,844	1,775
Overhead line	HVAC	6 x Phosphorus DCCT 3,822 MVA	220	3,952	3,822	3,688	3,550
Overhead line	HVAC	Stage 1 development: 6 x Phosphorus DCCT 3,822 MVA	220	3,952	3,822	3,688	3,550
Overhead line	HVAC	Stage 2 development: 6 x Phosphorus DCCT 3,822 MVA	220	3,952	3,822	3,688	3,550
Overhead line	HVAC	2 x Phosphorus DCST 1,274 MVA	220	1,317	1,274	1,229	1,183
Overhead line	HVAC	2 x Paw Paw SCST 797 MVA	220	827	797	766	733
Overhead line	HVAC	2 x Paw Paw DCST 1,594 MVA	220	1,654	1,594	1,532	1,466
Overhead line	HVAC	3 x Phosphorus SCST 956 MVA	220	988	956	922	887
Overhead line	HVAC	3 x Phosphorus DCST 1,912 MVA	220	1,976	1,912	1,844	1,774
Overhead line	HVAC	Stage 1 development: 3 x Phosphorus DCCT 1,912 MVA	220	1,976	1,912	1,844	1,774
Overhead line	HVAC	Stage 2 development: 3 x Phosphorus DCCT 1,912 MVA	220	1,976	1,912	1,844	1,774
Overhead line	HVAC	3 x Sulphur SCST 1,293 MVA	220	1,342	1,293	1,242	1,189
Overhead line	HVAC	3 x Sulphur DCST 2,586 MVA	220	2,684	2,586	2,484	2,378
Overhead line	HVAC	Stage 1 development: 3 x Sulphur DCST 2,586 MVA	220	2,684	2,586	2,484	2,378
Overhead line	HVAC	Stage 2 development: 3 x Sulphur DCST 2,586 MVA	220	2,684	2,586	2,484	2,378
Overhead line	HVAC	6 x Sulphur SCST 2,586 MVA	220	2,684	2,586	2,484	2,378
Overhead line	HVAC	6 x Sulphur DCST 5,172 MVA	220	5,368	5,172	4,968	4,756
Overhead line	HVAC	Stage 1 development: 6 x Sulphur DCST 5,172 MVA	220	5,368	5,172	4,968	4,756
Overhead line	HVAC	Stage 2 development: 6 x Sulphur DCST 5,172 MVA	220	5,368	5,172	4,968	4,756
Overhead line	HVAC	1 x Paw Paw SCST 399 MVA	220	414	399	383	367
Overhead line	HVAC	1 x Phosphorus SCST 191 MVA	132	198	191	184	177
Overhead line	HVAC	1 x Phosphorus DCST 382 MVA	132	396	382	368	354

Category	Subcategory	Detail	Voltage (kV)	Rating (MVA)			
				30ºC	35ºC	40ºC	45ºC
Overhead line	HVAC	Stage 1 development: 1 x Phosphorus DCST 382 MVA	132	396	382	368	354
Overhead line	HVAC	Stage 2 development: 1 x Phosphorus DCST 382 MVA	132	396	382	368	354
Overhead line	HVAC	1 x Olive SCST 221 MVA	132	229	221	213	204
Overhead line	HVAC	1 x Olive DCST 442 MVA	132	458	442	426	408
Overhead line	HVAC	Stage 1 development: 1 x Olive DCST 442 MVA	132	458	442	426	408
Overhead line	HVAC	Stage 2 development: 1 x Olive DCST 442 MVA	132	458	442	426	408
Overhead line	HVAC	1 x Sulphur SCST 259 MVA	132	268	259	248	238
Overhead line	HVAC	1 x Sulphur DCST 518 MVA	132	536	518	496	476
Overhead line	HVAC	Stage 1 development: 1 x Sulphur DCST 518 MVA	132	536	518	496	476
Overhead line	HVAC	Stage 2 development: 1 x Sulphur DCST 518 MVA	132	536	518	496	476
Overhead line	HVAC	1 x Uranus SCST 221 MVA	132	229	221	213	204
Overhead line	HVAC	1 x Uranus DCST 442 MVA	132	458	442	426	408
Overhead line	HVAC	Stage 1 development: 1 x Uranus DCST 442 MVA	132	458	442	426	408
Overhead line	HVAC	Stage 2 development: 1 x Uranus DCST 442 MVA	132	458	442	426	408
Overhead line	HVAC	1 x Taurus SCST 173 MVA	132	178	173	167	161
Overhead line	HVAC	1 x Taurus DCST 346 MVA	132	356	346	334	322
Overhead line	HVAC	Stage 1 development: 1 x Taurus DCST 346 MVA	132	356	346	334	322
Overhead line	HVAC	Stage 2 development: 1 x Taurus DCST 346 MVA	132	356	346	334	322
Overhead line	HVAC	1 x Oxygen SCST 170 MVA	132	176	170	164	158
Overhead line	HVAC	1 x Oxygen DCST 340 MVA	132	352	340	328	316
Overhead line	HVAC	Stage 1 development: 1 x Oxygen DCST 340 MVA	132	352	340	328	316
Overhead line	HVAC	Stage 2 development: 1 x Oxygen DCST 340 MVA	132	352	340	328	316
Overhead line	HVAC	1 x Nitrogen SCST 146 MVA	132	150	146	141	136
Overhead line	HVAC	1 x Nitrogen DCST 292 MVA	132	300	292	282	272
Overhead line	HVAC	Stage 1 development: 1 x Nitrogen DCST 292 MVA	132	300	292	282	272

Category	Subcategory	Detail	Voltage (kV)	Rating (MVA)			
				30ºC	35ºC	40ºC	45ºC
Overhead line	HVAC	Stage 2 development: 1 x Nitrogen DCST 292 MVA	132	300	292	282	272
Overhead line	HVAC	1 x Neptune SCST 109 MVA	132	112	109	106	103
Overhead line	HVAC	1 x Neptune DCST 218 MVA	132	224	218	212	206
Overhead line	HVAC	Stage 1 development: 1 x Neptune DCST 218 MVA	132	224	218	212	206
Overhead line	HVAC	Stage 2 development: 1 x Neptune DCST 218 MVA	132	224	218	212	206
Overhead line	HVAC	1 x Neon SCST 128 MVA	132	131	128	124	120
Overhead line	HVAC	1 x Neon DCST 256 MVA	132	262	256	248	240
Overhead line	HVAC	Stage 1 development: 1 x Neon DCST 256 MVA	132	262	256	248	240
Overhead line	HVAC	Stage 2 development: 1 x Neon DCST 256 MVA	132	262	256	248	240
Overhead line	HVAC	1 x Mango SCST 183 MVA	132	190	183	177	170
Overhead line	HVAC	1 x Mango DCST 366 MVA	132	380	366	354	340
Overhead line	HVAC	Stage 1 development: 1 x Mango DCST 366 MVA	132	380	366	354	340
Overhead line	HVAC	Stage 2 development: 1 x Mango DCST 366 MVA	132	380	366	354	340
Overhead line	HVAC	1 x Lemon SCST 134 MVA	132	138	134	130	125
Overhead line	HVAC	1 x Lemon DCST 268 MVA	132	276	268	260	250
Overhead line	HVAC	Stage 1 development: 1 x Lemon DCST 268 MVA	132	276	268	260	250
Overhead line	HVAC	Stage 2 development: 1 x Lemon DCST 268 MVA	132	276	268	260	250
Overhead line	HVAC	1 × Sulphur SCST 215 MVA	110	224	215	207	198
Overhead line	HVAC	1 × Sulphur DCST 430 MVA	110	448	430	414	396
Overhead line	HVAC	Stage 1 development: 1 × Sulphur DCST 430 MVA	110	448	430	414	396
Overhead line	HVAC	Stage 2 development: 1 × Sulphur DCST 430 MVA	110	448	430	414	396
Overhead line	HVAC	1 × Phosphorus SCST 159 MVA	110	165	159	154	148
Overhead line	HVAC	1 × Phosphorus DCST 318 MVA	110	330	318	308	296
Overhead line	HVAC	Stage 1 development: 1 × Phosphorus DCST 318 MVA	110	330	318	308	296
Overhead line	HVAC	Stage 2 development: 1 × Phosphorus DCST 318 MVA	110	330	318	308	296

Category	Subcategory	Detail	Voltage (kV)	Rating (MVA)			
				30ºC	35ºC	40ºC	45ºC
Overhead line	HVAC	1 × Nitrogen SCST 122 MVA	110	125	122	118	114
Overhead line	HVAC	1 × Nitrogen DCST 244 MVA	110	250	244	236	228
Overhead line	HVAC	Stage 1 development: 1 × Nitrogen DCST 244 MVA	110	250	244	236	228
Overhead line	HVAC	Stage 2 development: 1 × Nitrogen DCST 244 MVA	110	250	244	236	228
Overhead line	HVAC	1 × Krypton SCST 89 MVA	110	92	89	87	84
Overhead line	HVAC	1 × Krypton DCST 178 MVA	110	184	178	174	168
Overhead line	HVAC	Stage 1 development: 1 × Krypton DCST 178 MVA	110	184	178	174	168
Overhead line	HVAC	Stage 2 development: 1 × Krypton DCST 178 MVA	110	184	178	174	168
Overhead line	HVAC	1 × Neon SCST 106 MVA	110	109	106	103	100
Overhead line	HVAC	1 × Neon DCST 212 MVA	110	218	212	206	200
Overhead line	HVAC	Stage 1 development: 1 × Neon DCST 212 MVA	110	218	212	206	200
Overhead line	HVAC	Stage 2 development: 1 × Neon DCST 212 MVA	110	218	212	206	200
Overhead line	HVAC	1 × Uranus SCST 111 MVA	66	114	111	106	102
Overhead line	HVAC	1 × Uranus DCST 222 MVA	66	228	222	212	204
Overhead line	HVAC	Stage 1 development: 1 × Uranus DCST 222 MVA	66	228	222	212	204
Overhead line	HVAC	Stage 2 development: 1 × Uranus DCST 222 MVA	66	228	222	212	204
Overhead line	HVAC	1 × Taurus SCST 86 MVA	66	89	86	84	81
Overhead line	HVAC	1 × Taurus DCST 172 MVA	66	178	172	168	162
Overhead line	HVAC	Stage 1 development: 1 × Taurus DCST 172 MVA	66	178	172	168	162
Overhead line	HVAC	Stage 2 development: 1 × Taurus DCST 172 MVA	66	178	172	168	162
Overhead line	HVAC	1 × Neptune SCST 55 MVA	66	56	55	53	51
Overhead line	HVAC	1 × Neptune DCST 110 MVA	66	112	110	106	102
Overhead line	HVAC	Stage 1 development: 1 × Neptune DCST 110 MVA	66	112	110	106	102
Overhead line	HVAC	Stage 2 development: 1 × Neptune DCST 110 MVA	66	112	110	106	102
Overhead line	HVAC	3 × Neptune SCST 82 MVA	33	84	82	79	77

Category	Subcategory	Detail	Voltage (kV)	Rating (MVA)			
				30ºC	35ºC	40ºC	45ºC
Overhead line	HVAC	3 × Neptune DCST 164 MVA	33	168	164	158	154
Overhead line	HVAC	Stage 1 development: 3 × Neptune DCST 164 MVA	33	168	164	158	154
Overhead line	HVAC	Stage 2 development: 3 × Neptune DCST 164 MVA	33	168	164	158	154
Overhead line	HVAC	1 × Uranus SCST 55 MVA	33	57	55	53	51
Overhead line	HVAC	1 × Uranus DCST 110 MVA	33	114	110	106	102
Overhead line	HVAC	Stage 1 development: 1 × Uranus DCST 110 MVA	33	114	110	106	102
Overhead line	HVAC	Stage 2 development: 1 × Uranus DCST 110 MVA	33	114	110	106	102
Overhead line	HVAC	1 × Taurus SCST 43 MVA	33	45	43	42	41
Overhead line	HVAC	1 × Taurus DCST 86 MVA	33	90	86	84	82
Overhead line	HVAC	Stage 1 development: 1 × Taurus DCST 86 MVA	33	90	86	84	82
Overhead line	HVAC	Stage 2 development: 1 × Taurus DCST 86 MVA	33	90	86	84	82
Overhead line	HVAC	3 × Neptune SCST 55 MVA	22	56	55	53	51
Overhead line	HVAC	3 × Neptune DCST 110 MVA	22	112	110	106	102
Overhead line	HVAC	Stage 1 development: 3 × Neptune DCST 110 MVA	22	112	110	106	102
Overhead line	HVAC	Stage 2 development: 3 × Neptune DCST 110 MVA	22	112	110	106	102
Overhead line	HVAC	3 × Fluorine SCST 26 MVA	22	27	26	26	25
Overhead line	HVAC	3 × Fluorine DCST 52 MVA	22	54	52	52	50
Overhead line	HVAC	Stage 1 development: 3 × Fluorine DCST 52 MVA	22	54	52	52	50
Overhead line	HVAC	Stage 2 development: 3 × Fluorine DCST 52 MVA	22	54	52	52	50

Table 2.21 summarises the new building blocks from the category “Overhead lines”, subcategory “HVAC with “HTLS conductor” added to the transmission cost database in this update. We have incorporated the complete cost information in the Excel Workbook Tab “Data Building Block escalated”.

We calculated the ratings for 1 m/s wind speed, and a summer day with the following air temperatures: 30ºC, 35ºC (standard adopted), 40ºC, and 45ºC.

Table 2.21: HVAC HTLS overhead lines – new building blocks

Category	Subcategory	Detail	Voltage (kV)	Rating (MVA)			
				30ºC	35ºC	40ºC	45ºC
Overhead line	HVAC with HTLS conductor	1 × HTLS Conductor SCST 1,045 MVA	330	1,103	1,045	994	941

Category	Subcategory	Detail	Voltage (kV)	Rating (MVA)			
				30ºC	35ºC	40ºC	45ºC
Overhead line	HVAC with HTLS conductor	2 × HTLS Conductor SCST 1,302 MVA	330	1,375	1,302	1,237	1,172
Overhead line	HVAC with HTLS conductor	2 × HTLS Conductor DCST 2,090 MVA	330	2,206	2,090	1,987	1,882
Overhead line	HVAC with HTLS conductor	Stage 1 development:2 × HTLS Conductor DCST 2,090 MVA	330	2,206	2,090	1,987	1,882
Overhead line	HVAC with HTLS conductor	Stage 2 development: 2 × HTLS Conductor DCST 2,090 MVA	330	2,206	2,090	1,987	1,882
Overhead line	HVAC with HTLS conductor	2 × HTLS Conductor DCST 2,604 MVA	330	2,750	2,604	2,474	2,343
Overhead line	HVAC with HTLS conductor	Stage 1 development:2 × HTLS Conductor DCST 2,604 MVA	330	2,750	2,604	2,474	2,343
Overhead line	HVAC with HTLS conductor	Stage 2 development: 2 × HTLS Conductor DCST 2,604 MVA	330	2,750	2,604	2,474	2,343
Overhead line	HVAC with HTLS conductor	2 × HTLS Conductor DCST 2,206 MVA	275	2,330	2,206	2,096	1,985
Overhead line	HVAC with HTLS conductor	Stage 1 development: 2 × HTLS Conductor DCST 2,206 MVA	275	2,330	2,206	2,096	1,985
Overhead line	HVAC with HTLS conductor	Stage 2 development: 2 × HTLS Conductor DCST 2,206 MVA	275	2,330	2,206	2,096	1,985
Overhead line	HVAC with HTLS conductor	2 × HTLS Conductor SCST 912 MVA	275	962	912	866	820
Overhead line	HVAC with HTLS conductor	2 × HTLS Conductor SCST 1,214 MVA	275	1,281	1,214	1,154	1,093
Overhead line	HVAC with HTLS conductor	2 × HTLS Conductor DCST 1,724 MVA	220	1,820	1,724	1,638	1,552
Overhead line	HVAC with HTLS conductor	Stage 1 development: 2 × HTLS Conductor DCST 1,724 MVA	220	1,820	1,724	1,638	1,552
Overhead line	HVAC with HTLS conductor	Stage 2 development: 2 × HTLS Conductor DCST 1,724 MVA	220	1,820	1,724	1,638	1,552
Overhead line	HVAC with HTLS conductor	2 × HTLS Conductor DCST 2,018 MVA	220	2,131	2,018	1,917	1,817
Overhead line	HVAC with HTLS conductor	Stage 1 development: 2 × HTLS Conductor DCST 2,018 MVA	220	2,131	2,018	1,917	1,817
Overhead line	HVAC with HTLS conductor	Stage 2 development: 2 × HTLS Conductor DCST 2,018 MVA	220	2,131	2,018	1,917	1,817
Overhead line	HVAC with HTLS conductor	2 × HTLS Conductor SCST 1,009 MVA	220	1,066	1,009	959	909
Overhead line	HVAC with HTLS conductor	1 × HTLS Conductor SCST 505 MVA	220	533	505	479	454
Overhead line	HVAC with HTLS conductor	1 × HTLS Conductor SCST 259 MVA	132	273	259	246	233

3 Forecasting future prices

In Section 2 above we described our method used to break down project costs into separate baskets, for which the costs of each are escalated using weighted averages of a group of published price indices. In this section we describe how we have estimated future project costs by developing forecasts of each of the economic indices.

3.1 Forecast method

We undertook statistical analysis to confirm and quantify our understanding of what drives the cost of each index within each basket of items. Seven of the economic indices listed in **Table 2.1** represent the prices of different types of industry outputs. Two other indices we used are the Australian Consumer Price Index (CPI) representing general movements in consumer prices, and the Australian dollar Trade-Weighted Index (TWI) which measures the effective value of the exchange rate against a basket of currencies. A further three indices relate to property transaction costs.

We also endeavoured to represent empirically the general expectation that a large pipeline of engineering construction, particularly large electricity transmission projects, will result in an increase in prices in real terms due to materials supply constraints and a scarcity of experienced personnel.

From our statistical analysis, we established reliable linear relationships between each price index (transformed to real terms by deflating by CPI) and a combination of significant drivers, including:

- resource commodity prices (export prices for aluminium, copper, steel etc.)
- labour costs
- supply constraints, which we represented by the volume of construction activity (as a proxy for demand pressure during cyclic construction activity).

The estimated relationships are based on quarterly observations since 2010. We converted the TWI to a quarterly series by averaging monthly data. We used an autoregressive distributed lag (ARDL) structure estimated by least squares to capture lagged effects of inputs changes on output prices. Lag lengths of up to eight quarters were tested and optimised by minimising the Akaike criterion (AIC).

Finally, we used the estimated relationships to produce forecasts of the price indices based on assumptions about the input variables.

3.1.1 Forecasting equations

Table 3.1 shows the explanatory variables included in estimated relationships developed for each index. Note that construction work done (as a proxy for supply constraints) is a significant explanatory factor for the costs of construction, design services and ferrous metals.

Table 3.1: Included explanatory variables

	ALCU	CABLE	CONST	DESGN	ELEC	LEGAL	OIL	RE	STEELIND
	Basic non-ferrous metal manufacturing	Electric cable and wire manufacturing	Other heavy and civil engineering construction	Engineering design and engineering consulting services	Other electrical equipment manufacturing	Legal services	Petroleum refining and petroleum fuel manufacturing	Real estate services	Iron smelting and steel manufacturing
Lagged dependent variable	✓	✓	✓	✓	✓	✓	✓	✓	✓
Aluminium export price	✓	✓							✓
Copper export price	✓	✓			✓				
Construction wages			✓						
Professional wages				✓		✓		✓	
Steel					✓				✓
Oil spot price							✓		
Construction work done			✓	✓					✓
Exchange rate							✓		
Deterministic trend		✓							
Adjusted R squared	0.936	0.879	0.860	0.905	0.923	0.956	0.964	0.974	0.966
Durbin-Watson stat.	1.962	1.868	1.935	1.615	1.873	1.597	1.733	2.004	1.787

The final estimated relationships provide evidence that the price of:

- basic non-ferrous metals is strongly correlated with aluminium and copper resource prices
- electric cable and wire is strongly influenced by aluminium and copper prices
- other heavy and civil engineering construction is driven by construction industry labour costs and the amount of construction activity
- engineering design and engineering consulting services is related to the cost of labour for these kinds of services
- other electrical equipment is largely driven by the costs of material inputs
- legal costs are driven by professional wages
- petroleum refining and petroleum fuel manufacturing is simply explained by the international oil price and the Australian dollar exchange rate
- real estate services is driven by professional wages
- iron smelting and steel manufacturing is strongly related to world prices that can be achieved for steel and construction industry demand.

3.2 Input data and assumptions

3.2.1 Commodity prices

Our source for historical commodity prices was Resources and Energy Quarterly.[16] The price of steel was calculated from trade values and volumes from the same source. Since this was an empirical exercise to determine movements in certain price indices outside of general inflationary price movements, we deflated all price indices by CPI.

This avoids picking up spuriously strong relationships between series that generally trend upwards. It is also provides a convenient form for our index forecasts in real terms to develop baskets of project costs in June 2022 dollars, without the need for further manipulation.

3.2.2 Labour costs

We have represented the cost of labour by two series from ABS Wage Price Indices, with the following identifiers:

- Construction − ABS 6345.0 original (quarterly index numbers) series ID A2603589K
- Professional, scientific, and technical services − ABS 6345.0 original (quarterly index numbers) series ID A2603479W.

3.2.3 Supply constraints/demand pressure

We captured demand for resources with the volume of construction activity, measured by the total real value of construction work done, sourced from ABS 8762.0 Table 1, with series identifier A1831455A.

3.2.4 Future input values

We sourced commodity price forecasts to June 2024 from Resources and Energy Quarterly[17]. In the longer term, commodity prices undergo cycles. However, we considered that there is no strong evidence that they may go up or down, and the timing of cyclic behaviour, over the forecast horizon. Accordingly, beyond June 2024, we assumed commodity prices remain

[16] Department of Industry, Science and Resources, Commonwealth of Australia, Resources and Energy Quarterly December 2022, published 19/12/2022.

[17] Ibid.

constant in real terms reflecting on-going global supply/demand constraints for transmission infrastructure specific goods and services.

The same publication also informed forecasts for CPI and TWI to June 2024. Beyond that, we have assumed that CPI will return to an annual rate of increase of 2.5 per cent per annum in line with the Australia Reserve Bank target for CPI and we have assumed the TWI to remain constant at its June 2024 value, on the grounds that longer term movements in the exchange rates involved are essentially unknowable.

There have been periods in Australian economic history when real wages have generally risen and a long recent period when they have declined. We see no strong reason to believe that they will generally go up or down over the forecast horizon.

Therefore, for the purpose of the forecasts, we assumed future labour costs will increase at the same rate as CPI, i.e., constant in real terms due to the reduced bargaining power of workers evidenced in the last decade.

We also assumed that future construction activity (measured in real dollar values) will continue to increase at current levels until 2026 then remains steady in real terms until 2030 when it begins steadily declining in real turns, reflecting a high level of construction activity, particularly in this sector, until at least 2030 in line with AEMO's 2022 Integrated System Plan.

3.2.5 Land values

Project specific land values feed into easement and property acquisition costs. To develop a generalised project cost escalation, we have applied the latest year's average state-based farmland value, escalated in each future year by the state-specific 10-year compound average growth rate for the next 4 years.

We considered that the last ten years mostly represent an upswing in the property price cycle and that longer term growth will on average be less than the historical 10-year compound average growth rate. We also considered that the fixed quantity of land makes it subject to an increasing scarcity value (unlike labour and commodities).

Therefore, beyond 2026 and up to 2040 we assumed that land values will tend to grow at greater than zero and less than the current 10-year growth rate in real terms, averaging at half that growth rate to reflect on-going high bargaining power of landowners as available routes for transmission infrastructure diminish.

3.3 Forecast results

Forecast outcomes in real terms[18], shown below in Figure 3.1 and Table 3.2 may be summarised as follows:

- Recent strong increases in the cost of basic non-ferrous metals (ALCU) come to an end in the forecast period, consistent with our assumption above that real commodity prices are fixed beyond 2024 at their June 2024 levels
- Consequently, the cost of electric cable and wire (CABLE) also starts to level off after 2024 in line with our assumptions about Aluminium and Copper prices
- The cost of other heavy and civil engineering construction (CONST) continues to rise gradually but steadily due to the estimated impact of increasing costs of specialised labour despite overall construction activity in this sector declining from 2030
- The cost of specialised engineering design and engineering consulting services (DESGN) continues to rise to 2025-26 then begins steadily falling in real terms despite wage increases

[18] All indices were deflated by CPI.

due to our assumption above about high levels of overall construction activity beginning to ease in the second half of the decade. This is consistent with the circa ten year time frame in bringing qualified and experienced transmission infrastructure engineers and technicians to market

- The cost of other electrical equipment (ELEC) will level off after 2024 in line with our assumptions about copper and steel prices
- The cost of specialised real estate services (RE) will ease in response to falling activity in this sector generally, before starting to rise at close to historic rates over the forecast period, reflecting the increase in demand for such services specific to transmission infrastructure projects
- The cost of legal services (LEGAL) rises steadily in real terms over the forecast period, in line with historical movement over the last 10 years. Such services are not specific, per se, to this sector
- The cost of petroleum refining and petroleum fuel manufacturing (OIL) returns to more normal levels following the recent impact on energy prices of the invasion of Ukraine. Consistent with our assumption above longer-term commodity prices, OIL then stays constant in real terms as fuel supplies re-balance
- The cost of iron smelting and steel manufacturing (STEELIND) takes a long time to react to moderating steel prices, but this cost is also affected and supported by continuing high construction industry demand in this sector until 2030 (in line with AEMO's 2022 Integrated System Plan).

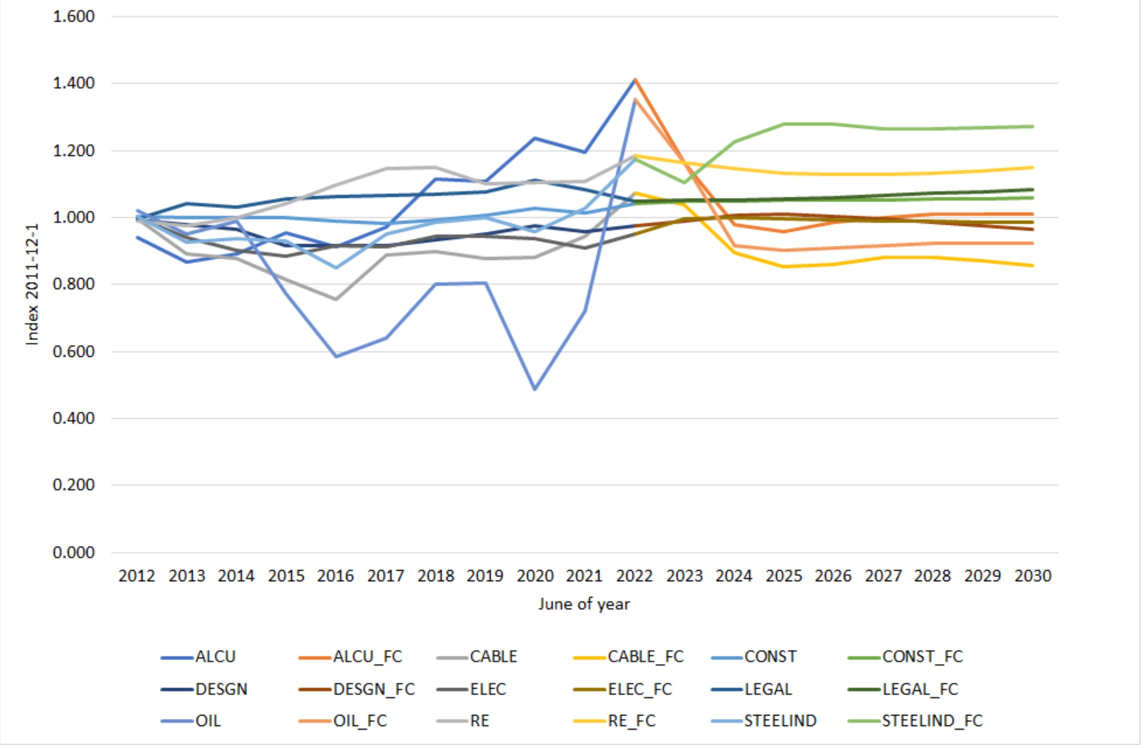

Figure 3.1: Financial year indices and index forecasts deflated by CPI

3.3.1 Escalation factors forecasts

We have included in the Excel Workbook tab “dataforecasts” the forecast costs for all building blocks and cost components for the period 2023-2040. We used the method explained in Section 2 and applied the escalation factors shown in Table 3.3[19].

However, to assess the present value of the future costs presented in the Tab “dataforecasts”, a discount rate will need to be applied to bring the values from the future year to the present, as described in the formula 11.

$$PV = \frac{FV}{(1+i)^n} \quad (11)$$

Where:

- PV is the present value
- FV is the future value
- i is the discount rate (to be chosen by AEMO)
- n is the period (number of years between the future value and the present value)

Table 3.3 presents the escalation factors[20] accumulated for each basket of indices from June 2023 to June 2040, taking June 2022 as the reference. We have therefore applied those escalation factors to the building blocks cost components updated up to June 2022. A discount rate will need to be applied to bring the values from the future year to the present.

Table 3.4 presents the accumulated escalation factors[21] forecasts from June 2023 to June 2040 for the specific building blocks aggregated under basket 1, using June 2022 as the reference. We have applied those escalation factors to each updated cost component to June 2022. A discount rate will need to be applied to bring the values from the future year to the present.

Basket 1 includes the following building blocks:

- switch bay
- property site work and building
- secondary system building.

Table 3.5 presents the accumulated escalation factors[22] forecasts from June 2023 to June 2040 for the specific building blocks aggregated under basket 2, with June 2022 as the reference. We have applied those escalation factors to each cost component updated up to June 2022. A discount rate will need to be applied to bring the values from the future year to the present.

Basket 2 includes the following building block:

- underground cables (HVAC /HVDC)

Table 3.6 presents the accumulated escalation factors[23] forecasts from June 2023 to June 2040 for the specific building blocks aggregated under basket 5, with June 2022 as the reference. We have applied those escalation factors to each cost component updated up to June 2022. A discount rate will need to be applied to bring the values from the future year to the present.

Basket 5 includes the following building blocks:

- CB (circuit breaker)
- CVT (current-voltage transformer)

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[19] CPI was considered as one of the components of baskets 1, 2, 3, 5, 6 and 8 to calculate the escalation factor, but the other components were previously deflated by CPI.

[20] In real terms.

[21] In real terms.

[22] In real terms.

[23] In real terms.

- SA (surge arrestor)
- CT (current transformer)
- ES (earth switch)
- ROI (outdoor insulator)
- HVDC converters
- modular power flow controller.

Table 3.7 presents the accumulated escalation factors[24] forecasts from June 2023 to June 2040 for the specific building blocks aggregated under basket 6, taking June 2022 as the reference. We have applied those escalation factors to each cost component updated up to June 2022. A discount rate will need to be applied to bring the values from the future year to the present.

Basket 6 includes the following building blocks:

- phase shifting transformer
- SVC (Static Var Compensators)
- reactor
- capacitor
- statcom (static synchronous compensator)
- synchronous condenser
- transformer.

Table 3.8 presents the accumulated escalation factors[25] forecasts from June 2023 to June 2040 for the specific building blocks aggregated under basket 6, with June 2022 as the reference. We have applied those escalation factors to each cost component updated up to June 2022. A discount rate will need to be applied to bring the values from the future year to the present.

Basket 8 includes the following building block:

- overhead lines (HVAC /HVDC).

Figure 3.2 provides a summary of the procedures applied to estimate the building block cost components from 2023 to 2040 and bring them to the present value.

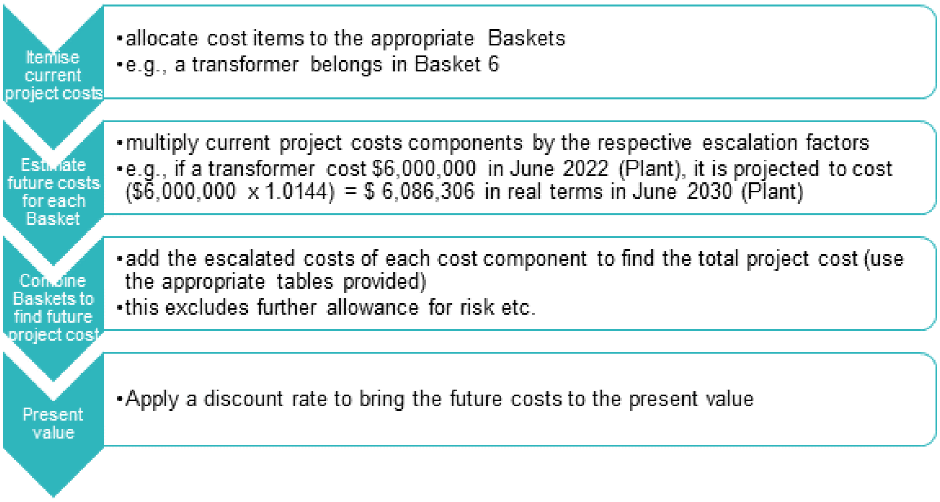

Figure 3.2: Forecasting future costs

[24] In real terms.

[25] In real terms.

Table 3.2: Yearly indices and index forecasts deflated by CPI

June quarter	ALCU	CABLE	CONST	DESGN	ELEC	LEGAL	OIL	RE	STEELIND	TWI	CPI[26]
2011	110.7	99.1	99.6	96.0	100.5	96.9	99.7	103.4	103.0	102.4	99.2
2012	94.2	99.7	100.4	99.5	100.0	99.6	102.3	98.9	100.4	99.2	100.4
2013	86.9	89.1	100.2	98.0	94.0	104.4	95.2	97.7	92.6	97.8	102.8
2014	89.3	87.7	99.9	96.5	90.2	103.1	99.1	100.2	93.6	93.9	105.9
2015	95.4	81.4	100.1	91.7	88.4	105.6	77.3	104.3	93.1	84.2	107.5
2016	91.4	75.6	98.9	91.8	91.8	106.4	58.6	109.9	85.2	82.1	108.6
2017	97.3	88.7	98.4	91.5	91.1	106.8	64.0	114.5	95.0	84.7	110.7
2018	111.5	90.0	99.5	93.5	94.3	107.1	80.3	115.1	98.7	81.9	113.0
2019	111.0	87.7	100.9	95.0	94.3	107.8	80.7	110.0	100.0	78.9	114.8
2020	123.6	88.1	102.7	97.7	93.9	111.1	48.9	110.7	95.9	77.1	114.4
2021	119.7	94.6	101.3	96.0	91.1	108.5	72.1	110.8	102.8	83.3	118.8
2022	141.3	107.5	104.0	97.5	95.1	105.0	135.1	118.5	117.4	82.2	126.1
2023f	116.6	103.7	104.9	98.8	99.7	105.2	116.5	116.3	110.6	80.5	133.9
2024f	98.0	89.7	105.0	100.8	100.1	105.4	91.5	114.7	122.5	81.3	140.0
2025f	95.8	85.4	105.1	101.1	99.7	105.7	90.2	113.4	128.0	81.2	143.5
2026f	98.6	86.0	105.2	100.4	99.4	106.1	90.8	112.8	128.1	81.2	147.1
2027f	100.2	88.1	105.4	99.6	99.1	106.6	91.6	112.8	126.4	81.1	150.9
2028f	101.2	88.2	105.5	98.7	98.9	107.2	92.4	113.3	126.4	81.0	154.7
2029f	101.2	87.0	105.7	97.7	98.8	107.8	92.5	114.0	126.7	81.0	158.6
2030f	101.2	85.7	105.8	96.6	98.7	108.4	92.5	114.9	127.1	81.0	162.6
2031f	101.1	84.7	106.0	95.5	98.6	109.0	92.5	115.9	127.0	81.0	166.7
2032f	101.2	83.8	106.2	94.3	98.5	109.6	92.5	116.9	126.2	81.0	170.9

[26] CPI used to deflate the other indices.

June quarter	ALCU	CABLE	CONST	DESGN	ELEC	LEGAL	OIL	RE	STEELIND	TWI	CPI[26]
2033f	101.2	83.0	106.3	93.2	98.5	110.3	92.5	118.0	125.3	81.0	175.2
2034f	101.2	82.1	106.5	92.1	98.4	110.9	92.5	119.1	124.4	81.0	179.6
2035f	101.2	81.2	106.7	91.0	98.4	111.6	92.5	120.2	123.6	81.0	184.1
2036f	101.2	80.3	106.9	90.0	98.3	112.2	92.5	121.3	122.8	81.0	188.8
2037f	101.2	79.3	107.1	89.0	98.3	112.9	92.5	122.4	122.0	81.0	193.6
2038f	101.2	78.4	107.3	88.1	98.3	113.6	92.5	123.5	121.2	81.0	198.4
2039f	101.2	77.5	107.5	87.2	98.3	114.2	92.5	124.7	120.5	81.0	203.4
2040f	101.2	76.6	107.7	86.3	98.3	114.9	92.5	125.8	119.7	81.0	208.6

Table 3.3: Escalation factors forecasts per basket of indices deflated by CPI

Escalation factors – reference Jun/22									
June quarter	Basket 1	Basket 2	Basket 3	Basket 4	Basket 5	Basket 6	Basket 7	Basket 8	Basket 9
Jun-23	0.9654	0.9741	1.0234	1.0085	0.9949	0.9844	1.0140	0.9668	1.0222
Jun-24	1.0580	0.8979	1.0389	1.0092	1.0131	0.9921	1.0342	0.9619	1.0578
Jun-25	1.1010	0.8736	1.0420	1.0102	1.0197	1.0010	1.0370	0.9627	1.1125
Jun-26	1.1072	0.8800	1.0455	1.0113	1.0225	1.0056	1.0303	0.9680	1.1705
Jun-27	1.1012	0.8966	1.0493	1.0126	1.0227	1.0058	1.0216	0.9750	1.1899
Jun-28	1.1066	0.8993	1.0534	1.0140	1.0248	1.0088	1.0123	0.9777	1.2099
Jun-29	1.1146	0.8929	1.0581	1.0155	1.0274	1.0116	1.0023	0.9757	1.2304
Jun-30	1.1229	0.8863	1.0630	1.0171	1.0301	1.0144	0.9916	0.9737	1.2514
Jun-31	1.1274	0.8811	1.0680	1.0187	1.0322	1.0162	0.9796	0.9710	1.2728
Jun-32	1.1276	0.8767	1.0731	1.0204	1.0336	1.0169	0.9677	0.9673	1.2946
Jun-33	1.1268	0.8720	1.0782	1.0221	1.0349	1.0174	0.9561	0.9630	1.3168
Jun-34	1.1262	0.8670	1.0834	1.0239	1.0363	1.0180	0.9449	0.9585	1.3394
Jun-35	1.1260	0.8618	1.0887	1.0257	1.0378	1.0187	0.9341	0.9541	1.3624

Escalation factors – reference Jun/22									
June quarter	**Basket 1**	**Basket 2**	**Basket 3**	**Basket 4**	**Basket 5**	**Basket 6**	**Basket 7**	**Basket 8**	**Basket 9**
Jun-36	1.1259	0.8566	1.0940	1.0275	1.0393	1.0195	0.9236	0.9498	1.3857
Jun-37	1.1258	0.8515	1.0994	1.0293	1.0408	1.0203	0.9134	0.9455	1.4095
Jun-38	1.1258	0.8463	1.1049	1.0311	1.0424	1.0212	0.9037	0.9412	1.4337
Jun-39	1.1259	0.8411	1.1104	1.0330	1.0440	1.0221	0.8942	0.9368	1.4583
Jun-40	1.1260	0.8358	1.1159	1.0349	1.0456	1.0231	0.8851	0.9325	1.4833

Table 3.4: Escalation factors[27] forecasts per cost components - Building blocks Basket 1

Escalation factors for Building Blocks inside Basket 1 – reference June/2022								
June quarter	**Plant**	**Civil**	**Electrical**	**Secondary systems**	**Design**	**Testing**	**Project management**	**Easement**
Jun-23	0.9654	1.0085	1.0085	1.0234	1.0140	1.0085	1.0140	1.0222
Jun-24	1.0580	1.0092	1.0092	1.0389	1.0342	1.0092	1.0342	1.0578
Jun-25	1.1010	1.0102	1.0102	1.0420	1.0370	1.0102	1.0370	1.1125
Jun-26	1.1072	1.0113	1.0113	1.0455	1.0303	1.0113	1.0303	1.1705
Jun-27	1.1012	1.0126	1.0126	1.0493	1.0216	1.0126	1.0216	1.1899
Jun-28	1.1066	1.0140	1.0140	1.0534	1.0123	1.0140	1.0123	1.2099
Jun-29	1.1146	1.0155	1.0155	1.0581	1.0023	1.0155	1.0023	1.2304
Jun-30	1.1229	1.0171	1.0171	1.0630	0.9916	1.0171	0.9916	1.2514
Jun-31	1.1274	1.0187	1.0187	1.0680	0.9796	1.0187	0.9796	1.2728
Jun-32	1.1276	1.0204	1.0204	1.0731	0.9677	1.0204	0.9677	1.2946
Jun-33	1.1268	1.0221	1.0221	1.0782	0.9561	1.0221	0.9561	1.3168
Jun-34	1.1262	1.0239	1.0239	1.0834	0.9449	1.0239	0.9449	1.3394
Jun-35	1.1260	1.0257	1.0257	1.0887	0.9341	1.0257	0.9341	1.3624
Jun-36	1.1259	1.0275	1.0275	1.0940	0.9236	1.0275	0.9236	1.3857

[27] Deflated by CPI.

June quarter	Plant	Civil	Electrical	Secondary systems	Design	Testing	Project management	Easement
Jun-37	1.1258	1.0293	1.0293	1.0994	0.9134	1.0293	0.9134	1.4095
Jun-38	1.1258	1.0311	1.0311	1.1049	0.9037	1.0311	0.9037	1.4337
Jun-39	1.1259	1.0330	1.0330	1.1104	0.8942	1.0330	0.8942	1.4583
Jun-40	1.1260	1.0349	1.0349	1.1159	0.8851	1.0349	0.8851	1.4833

Table 3.5: Escalation factors[28] forecasts per cost components - Building blocks Basket 2

Escalation factors for Building Blocks inside Basket 2 – reference June/2022								
June quarter	Plant	Civil	Electrical	Secondary systems	Design	Testing	Project management	Easement
Jun-23	0.9741	1.0085	1.0085	1.0234	1.0140	1.0085	1.0140	1.0222
Jun-24	0.8979	1.0092	1.0092	1.0389	1.0342	1.0092	1.0342	1.0578
Jun-25	0.8736	1.0102	1.0102	1.0420	1.0370	1.0102	1.0370	1.1125
Jun-26	0.8800	1.0113	1.0113	1.0455	1.0303	1.0113	1.0303	1.1705
Jun-27	0.8966	1.0126	1.0126	1.0493	1.0216	1.0126	1.0216	1.1899
Jun-28	0.8993	1.0140	1.0140	1.0534	1.0123	1.0140	1.0123	1.2099
Jun-29	0.8929	1.0155	1.0155	1.0581	1.0023	1.0155	1.0023	1.2304
Jun-30	0.8863	1.0171	1.0171	1.0630	0.9916	1.0171	0.9916	1.2514
Jun-31	0.8811	1.0187	1.0187	1.0680	0.9796	1.0187	0.9796	1.2728
Jun-32	0.8767	1.0204	1.0204	1.0731	0.9677	1.0204	0.9677	1.2946
Jun-33	0.8720	1.0221	1.0221	1.0782	0.9561	1.0221	0.9561	1.3168
Jun-34	0.8670	1.0239	1.0239	1.0834	0.9449	1.0239	0.9449	1.3394
Jun-35	0.8618	1.0257	1.0257	1.0887	0.9341	1.0257	0.9341	1.3624
Jun-36	0.8566	1.0275	1.0275	1.0940	0.9236	1.0275	0.9236	1.3857
Jun-37	0.8515	1.0293	1.0293	1.0994	0.9134	1.0293	0.9134	1.4095
Jun-38	0.8463	1.0311	1.0311	1.1049	0.9037	1.0311	0.9037	1.4337
Jun-39	0.8411	1.0330	1.0330	1.1104	0.8942	1.0330	0.8942	1.4583

[28] Deflated by CPI.

June quarter	Plant	Civil	Electrical	Secondary systems	Design	Testing	Project management	Easement
Jun-40	0.8358	1.0349	1.0349	1.1159	0.8851	1.0349	0.8851	1.4833

Table 3.6: Escalation factors[29] forecasts per cost components - Building blocks Basket 5

Escalation factors for Building Blocks inside Basket 5 – reference June/2022								
June quarter	Plant	Civil	Electrical	Secondary systems	Design	Testing	Project management	Easement
Jun-23	0.9949	1.0085	1.0085	1.0234	1.0140	1.0085	1.0140	1.0222
Jun-24	1.0131	1.0092	1.0092	1.0389	1.0342	1.0092	1.0342	1.0578
Jun-25	1.0197	1.0102	1.0102	1.0420	1.0370	1.0102	1.0370	1.1125
Jun-26	1.0225	1.0113	1.0113	1.0455	1.0303	1.0113	1.0303	1.1705
Jun-27	1.0227	1.0126	1.0126	1.0493	1.0216	1.0126	1.0216	1.1899
Jun-28	1.0248	1.0140	1.0140	1.0534	1.0123	1.0140	1.0123	1.2099
Jun-29	1.0274	1.0155	1.0155	1.0581	1.0023	1.0155	1.0023	1.2304
Jun-30	1.0301	1.0171	1.0171	1.0630	0.9916	1.0171	0.9916	1.2514
Jun-31	1.0322	1.0187	1.0187	1.0680	0.9796	1.0187	0.9796	1.2728
Jun-32	1.0336	1.0204	1.0204	1.0731	0.9677	1.0204	0.9677	1.2946
Jun-33	1.0349	1.0221	1.0221	1.0782	0.9561	1.0221	0.9561	1.3168
Jun-34	1.0363	1.0239	1.0239	1.0834	0.9449	1.0239	0.9449	1.3394
Jun-35	1.0378	1.0257	1.0257	1.0887	0.9341	1.0257	0.9341	1.3624
Jun-36	1.0393	1.0275	1.0275	1.0940	0.9236	1.0275	0.9236	1.3857
Jun-37	1.0408	1.0293	1.0293	1.0994	0.9134	1.0293	0.9134	1.4095
Jun-38	1.0424	1.0311	1.0311	1.1049	0.9037	1.0311	0.9037	1.4337
Jun-39	1.0440	1.0330	1.0330	1.1104	0.8942	1.0330	0.8942	1.4583
Jun-40	1.0456	1.0349	1.0349	1.1159	0.8851	1.0349	0.8851	1.4833

[29] Deflated by CPI.

Table 3.7: Escalation factors[30] forecasts per cost components - Building blocks Basket 6

Escalation factors for Building Blocks inside Basket 6 – reference June/2022								
June quarter	**Plant**	**Civil**	**Electrical**	**Secondary systems**	**Design**	**Testing**	**Project management**	**Easement**
Jun-23	0.9844	1.0085	1.0085	1.0234	1.0140	1.0085	1.0140	1.0222
Jun-24	0.9921	1.0092	1.0092	1.0389	1.0342	1.0092	1.0342	1.0578
Jun-25	1.0010	1.0102	1.0102	1.0420	1.0370	1.0102	1.0370	1.1125
Jun-26	1.0056	1.0113	1.0113	1.0455	1.0303	1.0113	1.0303	1.1705
Jun-27	1.0058	1.0126	1.0126	1.0493	1.0216	1.0126	1.0216	1.1899
Jun-28	1.0088	1.0140	1.0140	1.0534	1.0123	1.0140	1.0123	1.2099
Jun-29	1.0116	1.0155	1.0155	1.0581	1.0023	1.0155	1.0023	1.2304
Jun-30	1.0144	1.0171	1.0171	1.0630	0.9916	1.0171	0.9916	1.2514
Jun-31	1.0162	1.0187	1.0187	1.0680	0.9796	1.0187	0.9796	1.2728
Jun-32	1.0169	1.0204	1.0204	1.0731	0.9677	1.0204	0.9677	1.2946
Jun-33	1.0174	1.0221	1.0221	1.0782	0.9561	1.0221	0.9561	1.3168
Jun-34	1.0180	1.0239	1.0239	1.0834	0.9449	1.0239	0.9449	1.3394
Jun-35	1.0187	1.0257	1.0257	1.0887	0.9341	1.0257	0.9341	1.3624
Jun-36	1.0195	1.0275	1.0275	1.0940	0.9236	1.0275	0.9236	1.3857
Jun-37	1.0203	1.0293	1.0293	1.0994	0.9134	1.0293	0.9134	1.4095
Jun-38	1.0212	1.0311	1.0311	1.1049	0.9037	1.0311	0.9037	1.4337
Jun-39	1.0221	1.0330	1.0330	1.1104	0.8942	1.0330	0.8942	1.4583
Jun-40	1.0231	1.0349	1.0349	1.1159	0.8851	1.0349	0.8851	1.4833

[30] Deflated by CPI.

Table 3.8: Escalation factors[31] forecasts per cost components - Building blocks Basket 8

Escalation factors for Building Blocks inside Basket 8 – reference June/2022								
June quarter	**Plant**	**Civil**	**Electrical**	**Secondary systems**	**Design**	**Testing**	**Project management**	**Easement**
Jun-23	0.9668	1.0085	1.0085	1.0234	1.0140	1.0085	1.0140	1.0222
Jun-24	0.9619	1.0092	1.0092	1.0389	1.0342	1.0092	1.0342	1.0578
Jun-25	0.9627	1.0102	1.0102	1.0420	1.0370	1.0102	1.0370	1.1125
Jun-26	0.9680	1.0113	1.0113	1.0455	1.0303	1.0113	1.0303	1.1705
Jun-27	0.9750	1.0126	1.0126	1.0493	1.0216	1.0126	1.0216	1.1899
Jun-28	0.9777	1.0140	1.0140	1.0534	1.0123	1.0140	1.0123	1.2099
Jun-29	0.9757	1.0155	1.0155	1.0581	1.0023	1.0155	1.0023	1.2304
Jun-30	0.9737	1.0171	1.0171	1.0630	0.9916	1.0171	0.9916	1.2514
Jun-31	0.9710	1.0187	1.0187	1.0680	0.9796	1.0187	0.9796	1.2728
Jun-32	0.9673	1.0204	1.0204	1.0731	0.9677	1.0204	0.9677	1.2946
Jun-33	0.9630	1.0221	1.0221	1.0782	0.9561	1.0221	0.9561	1.3168
Jun-34	0.9585	1.0239	1.0239	1.0834	0.9449	1.0239	0.9449	1.3394
Jun-35	0.9541	1.0257	1.0257	1.0887	0.9341	1.0257	0.9341	1.3624
Jun-36	0.9498	1.0275	1.0275	1.0940	0.9236	1.0275	0.9236	1.3857
Jun-37	0.9455	1.0293	1.0293	1.0994	0.9134	1.0293	0.9134	1.4095
Jun-38	0.9412	1.0311	1.0311	1.1049	0.9037	1.0311	0.9037	1.4337
Jun-39	0.9368	1.0330	1.0330	1.1104	0.8942	1.0330	0.8942	1.4583
Jun-40	0.9325	1.0349	1.0349	1.1159	0.8851	1.0349	0.8851	1.4833

[31] Deflated by CPI.

4 Stakeholder engagements

Following the description of supplies, we delivered two webinars together with AEMO for key stakeholders, including representatives from TNSPs, electricity consumers, as well as staff from AEMO.

4.1 Webinar 1

The first webinar was held on 21 October 2022 and the main discussion and feedback received is summarised as follows:

- Community engagement (to secure a social licence to operate) is important to reduce the barriers for new projects
- The commodity prices and labour costs are used as a proxy to forecast future prices for new transmission projects
- State government announcements of renewable energy zones and similar initiatives to attract investment for each state transmission system would impact the future costs.

4.2 Webinar 2

The second webinar was held on 25 November 2022. The main discussion and feedback received is summarised as follows:

- Due to social licence issues in some areas, there should be benchmarking for underground cables and AEMO should consider this option more often within its studies. There is limited information about the cost of underground transmission projects in Australia
- CPI might not be a suitable index to update the easement/property costs and environmental offset costs. The New South Wales $200k/km incentive and its potential impacts on the costs of new projects were also mentioned
- One of agreements made during the webinar was to have a workshop with Mark Grenning, from the AEMO ISP Consumer Panel, to discuss land access/biodiversity and the need to take into consideration planned activity in this sector, tempored by likely outturn of transmission infrastructure build out over time. I.e., to take account of the capacity constraints, of supplies, contractors and TNSPs arising from the projected material increase in transmission infrastructure over that which occurred in Australia in the last decade
- The proposal to use LME[32] copper and aluminium futures costs as a proxy for forecasting transmission costs were well discussed in the Q&A session. Stakeholders suggested that Mott MacDonald's report should present the correlations between the previous data from LME with the selected ABS economic indices to justify their use to forecast the transmission costs
- Some state governments had introduced incentives to encourage local manufacture of infrastructure goods, including transmission cables and towers. Stakeholders discussed how these might be addressed in the future price forecasts
- Stakeholders discussed that the number of infrastructure projects and the scale in the forecasting period is uncertain: both projected and actual outturn of the number of projects may impact on costs from a supply/demand balance perspective.

A workshop session with representatives from the ISP Consumer Panel (including Mark Grenning), AEMO and Mott MacDonald was held on 5 December 2022. At this workshop,

[32] The London Metal Exchange is an international centre for the trading of industrial metals

stakeholders provided feedback on easement and property costs, biodiversity impacts and costs, as well as future price forecasts. We have considered all feedback received from stakeholders to write this report.

5 Areas for improvement

In the short term (up to 3 years), we consider that the escalation factors approach we have taken to update the cost components of the building blocks is well designed but that any escalations adopted will benefit from a periodic update of the economic indices by AEMO.

During this period, it will be important for AEMO to have a well-established procedure to collect data from new transmission projects developed by TNSPs. This will provide an Australian benchmark for the Transmission Cost Database and could be used to re-calibrate the parameters adopted in this report and incorporate new building blocks after 3 years.

As such and in order to optimise this process and reduce the time spent to assess and validate transmission cost data provided by TNSPS we consider that there will be merit in AEMO periodically collecting transmission infrastructure cost data e.g., from TNSPs. We further consider that the process for collecting such data will be improved by AEMO specifying example projects / infrastructure for which costs are being sought.

Another alternative to improve the availability of data from transmission projects would be a partnership between AEMO and AER to share the appropriate data used by the regulator to assess the regulatory investment test for transmission (RIT-T). The AER has access to a broader list of technical parameters of the main assets, as well as their performance measured by AEMO.

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