GHD Advisory

ISP Transmission Cost Database Tool: 2025 Update

AEMO

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→ The Power of Commitment

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Executive summary

Context

The Australian Energy Market Operator Limited (AEMO) oversees the energy markets and systems in eastern, south-eastern, and western Australia. One of AEMO's key objectives is to foster efficient investment and operation within Australia's electricity market, ensuring long-term benefits for consumers in terms of price, quality, safety, reliability, and security of energy supply.

As part of this objective, AEMO, in its role as the National Transmission Planner for the National Electricity Market (NEM), publishes the Integrated System Plan (ISP) every two years. A critical component in developing the ISP is obtaining accurate and market reflective cost estimate data for future electricity transmission networks augmentations within the NEM, which is provided by the Transmission Cost Database (TCD). The TCD is a Microsoft Excel based tool containing the Cost and Risk Data workbook (database file) and the estimation tool using macro programs with the database file embedded in it. It generates repeatable transparent cost estimate results.

AEMO engaged GHD, in collaboration with Amplitude Consultants, to update the TCD with present-day market cost information to inform its upcoming 2026 Integrated System Plan (ISP).

Approach

GHD updated the cost estimates and its adjustment variables for high voltage alternating current (HVAC) assets based on survey responses from NEM transmission network service providers (TNSPs) covering various asset classes, kV levels and across jurisdictions. Amplitude Consultants updated the cost estimate and its adjustment variable for high voltage direct current (HVDC) assets based on its internal database informed by recent global project delivery experience. Additionally, both GHD and Amplitude Consultants, along with their connections to Original Equipment Manufacturers (OEMs) collected equipment/plant cost information on wide range of assets.

The considerable number of transmission projects currently planned or underway by various TNSPs across the NEM, allowed for a comprehensive cost information update across a wide range of assets — an opportunity that was not as extensively available during the inaugural development of the TCD in 2021 or its update in 2023.

Following the review and update of variables within the Cost and Risk Data workbook based on industry survey responses, one-on-one workshop with each survey participant, extrapolation of available cost data, and use of engineering judgement, GHD and Amplitude Consultants performed benchmarking of cost estimate results generated from the updated 2025 TCD against multiple projects from jurisdictional planning bodies. These benchmarking projects were not part of the survey response. This led to calibration and refinement (i.e., adjustment) of the variables within the Cost and Risk Data workbook to have the TCD Tool output better match the benchmarking project estimates.

GHD and Amplitude Consultants also delivered two webinars while delivering this engagement, first to the ISP Consumer Panel on 9 December 2024 and the second to NEM TNSPs and jurisdictional planning bodies on 13 December 2024. These webinars presented the TCD update approach, initial observations based on macroeconomic analysis, sample from survey response, and likely drivers of change.

This work was undertaken from November 2024 to March 2025. The scope of this work is detailed in Section 1.1 and this approach is detailed in Section 1.2.

Updates to asset building block baseline estimates

The 2025 TCD update has led to removal of a few asset building blocks (for e.g., HVAC distribution overhead lines), description changes or rewording of a few asset building blocks (for e.g., HVDC and modular power flow controller assets), and inclusion of new asset building blocks (for e.g., HVDC assets, station property site work and building for larger areas etc.).

The 2025 TCD update has led to adjustment of all asset building block baseline estimates. For asset building blocks for which direct survey response was unavailable, they were updated by extrapolating changes observed in similar asset subcategories, asset technologies or construction process and relied on engineering judgement.

Readers and TCD Tool users are cautioned not to compare the asset building block baseline estimates between the updated 2025 TCD and the previous 2023 TCD version as this can lead to misleading conclusions. Some of the asset building block baseline estimates have been re-baselined or corrected. For e.g., in the updated 2025 TCD Tool, the baseline estimates for all overhead lines asset category are now based on projects being constructed in a regional location (which gets adjusted in subsequent input steps based on user location selection), whereas it was based on project being constructed in an urban location in the previous 2023 TCD version. Similarly, the baseline estimates for all HVDC converter station asset subcategory have been corrected. This update is described in Section 2.1 in detail.

Update to project attribute factors

The 2025 TCD update resulted in amalgamation of two project attribute factors into one (jurisdiction and land use), changes to choices available within two project attribute factors (project network element size and the amalgamated factor), and also the percentage adjustment values for few project attribute factors. The location/distance factor saw significant change to the percentage adjustment values. These updates are described in Section 2.2 in detail.

Update to known risk factors

The 2025 TCD update has resulted in changes to choices available within a known risk factor (environmental offset risks) and the percentage adjustment values for a few known risk factors. The market activity known risk factor saw significant change to the percentage adjustment values. These updates are described in Section 2.2in detail.

Update to unknown risk factors

The 2025 TCD update did not result in any changes to the factors or the choices available within unknown risk factors. Review of unknown risk factors found no need for material change or update to the percentage adjustment values. These updates are described in Section 2.4 in detail.

Updates to indirect cost

The 2025 TCD update has resulted in changes to the percentage adjustment values for few capex estimate brackets (for larger projects). Presently there is a bug in the TCD Tool wherein it does not consistently calculate three cost components within the indirect costs. This occurs when the following two indirect cost factors, contract delivery model and stakeholder and community sensitive region, are selected. This results in non-material error in estimating the total project costs.

These updates together with this calculation issue is described in Section 2.5 in detail. This calculation issue will be addressed in the next TCD Tool version update in July 2025 alongside the publication of AEMO's final 2025 Electricity Network Options Report.

Enhancement to TCD Tool user interface

GHD also debugged three issues identified by AEMO to enhance user experience of the TCD Tool pertaining to output cost estimate files containing rows with $0 costs, rounding value less than 1 unit of quantity (km, lot, ea), and managing network elements when they have the same names. This enhancement is described in Section 3 in detail.

Changes from 2023 TCD

Some asset categories and subcategories have experienced substantial changes. It is important to note that such increases are not solely due to general inflation in the economy. Generally, increases are primarily driven by one or more of the following causes:

– Rising prices due to restricted supply to increase demand or tight market condition resulting in higher labour and contracting cost (as generally reflected within the 'Civil and structural works', 'Electrical works' and 'Contractor project management & overheads' cost components in the asset building block baseline estimates).

– Rising overhead in tenderers' bids to service their rising insurance coverage and other mitigation arrangements in response to increasing size of contracts (as reflected within the 'Contractor project management & overheads' cost components in the asset building block baseline estimates).
– Rising prices due to projects being developed in further locations and incurring overhead such as labour LAFHA, mobilisation, transportation, accommodations, site office set-up, plant delivery-to-site etc. being greater than before (as generally reflected within the 'Civil and structural works', 'Electrical works' and 'Contractor project management & overheads' cost components in the asset building block baseline estimates).
– Revising the baseline estimate for biodiversity offset costs (as reflected within the 'Environmental offset costs' component in the asset building block baseline estimates) which was calculated from first principle basis resulting in significant increase from previous TCD version.
– Increasing cost and time to complete successful community and stakeholder engagement activity in lead up to transmission network projects, especially for overhead transmission line corridors.
– Revising the baseline estimate for certain asset building blocks, because they were potentially underestimated in previous TCD version (for e.g., HVDC converter station asset sub-categories) due to limited example data sets.

To provide an indicative quantum of change in project estimate, three indicative project estimates were compiled using the updated 2025 TCD and the 2023 TCD (escalated to real 2024/25FY $). Two scenarios were created for each indicative project, with unfavourable and favourable conditions, to compile the estimate for each project to demonstrate the upper and lower bounds of estimate range. The range of indicative change across three indicative projects is as follows:

– Total estimate increased by approximately 25% to 55% in real dollar term for a representative HVAC overhead line project between the 2025 TCD and 2023 TCD output depending on the project conditions.
– Total estimate increased by approximately 10% to 35% in real dollar term for a representative HVAC AIS station project between the 2025 TCD and 2023 TCD output depending on the project conditions.
– Total estimate increased by approximately 0% to 35% in real dollar term for a representative HVAC underground cables project between the 2025 TCD and 2023 TCD output depending on the project conditions.
– Total estimate increased by approximately 140% to 180% in real dollar term for a representative HVDC converter station project between the 2025 TCD and 2023 TCD output depending on the project conditions.
– Total estimate increased by approximately 40% to 50% in real dollar term for a representative HVDC subsea cable project between the 2025 TCD and 2023 TCD output depending on the project conditions.
– Total estimate increased by approximately 10% to 30% in real dollar term for a representative HVDC underground cable project between the 2025 TCD and 2023 TCD output depending on the project conditions.
– Total estimate increased by approximately -10% to 25% in real dollar term for a representative HVDC overhead line project between the 2025 TCD and 2023 TCD output depending on the project conditions.

In a few cases, the 2025 TCD update also led to decreases in some cost components (for e.g., 'Plant' cost component of underground cables) informed by survey feedback. However, such decreases have mostly been offset by increases in other cost components.

All these changes are described in Section 5 in detail.

Conclusion

GHD is confident that the 2025 TCD update will provide the users of TCD Tool with significantly improved information for developing new Class 5b cost estimates for transmission network projects.

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Abbreviations

Abbreviation	Meaning
AACE	Association for the Advancement of Cost Engineering
ABARES	Australian Bureau of Agricultural and Resource Economics and Science
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AIS	Air Insulated Switchgear
BAU	Business As Usual
CPA	Contingent Project Application
DCST	Double Circuit Steel Tower
FY	Financial Year
GIS	Gas Insulated Switchgear
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
HTLS	High Temperature Low Sag
ISP	Integrated System Plan
kV	Kilo Volt
LAFHA	Living Away from Home Allowance
LCC	Line Commutated Converter
MVA	Mega Volt Ampere
NEM	National Electricity Market (consisting of jurisdictions of Queensland, New South Wales, Australian Capital Territory, Victoria, South Australia and Tasmania)
OEM	Original Equipment Manufacturer
RIT-T	Regulatory Investment Test for Transmission
SCST	Single Circuit Steel Tower
SVC	Static VAR Compensator
Syncon	Synchronous Condenser
TCD	Transmission Cost Database
TNSP	Transmission Network Service Provider
VSC	Voltage Source Converter

1. Introduction

GHD developed the inaugural TCD in 2021 for the AEMO to inform its 2022 ISP. This was achieved by analysing examples of cost estimation of major projects in the NEM, progressing from early to advanced project stages to deduce the accuracy range and risk factors in early-stage cost estimates. It also referred to the industry recognised Association for the Advancement of Cost Engineering International (AACE) guideline and recommended practice note and then tailoring that guidance to the Australian context.

The TCD generates Class 5b/5a (early stage) project cost estimates in a deterministic fashion, compiling various cost components that make up the total cost. The TCD does this by assembling varieties of asset building blocks from a comprehensive database to match the given scope of work and adjusts their costs to reflect project specific attributes and risk exposures based on user inputs. The TCD was developed in a Microsoft Excel platform and consists of:

– a database of logical building blocks of electricity transmission infrastructure asset estimates and choices of various project scenarios, described by project specific attributes and risks, that can adjust the estimates (this is the Cost and Risk Data workbook); and
– an interface dashboard that allows the user to compile capex estimate by choosing the relevant quantities of infrastructure assets building blocks and describing their project scenarios in a step-by-step manner (this is the estimation tool using macro program); and
– A user manual that provides step-by-step instructions to the TCD Tool user on how to compile the capex estimate.

The TCD is intended to be used by AEMO to estimate the cost of candidate future ISP projects, at early stages of development. It is not intended to be used for detailed estimation of more advanced projects, which require greater design and project definition.

Since 2021, AEMO has made this tool publicly available via its website, and hence this tool is widely used by various industry stakeholders for their own capital project estimate at early stages of project development.

AEMO updated the TCD in 2023 to inform its 2024 ISP. This involved updating the baseline estimate of the infrastructure assets building blocks within the Cost and Risk Data workbook. This update was based mostly on cost escalation or price indexation observed from 2021 to 2023 of resources constituting the cost components in the asset building blocks. This update did not result in any changes to the project attribute factors, risk factors, their selection choices and their percentage adjustment values.

AEMO have engaged GHD, in collaboration with Amplitude Consultants, to update its TCD (2025 update) to reflect the current market cost information to inform its upcoming 2026 ISP.

1.1 Scope

The scope of this work is as follows:

– Update the Cost and Risk Data workbook, using updated project data provided by NEM TNSPs and jurisdictional entities, including:
  - Costs associated with infrastructure asset building blocks and their cost components (Plant, Civil and structural works, Electrical works, Secondary systems, Design & survey, Testing & commissioning, Contractor project management & overheads, Easement/Property costs and Environmental offset costs).
  - Project attribute factors with their percentage adjustment values.
  - Known risk factors with their percentage adjustment values.
  - Unknown risk factor with their percentage adjustment values.
  - Indirect costs with their percentage adjustment values.
  - Associated tasks including advising on the need for additional asset building blocks, project attributes and risk factors (with action on such advice subject to further agreement with AEMO).

– Enhancements to the existing user interface dashboard by debugging three specific issues identified by AEMO.
– Benchmark and test the updated 2025 TCD Tool (taking care to achieve a reasonable level of accuracy against a limited set of test projects with agreement from AEMO).
– Compile a detailed draft report describing what was done and the outcomes, with feedback from AEMO incorporated in the draft report. Before finalising the report for publication, a draft of the TCD Tool will be provided after benchmarking.
– Prepare and deliver two webinars, one for the ISP Consumer Panel and the other for the TNSPs and other stakeholders (by agreement with AEMO) before the end of 2024.
– Prepare and be available to attend a public webinar to be hosted by AEMO after March 2025.

1.2 Approach

With significant investment in the transmission network infrastructure across Australia's east coast to support the energy transition, numerous new HVAC transmission overhead lines and stations are presently being planned, developed for near term delivery, and some being built. This presented GHD an opportunity to survey the NEM TNSPs and OEMs to collect and assess cost information data that they prepared in recent times for their respective capital projects and budgetary quotes for equipment. While GHD prepared a template and instruction notes for the survey participants to populate with cost information, significant effort was needed to appropriately interpret the survey responses and reorganise information provided, for it to suitably inform the updating of the Cost and Risk Data workbook.

Given the unique organisational practices of each participant, their accounting structures, estimating process, organisations of estimate and cost records, project timing, and project contexts meant that a series of one-to-one workshops with each participant were needed to seek clarification, confirm understanding and to request further cost data. Considerable effort was needed to identify inclusions/exclusions of cost items or premiums or risk allowances, within the survey template to filter them to standardise the baseline estimates. This allowed GHD to update the baseline cost estimate with realistic asset building blocks, rather than incorporating the embedded cost of unique project scenarios and risk profiles in the baseline cost estimate.

GHD relied on this survey information (including one to one workshops) to update the Cost and Risk Data workbook containing the HVAC asset building block baseline estimate and associated adjustment variables (i.e., project attribute factors, risk factors and indirect costs). The following table shows the extent of this survey activity without revealing the identity of the participants and their projects.

Table 1 Summary of survey participants and their projects/responses

Survey participants	Survey response
TNSP 1	6 × overhead line projects
	5 × AIS station projects
	1 × GIS station project
TNSP 2	2 × AIS station project
	4 × reactive plant station asset subcategory project
TNSP 3	2 × AIS station projects
	2 × individual AIS component station asset subcategory project
TNSP 4	2 × AIS station project
	2 × overhead line projects

Survey participants	Survey response
	1 × syncon station asset subcategory project
TNSP 5	1 × AIS station project
	1 × overhead line project
	1 × syncon station asset subcategory project
	1 × modular power flow controller station asset subcategory project
OEM 1	Various individual AIS component station asset subcategory – plant cost component
	Various power transformer station asset subcategory – plant cost component
OEM 2	Various individual AIS component station asset subcategory – plant cost component
OEM 3	Various underground cable asset category – plant cost component
OEM 4	GIS station asset subcategory – plant cost component
OEM 5	Various modular power flow controller station subcategory – plant cost component

The timing of projects' cost information surveyed ranged from 2016 to 2024 (calendar years). All historical cost information was updated to 2024/25FY dollar value, using the appropriate prices escalation indices[1].

Where multiple cost information, for the same asset subcategories was available, GHD prioritised the most recent (i.e., 2024/25FY) cost information to capture the present-day market environment. Asset subcategories and asset building blocks for which direct survey response was unavailable, were updated by extrapolating changes observed in similar asset subcategories or asset technologies or construction process by using engineering judgement.

Additionally, GHD also referred to the following three publicly available project information – actual from Powering Sydney's Future, estimate from Humelink undergrounding optioning report, and estimate from MISO Transmission Cost Estimation Guide 2024 report updated to 2024/25FY Australian dollars to cross-reference various asset subcategories building blocks estimates. The latter source of information is from North America and was referenced to appreciate the cost difference between kV or MVA specifications of same asset subcategory or asset building block.

Separately, Amplitude Consultants updated the HVDC asset building block baseline estimate based on its internal database informed by their recent global project delivery experience. Amplitude Consultants also surveyed an OEM to collect equipment/plant cost information of HVDC assets. Amplitude Consultants then reviewed the adjustment variables updated by GHD (i.e., project attribute factors, risk factors and indirect costs) to test suitability for HVDC assets.

GHD and Amplitude Consultants delivered the following two webinars while delivering this engagement:

– To the ISP Consumer Panel on 9 December 2024 to present the TCD update approach, survey response rate and coverage, and initial observation based on macroeconomic analysis.
– To NEM TNSPs and jurisdictional planning bodies on 13 December 2024 to present the TCD update approach, initial observation based on macroeconomic analysis, preliminary observation from survey response, and likely drivers of change in costs.

[1] Historical trend of various cost element baskets (Basket 1 to Basket 9) escalation indices, where each cost element basket index is assigned a fixed combination of underlying price changes in primary commodities, labour, land, other resource inputs, and demand for such resources. Please refer to GHD's 2025 Forecasting Methodology Report on price escalation for the basis of these indices and its usage.

After updating the TCD Tool as described above, GHD and Amplitude Consultant performed benchmarking of cost estimate results generated from the updated 2025 TCD Tool, against multiple projects from jurisdictional planning bodies as shown in the following table in an anonymised format. These benchmarking projects were not part of the survey response and hence independent from data informing the TCD update.

Table 2 Summary of benchmarking participants and their projects

Benchmarking participants	Independently prepared network element estimates for benchmarking
Jurisdictional planning body 1	9 × overhead line projects
	17 × AIS station projects
Jurisdictional planning body 2	2 × AIS station project
	2 × overhead line project
Jurisdictional planning body 3	2 × station project
	1 × undersea cable asset subcategory project
	1 × underground cable asset subcategory project

The benchmarking allowed the variables within the Cost and Risk Data workbook (i.e., asset building block baseline estimate cost components, project attribute factors and risk factors) to be calibrated and adjusted to have the TCD Tool output better match the benchmarking project estimates.

1.3 Contribution and confidentiality

Updating the TCD required significant effort from NEM TNSPs, OEMs, and jurisdictional planning bodies. They provided their cost information reorganised from their internal system and translated into the requested survey template, including engaging in multiple discussions thereafter in a series of one-on-one workshops. Some participants also participated in the benchmarking activities to calibrate and fine tune the variables in the updated TCD Tool.

AEMO, GHD and Amplitude Consultants would like to acknowledge and thank all the participants for their time and effort in updating the TCD Tool. Due to confidentiality requirements, contributing participants and their respective projects have not been identified. This report presents their information without revealing project locations, specification and project name or characteristics so that the readers cannot identify them.

1.4 Purpose of this report

This report provides explanations of the changes made to the TCD Tool due to the 2025 update carried out by GHD and Amplitude Consultants. This report provides AEMO and users of the TCD Tool a reference document of all changes to the previous 2023 TCD version.

1.5 Limitations and disclaimers

This report has been prepared by GHD, with input from Amplitude Consultants, for AEMO and may only be used and relied on by AEMO for the purpose agreed between GHD and AEMO as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than AEMO arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD 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 encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

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2. Update to Cost and Risk Data workbook

The Cost and Risk Data workbook consists of the following variables that are used to compile a project estimate.

– Asset building block baseline estimates consisting of 9 cost components
– Project attribute factors
– Known risk factors
– Unknown risk factors
– Indirect costs consisting of 6 cost components

This section describes the update or changes to each of these variables.

2.1 Update to asset building block baseline estimates

The configuration of asset building block baseline estimates within the Cost and Risk Data workbook is shown in the following illustration. The blue coloured texts immediately below the table indicate the elements of asset building block baseline estimates that were updated.

Figure 1 Organisation of asset building blocks

Asset building block baseline estimates			9 cost components								
			Plant	Civil and structural works	Electrical Works	Secondary systems	Design & survey	Testing & Commissioning	Contractor project management & overheads	Easement/ Property costs	Environmental offset costs
3 asset categories	**22 asset subcategories**	**1008 unique asset building blocks**	$	$	$	$	$	$	$	$	$
			$	$	$	$	$	$	$	$	$
			$	$	$	$	$	$	$	$	$
			$	$	$	$	$	$	$	$	$
			$	$	$	$	$	$	$	$	$
			$	$	$	$	$	$	$	$	$

Updated the description of a few asset subcategories and asset building blocks.

Updated using the survey response, workshops with participants, extrapolation and engineering judgement. Then finetuned by benchmarking.

Updated by recalculating the fundamental variables from first principle.

The asset building blocks are unique and discrete set of capital assets that describes a logical group or block of transmission network infrastructure elements. Each asset building block are described at fairly high level and may

consist of several individual cost items configured and grouped in a certain/standard manner. For e.g. an overhead transmission line asset building block consists of towers, foundations, conductors, insulators, fittings etc. The asset building block baseline estimate therefore represents the cost of delivering this logical and standardised transmission network infrastructure element without any premiums for unusual specification or project scenario. Diligent care has been taken while updating the asset building block baseline estimate to filter out any risk costs or bespoke scope or non-standard allowance.

The 2025 TCD update has resulted in:

- The removal of all distribution voltages (22kV, 33kV and 66kV) within the overhead line HVAC asset subcategory as they are outside the scope of TCD Tool.
- The removal of a specific overhead line asset building block (500kV 2×Olive DCST 3350MVA) within the overhead line HVAC asset subcategory as this specification is not used within the NEM.
- The description change or respecifying of all HVDC asset building blocks within the overhead lines, station and underground cables asset categories to more accurately describe these assets and to more easily match the HVDC system parameters with the equivalent HVDC converters, overhead lines and cables.
- The description change or respecifying of all modular power flow controller within the station asset category to more accurately describe the contemporary technology specification.
- Inclusion of various new HVDC asset building blocks within the overhead lines, station and underground cables asset categories to reflect contemporary technology offering in the market.
- Inclusion of few new modular power flow controller asset building blocks within the station asset category to reflect contemporary technology offering in the market.
- Inclusion of few new property site work and building establishment within the station asset category for larger sites.

The updated 2025 TCD has a total of 1008 unique and standardised asset building blocks, compared to 998 asset building blocks in 2023 TCD version. A complete list of changes to asset building blocks, between the 2023 TCD and 2025 TCD, is provided in the Appendix A.

Each asset building block consists of the 9 cost components as shown in the previous illustration. The first seven cost components were updated informed by the survey response, workshop with participants, extrapolation and using engineering judgement, and then further refined by benchmarking. The treatment of the survey response and the methodology adopted to update these seven cost components are described in the following table. The benchmarking is explained later in Section 4 of this report.

The last two cost components were updated by calculating $/m^2 land price and $/m^2 biodiversity offset price from first principle and then applying them to the size of easements or site footprint areas. The update to these two cost components is explained later in Sections 2.1.1 and 2.1.2 respectively.

Table 3 Description of survey response and the methodology adopted to update the first seven cost components

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
Overhead line - HVAC	The 2025 TCD now has a total of 212 asset building blocks in this asset subcategory across the following types/scenarios: • 132kV to 500kV • Single and double circuits • Different conductors (MVA capacity) • Multiple conductors bundling per phase • Staged development The survey response did not provide cost information for each asset building blocks. GHD inferred the change needed to universally update the asset building block baseline estimates in the 2025 TCD version based on the observed change in the cost information provided.	• 6 × 220kV double circuit (both 2022 early and 2024 mature estimates) • 330kV double circuit (2016 early, 2019 mid-stage and 2024 actuals) • 275kV double circuit (2025 actuals only) • 132kV one double circuit section and two single circuit section – contestable project (2023 mature estimate only) • 330kV double circuit (2023 actual) • 275kV double circuit (2022 actual) • 275kV double circuit future project (2024 early estimate) • 500kV double circuit (2024 early estimate only) • 500kV double circuit (2024 early estimate only)	• GHD received a total of fourteen individual project (per km) data points from the five NEM TNSPs. • Eight of these projects have more than one version of the cost data developed or measured at different point in time (for e.g., early estimate/ mature estimate/ actual). • Eleven of these projects have its cost data developed or measured recently (i.e., during 2024/25FY). • These projects covered 132kV, 220kV, 275kV, 330kV and 500kV. Most of them are double circuit projects. • Given the above diversity of the data points, GHD focused predominantly on those projects whose cost data were developed or measured recently. GHD also focused on those projects which has multiple versions of cost data for different points in time. • GHD paid less attention to survey response data that had project attribute and/or risk factors in-built into its baseline cost. • Excluding the risk contingency allowance, GHD observed that all project cost data represented a significant increase over the 2023 TCD asset building block baseline per km unit rates. • Each TNSP had to reallocate their own project costs structures to match the TCD cost structure. None of the TNSPs have a uniform project costs structures, this required significant engagement and interpretation of their data to ensure comparisons were compatible. • Finally, GHD arrived at various % increase to apply to the relevant cost components except for the 'Easement/Property costs' and 'Environmental offset costs' component of the asset building block baseline estimates. The benchmarking activity further refined these % increase before finalising the 2025 TCD update. • Significant increase is observed in 'Civil and structural works', 'Electrical works' and 'Contractor project management and overheads' cost components of the asset building block baseline estimates. Significant increase is also observed in 'Environmental offset costs' component which is explained separately in the next sub-section of this report.
Overhead line - HVAC line diversion	The 2025 TCD now has a total of 160 asset building blocks in this asset subcategory across the following types:	The survey response did not provide any cost information specific for this asset subcategory. GHD therefore inferred the change needed to universally update the building block	No cost information was available for this asset subcategory. Professional judgment was applied to estimate the cost, which was primarily based on GHD's view regarding changes observed in the HVAC overhead line asset category.

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
	• 132kV to 500kV • Type 1 to Type 6 design • Multiple conductors bundling per phase	baseline costs in the existing TCD version based on the observed change in the provided cost information for the HVAC subcategory.	
Overhead line - HVAC with HTLS conductor	The TCD now has a total of 65 asset building blocks in this asset subcategory across the following types/scenarios: • 132kV to 330kV • Single and double circuits • Different MVA capacity • Multiple conductors bundling per phase • Staged development	The survey response did not provide any cost information specific for this asset subcategory. GHD therefore inferred the change needed to universally update the building block baseline costs in the existing TCD version based on the observed change in the provided cost information for the HVAC subcategory.	No cost information was available for this asset subcategory. Professional judgment was applied to estimate the cost, which was primarily based on GHD's view regarding changes to HVAC overhead line asset category.
Overhead line - HVDC - LCC	The TCD now has a total of 15 asset building blocks in this asset subcategory across the following types/scenarios: • 320kV, 525kV and 640kV. • Monopole and bipole configurations. • Different MW/pole capacities. • Staged development.	No survey was undertaken for this HVDC asset subcategory.	The asset building blocks in this asset subcategory have been updated with new asset detail, description and notes to better reflect the terminology, specification and real-world configuration/usage of this technology. The cost for these asset building blocks were updated based on bottom-up estimation, market research and Amplitude Consultant's knowledge of this technology. The HVDC cost estimation build-up was tested and adjusted with reference to the 220kV HVAC overhead cost estimating.
Overhead line - HVDC - VSC	The TCD now has a total of 23 asset building blocks in this asset subcategory across the following types/scenarios: • ±320kV, ±525kV and ±640kV.	No survey was undertaken for this HVDC asset subcategory	The asset building blocks in this asset subcategory have been updated with new asset detail, description and notes to better reflect the terminology, specification and real-world configuration/usage of this technology. The cost for these asset building blocks were updated based on bottom-up estimation, market research and Amplitude Consultant's knowledge of this technology. The HVDC cost estimation build-up was tested and adjusted with reference to the 220kV HVAC overhead cost estimates.

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
	• Symmetric monopole, bipole and double symmetric monopole configurations. • Different MW/pole capacities. • Staged development.		
Station - AIS individual component [Circuit Breaker, Capacitive Voltage Transformer, Current Transformer, Earth Switch, Disconnector, Surge Arrestor etc.]	The TCD now has a total of 56 asset building blocks in this asset subcategory across the following types: • 132kV to 500kV • Different switchgear equipment The survey response provided the estimates for the plant cost component for each asset building block, and for many of them two sets of data were received.	• AIS individual equipment (various kV) (2024 budgetary estimate for plant cost component) • AIS individual equipment (various kV) (2024 budgetary estimate for plant cost component) • 500kV and 220kV AIS individual equipment (CT, CB and Disc) – non-contestable project (2024 early estimates) • AIS individual equipment (various kV) (2024 early estimate)	• GHD referred to four different sources. Two were from OEMs providing the only the plant cost component estimate. The third source was from TNSP replacement project providing estimates for circuit breaker, current transformer and disconnector. The fourth source were estimates from the USA. • TNSP provided estimates for 500kV and 220kV for circuit breaker, current transformer and disconnector were magnitude times more (for e.g., ×5) than the previous 2023 TCD version. While GHD confirmed that there was no inclusion of risk contingency, GHD suspected that it contained elements of other project scope (for e.g., property site establishment cost) in the unit rate and hence ignored TNSP estimates. • Based on the qualification of provided estimates, inclusion of necessary scope elements, and coverage of different kV level and asset types, GHD opted to use the OEM provided estimates to update the plant cost component. • The remaining cost components in the baseline estimate were increased by similar % as observed in the AIS Switchbay asset subcategory cost components.
Station - AIS individual component [busbar, rack]	The TCD now has a total of 10 asset building blocks in this asset subcategory across the following types: • 132kV to 500kV • Different switchyard structure	The survey response did not provide any cost information specific for this asset subcategory. GHD therefore inferred the change needed to universally update the building block baseline costs in the existing TCD version based on the cost updates performed for AIS Switchbay assets.	• These are substation structures and gantries, and GHD did not receive any cost information on these specific asset subcategory and types in isolation. • The applicable cost components were increased by similar % as observed in the AIS Switchbay asset subcategory cost components.
Station - AIS Switchbay	The TCD now has a total of 30 asset building blocks in this asset subcategory across the following types/scenarios:	• 220kV AIS switching station (both 2022 early and 2024 mature estimates)	• GHD received a total of sixteen individual substation project cost data with AIS Switchbay scope from the five NEM TNSPs. • Nine of these projects have more than one version of the cost data developed or measured at different point in time (for e.g., early estimate/ mature estimate).

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
	• 132kV to 500kV • Different configuration • Different qty of circuit breaker in each configuration The survey response did not provide cost information for each building block assets with exact matching scope. GHD inferred the change needed to universally update the building block baseline estimates in the existing TCD version based on the observed change in the provided cost information and after isolating the matching scope as much as possible.	• 220kV AIS switching station (both 2022 early and 2024 mature estimates) • 220kV AIS switching station (both 2022 early and 2024 mature estimates) • 220kV AIS switching station (both 2022 early and 2024 mature estimates) • 220kV AIS switching station (both 2022 early and 2024 mature estimates) • 330kV and 275kV AIS substation – provided separately (2016 early, 2019 mid-stage and 2024 actuals) • 220/33kV AIS substation – contestable project 1 (2024 mature estimate only) • 500/220kV AIS substation – contestable project 2 (2022 mature estimate only) • 220kV AIS bay – non-contestable project 1 (2023 mid-stage and 2024 mature estimate) • 220kV AIS bay – non-contestable project 1 (2022 early-stage and 2024 actual) • 500kV AIS bay – non-contestable project 2 (2024 mid-stage estimate only) • 330kV switchyard only AIS bays Project A (2023 actual) • 275kV switchyard only AIS bays Project B (2022 actual) • 275kV switchyard only AIS bays future project (2024 early estimate)	• These projects covered 220kV, 275kV, 330kV and 500kV. • Thirteen of these projects have its cost data developed or measured in recent time (i.e., during 2024/25FY). • Given the above diversity of the data points, GHD focused predominantly on those projects whose cost data were developed or measured in recent time. GHD also focused on those projects which has multiple versions of cost data from different point in time. However, in some instances where the basis of the mature and recent cost information did not consistently align with the explained scope of work or their earlier estimate version, GHD ignored such estimate version. • GHD excluded or stripped out portion of cost from those survey response data which had project attribute and/or risk factors embedded into its baseline estimate. GHD also stripped out portion of cost from those survey response data which had elements of property site establishment or bench extension scope embedded in them. • Following the above steps, GHD updated the estimate for each cost component by referencing the quantity of circuit breaker in the given configuration and the kV level (for e.g., the multiples of circuit breaker inform the magnitude of estimate for various cost components). GHD also rounded the updated estimate. • GHD observed that most asset building blocks baseline estimate, especially the higher voltage levels, to significantly increase over the 2023 TCD version for various configurations. • Finally, GHD arrived at various % increase to apply to the relevant cost components except for the 'Easement/Property Costs' and 'Environmental Offset Costs' component of the building block baseline estimate. The benchmarking activity further refined these % increase before finalising the 2025 TCD update. • Significant increase is observed in 'Civil and structural works', 'Electrical works' and 'Contractor project management and overheads' cost components of the baseline estimate.

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
		• 500/330kV substation, AIS bays both sides (2024 early estimate only)	
Station - Building	The TCD now has a total of 3 asset building blocks in this asset subcategory across the following type: • Building size	The survey response did not provide any cost information specific for this asset subcategory. GHD therefore inferred the change needed to universally update the asset building block baseline estimates in the existing TCD version based on the cost updates observed in 'Civil and structural works' cost component of other asset subcategories.	• This asset subcategory is specific for GIS station housing infrastructure. GHD did not receive any cost data from the survey. • GHD deduced the $\$/m^3$ volumetric space for this asset subcategory (observed average of $\$904/m^3$ in 2023 dollar) and updated this using $\$1,100/m^3$ rate. This increase considers the trend observed within the 'Civil and structural works' cost component in other asset subcategories building block baseline estimate.
Station - GIS Switchbay	The TCD now has a total of 30 asset building blocks in this asset subcategory across the following types/scenarios: • 132kV to 500kV • Different configuration • Different quantity of circuit breaker in each configuration	• 132kV GIS module equipment only (2024 early estimate) • 220kV GIS switching station (both 2022 early and 2024 mature estimates) • GIS module (various kV) (2024 budgetary estimate for plant cost component) The survey response did not provide cost information for each building block assets with exact matching scope. GHD inferred the change needed to universally update the asset building block baseline estimate in the existing TCD version based on the observed change in the provided cost information, after isolating the matching scope as much as possible, and few other considerations.	• GHD collected only three reference data points to update this asset subcategory from 132kV to 330kV. • GHD updated the 'plant' cost component of the asset building block baseline estimate to match GHD's 132kV GIS design project and also the OEM budgetary quote, then used the same increase proportion to update the kV levels asset types (extrapolation). • The remaining cost components was updated based on the cost increase observed within the AIS Switchbay asset subcategory, a TNSP project estimate, referencing the quantity of circuit breaker in the given configuration and the kV level (for e.g., the multiples of circuit breaker inform the magnitude of estimate for various cost components), and consideration of indoor work.
Station - HVDC converters - LCC	The TCD now has a total of 11 asset building blocks in this asset subcategory across the following types/scenarios:	No survey was undertaken for these HVDC asset sub-categories.	The challenge for LCC costing is that very few LCC systems at the power levels anticipated by the building blocks have been commenced or commissioned over the past five years. Publicly available cost information for such LCC projects was not identified.

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
	• ±320kV, ±525kV and ±640kV. • Monopole and bipole configurations. • Different MW/pole capacities. • Staged development.		The cost for these asset building blocks were developed based on advice from HVDC suppliers that the cost of LCC HVDC converter stations will be similar or the same as the equivalent VSC converter station. The asset building blocks in this asset subcategory has been updated with new asset detail, description and notes to better reflect the terminology, specification and real-world configuration/usage of this technology and to more easily align with the equivalent HVDC overhead and HVDC cable asset building blocks. Generally speaking, the baseline estimates for all converter stations in this asset subcategory have significantly increased over the 2023 TCD version. The smaller converter stations (less than or equal to 1.5GW total capacity) have increased more than the larger converter stations (greater than 1.5GW total capacity) in average over the 2023 TCD version for various configurations. Amplitude Consultants notes that this mostly due to correction of cost information in the TCD rather than solely due to price increase in the market.
Station - HVDC converters - VSC	The TCD now has a total of 17 asset building blocks in this asset subcategory across the following types/scenarios: • ±320kV, ±525kV and ±640kV • Symmetric monopole, bipole and double symmetric monopole configurations. • Different MW/pole capacities. • Staged development.	No survey was undertaken for these HVDC asset sub-categories.	The cost for these asset building blocks were updated based on costing data provided by two HVDC suppliers and scaled cost data identified in the public domain for similar projects. These cost sources were combined and assessed based on Amplitude Consultants knowledge of VSC HVDC technology to develop unit costings for the VSC HVDC converter stations. The cost component proportions were developed based on input from the HVDC suppliers, publicly available information and Amplitude Consultants knowledge and experience. The asset building blocks in this asset subcategory has been updated with new asset detail, description and notes to better reflect the terminology, specification and real-world configuration/usage of this technology and to more easily align with the equivalent HVDC overhead and HVDC cable building block assets. Generally speaking, the baseline estimates for all converter stations in this asset subcategory have significantly increased over the 2023 TCD version. The smaller converter stations (less than or equal to 1GW total capacity) have increased more than the larger converter stations (greater than 1GW total capacity) in average over the 2023 TCD version for various configurations. Amplitude Consultants notes that this mostly due to correction of cost information in the TCD rather than solely due to price increase in the market.

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
Station - Power Flow Controller [Phase Shifting Transformer]	The TCD now has a total of 16 asset building blocks in this asset subcategory across the following types: • 220kV to 500kV • Different MVA capacity • Different phase shift angle/degrees	The survey response did not provide any cost information specific for this asset sub-category. GHD therefore inferred the change needed to universally update the asset building block baseline estimates in the existing TCD version based on the observed change in the provided cost information for the power transformer asset subcategory. • Power transformer individual equipment (various kV and MVA sizes, 2024 budgetary estimate for plant cost component)	• GHD referred to OEM plant cost component estimate for power transformer of various kV and MVA sizes and inferred the similar change to Phase Shifting Transformers plant cost component also. • The remaining cost components of the baseline estimate was updated based on the cost changes observed within the AIS Switchbay asset subcategory and referencing the cost allocation for power transformer asset subcategory. GHD also rounded the updated estimate for these remaining cost components.
Station - Power Flow Controller [Modular Powerflow Controller]	The TCD now has a total of 15 asset building blocks in this asset subcategory across the following types: • 132kV to 500kV • Different Ohms and device modules specification	• Modular power flow controller (various Ohms, 2024 budgetary estimate for plant cost component) • 500/330kV substation (2024 early estimate only)	• GHD referred to the OEM response to update the asset description (now with Ohms specification) and better description (for e.g., quantities of modules per phase). The OEM also provided the estimates for additional new sizes. • GHD referred to OEM to update the plant cost component for various kV and Ohms sizes. Given the change in asset description, the cost change from the previous TCD version may not be comparable. • The remaining cost components was updated based on a TNSP provided information for 60 OEM devices (SV-1800) which is double stacked and includes various other scopes such as buildings, site benchwork, and other project attributes (e.g., FIFO workers). GHD stripped the provided costs to exclude such additional scope and attributes and observed the closet matching quantity of device in OEM information at 500kV to deduce the asset multiples for 27, 18, 9 etc. device modules.
Station - Property site work	The TCD now has a total of 3 asset building blocks in this asset subcategory across the following type: • Size of site footprint area	The survey response did not provide any cost information specific for this asset subcategory. GHD therefore inferred the change needed to universally update the asset building block baseline estimates in the existing TCD version based on the cost updates observed in 'Civil and structural works' cost component of other asset subcategories building block baseline estimate.	• This asset subcategory is specific for GIS station site infrastructure. GHD did not receive any cost data from the survey. • GHD deduced the $/m^2 footprint area for this asset subcategory (observed average of $202/m^2 in 2023 dollar) and updated this using average of $250/m^2 rate. This increase considers the trend observed within the 'Civil and structural works' cost component in other asset subcategories building block baseline estimate.

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
Station - Property site work and building	The TCD now has a total of 11 asset building blocks in this asset subcategory across the following type: • Size of site footprint area	• 330kV and 275kV AIS substation – provided separately (2016 early, 2019 mid-stage and 2024 actuals) • 220/33kV AIS substation – contestable project 1 (2024 mature estimate only) • 500/220kV AIS substation – contestable project 2 (2022 mature estimate only) • 330kV switchyard only AIS bays Project A (2023 actual) • 275kV switchyard only AIS bays Project B (2022 actual) • 275kV switchyard only AIS bays future project (2024 early estimate) • 500/330kV substation (2024 early estimate only)	• GHD received a total of eight individual substation project cost data with property site establishment work and buildings scope from the five NEM TNSPs. • Except for one survey response (with two actual cost data), all other responses were cost estimates for this asset subcategory and have other project element costs embedded in them or were embedded into other project elements. While GHD attempted to isolate the cost of this asset subcategory as much as possible, GHD mostly relied on the actual cost data from the survey response with actual cost data for a 28200m^2 switchyard and a 52300m^2 switchyard. • GHD also noted that these actual cost data were from contracts executed sometime ago and hence considered the increase for civil infrastructure work in recent years. • Based on the above consideration, GHD plotted the trend of the footprint area size against the cost estimate from the survey response and compared it against the same trend in the existing TCD. This resulted in generally increasing the cost of smaller site area and generally decreasing the cost of larger site area.
Station - Reactive Plant [Statcom, SVC]	The TCD now has a total of 50 asset building blocks in this asset subcategory across the following type: • 132kV to 500kV • Different MVAr specification	The survey response did not provide any cost information specific for this asset subcategory. GHD therefore inferred the change needed to universally update the asset building block baseline estimates in the existing TCD version based on the cost updates observed in capacitor and reactor asset subcategory.	• GHD did not received any cost data from the survey response on these asset subcategories. • Therefore, GHD have updated the 2023 TCD version cost with similar change observed across the capacitor and reactor asset subcategory.
Station - Reactive Plant [Reactor, Capacitor]	The TCD now has a total of 63 asset building blocks in this asset subcategory across the following type: • 132kV to 500kV • Different MVAr specification	• 330kV and 275kV AIS substation – provided separately (2016 early, 2019 mid-stage and 2024 actuals) • 275kV reactor with AIS bay (2024 tendered) • 275kVreactor with AIS bay (2024 tendered)	• GHD received a total of four individual substation project cost data containing one 275kV capacitor, one 330kV reactor and two 275kV reactors. • Two of these projects have more than one version of the cost data developed or measured at different point in time (for e.g., early estimate/ mature estimate/ actual). • All four of these projects have its cost data developed or measured in recent time (i.e., during 2024/25FY).

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
		The survey response did not provide cost information for each building block assets with exact matching scope. GHD inferred the change needed to universally update the baseline building block costs in the existing TCD version based on the observed change in the provided cost information, after isolating the matching scope as much as possible, and few other considerations.	• GHD focused predominantly on those projects whose cost data were developed or measured in recent time. • GHD universally updated the estimate for each cost component based on the above cost data.
Station - Reactive Plant [Syncon]	The TCD now has a total of 49 asset building blocks in this asset subcategory across the following type: • 132kV to 330kV • Different MVAr specification • With or without flywheel configuration • Single or twin machine	• 275kV syncon 800MVA fault level and 7MWs/MVA (2024 early estimate) • 330kV syncon 950MVA fault level and 1500MWs of inertia (2024 early estimate only) The survey response did not provide cost information for each asset building blocks with exact matching scope. GHD inferred the change needed to universally update the asset building block baseline estimate in the existing TCD version based on the observed change in the provided cost information, after aligning the matching scope as much as possible (i.e., reactive power MVAr specification to MVA fault level and MWs inertia specification).	• GHD received a total of two individual substation project cost data, with both of them being early estimates. Both these projects have its cost data developed in recent time (i.e., during 2024-25FY). • GHD universally updated the estimate for each cost component and across each building block asset based on the above cost data.
Station - Secondary system building	The TCD now has a total of 3 asset building blocks in this subcategory across the following type: • Building size	• Meeting discussion with a TNSP during the workshop post survey response. This communication provided the estimates for each building block assets.	• GHD received an indicative total estimate for each asset building block verbally during the workshop. • GHD updated the estimate to match the indicative total estimate.

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
Station - Special Protection Scheme	The TCD now has a total of 2 asset building blocks in this subcategory across the following type: • Scheme size	The survey response did not provide any cost information specific for this asset subcategory. GHD therefore inferred the change needed to universally update the asset building block baseline estimate in the existing TCD version based on the cost updates observed in 'secondary systems' cost component of other asset subcategories building block baseline estimate	• GHD did not receive any cost data from the survey on this specific asset sub-category. • GHD updated the baseline building block cost based on our observation of cost change within the secondary systems cost component of other asset sub-categories. The overall cost increase is ~8% in average across both scheme sizes • The survey response did not provide any cost information specific for this asset subcategory. GHD therefore inferred the change needed to universally update the asset building block baseline estimate in the existing TCD version based on the cost updates observed in 'secondary systems' cost component of other asset subcategories building block baseline estimate
Station - Transformer	The TCD now has a total of 83 asset building blocks in this asset subcategory across the following types: • 132kV to 500kV primary side • Different MVA capacity • Phase configuration (3 vs 1 phase)	• Power transformer individual equipment (various kV and MVA sizes, 2024 budgetary estimate for plant cost component) • 220/33kV AIS substation – contestable project 1 (2024 mature estimate only) • 500/220kV AIS substation – contestable project 2 (2022 mature estimate only)	• GHD referred to OEM budgetary quote for power transformer of various kV and MVA sizes to update the plant cost component of the baseline estimate. • The remaining cost components in the baseline estimate was universally updated based on the cost changes observed within two power transformer project information. GHD excluded or stripped out portion of cost which had project attribute and/or risk factors in-built into its base cost. GHD also stripped out portion of cost which has elements of property site establishment or bench extension scope embedded in them. GHD universally updated the estimate for the remaining cost components in the baseline estimate by referencing the size and phase configuration (or bank of phase) and thus the need for civil infrastructure to house them.
Underground Cable - HVAC tunnel installed cable	The TCD now has a total of 22 asset building blocks in this asset subcategory across the following types: • 132kV to 500kV • Different cable size or MVA capacity • Single or double circuit	• Cu XLPE 1C cable (220kV and 330kV various sizes, 2024 budgetary estimate for plant cost component)	• Plant cost component of the baseline estimate for this asset subcategory were reduced and are now consistent with the OEM budgetary quote. • No cost information was available for laying cables in concrete tunnels. The most likely location where concrete tunnels are to be used is urban environments. Due to lack of any supporting information, the existing civil and structural work cost component estimate were escalated to 2024/25FY values. • Professional judgment was applied to estimate the remaining cost components while being consistent with other underground cable asset subcategories estimate. Labour effort, crew size, productivity rate and labour rates were considered to estimate these cost components.
Underground Cable - HVAC underground	The TCD now has a total of 21 asset building blocks in this	• Cu XLPE 1C cable (220kV and 330kV various sizes, 2024	• GHD referred to OEM plant cost component estimate for underground cable of various kV and MVA sizes to update the plant cost component in the baseline estimate.

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
direct buried cable	asset subcategory across the following types: • 132kV to 500kV • Different cable size or MVA capacity • Single or double circuit	budgetary estimate for plant cost component) • 330kV Powering Sydney Future (2020 actual) • 500kV Humelink underground option study as part of the Government enquiry (2023 mid-stage estimate)	• The remaining cost components in the baseline estimate was universally updated based on the cost observed within two underground cabling project information – Humelink underground option study and Power Sydney Future. GHD excluded or stripped out portion of cost which had project attribute and/or risk factors in-built into its base cost. GHD also stripped out portion of cost which has elements of substation termination end with GIS switchbay embedded in them. GHD universally updated the estimate for the remaining cost components by referencing the trenching size and cable layout and circuit configuration.
Underground Cable - HVDC subsea cable	The TCD now has a total of 24 asset building blocks in this asset subcategory across the following types/scenarios: • ±320kV and ±525kV • Symmetric monopole, asymmetric monopole, bipole and double symmetric monopole configurations • Different MW/pole capacities • Staged development. Polymer and Mass Impregnated cable types ±640kV voltage level cables were not assessed as these cables are not commercially available at this time.	No survey was undertaken for this HVDC asset subcategory.	The cost for these asset building blocks were updated based on bottom-up estimations, market research and Amplitude Consultants knowledge of this technology. The cost estimate compilation included the costs associated with installation including transition, cable loadout and subsea cable installation and burial. Cable sizes required for each configuration, DC voltage and power level were determined through modelling based on typical input parameters. Cable costs were developed based on input from a HVDC cable vendor, combined with publicly available cable cost data and scaling according to conductor size and DC voltage. The asset building block in this asset subcategory has been updated with new asset detail, description and notes to better reflect the terminology, specification and real-world configuration/usage of this technology and to more easily align with the equivalent HVDC converter station asset building blocks. There has been significant increase over the 2023 TCD version across various sizes and configurations, however noting that the descriptions for this asset subcategory were changed, and new asset building blocks were also included.
Underground Cable - HVDC underground direct buried cable	The TCD now has a total of 24 asset building blocks in this asset subcategory across the following types/scenarios: • ±320kV and ±525kV. • Symmetric monopole, asymmetric monopole, bipole and double	No survey was undertaken for these HVDC asset sub-categories.	The cost for these asset building blocks were updated based on bottom-up estimations, market research and Amplitude Consultants knowledge of this technology. The cost estimate compilation included the costs associated with installation including trenching, cable laying and reinstatement. Cable sizes required for each configuration, DC voltage and power level were determined through modelling based on typical trench profiles and input parameters. Cable costs were developed based on publicly available cable cost data and scaling according to conductor size and DC voltage.

Asset subcategory	Number of asset building blocks	Survey response	Treatment of survey response data and methodology adopted to update the 2025 TCD
	symmetric monopole configurations. • Different MW/pole capacities. • Staged development. • Polymer and Mass Impregnated cable types. ±640 kV voltage level cables were not assessed as these cables are not commercially available at this time.		The asset building blocks in this asset subcategory has been updated with new asset detail, description and notes to better reflect the terminology, specification and real-world configuration/usage of this technology and to more easily align with the equivalent HVDC converter station building block assets. There has been significant increase over the 2023 TCD version across various sizes and configurations, however noting that the descriptions for this asset subcategory were changed and new asset building blocks were also included.

2.1.1 Update to ‘Easement/Property costs’ component within the asset building block baseline estimates

The ‘Easement/Property costs’ component of the baseline estimate is applied to all asset building blocks and is based on easement/property m^2 size requirement for that asset building block and the $/m^2 land price. As part of the 2025 TCD update, GHD recalculated the $/m^2 land price to update the ‘Easement/Property Costs’ component in the baseline estimate.

GHD used Australian Bureau of Agricultural and Resource Economics and Sciences[2] (ABARES) as an independent and reliable source for land prices, to collect the most recent farmland pricing data, for all subregions within the NEM. The average of all the subregions farmland pricing data, in $/m^2 was then used to derive the ‘Easement/Property Costs’ component in the baseline estimate for all asset building blocks.

This resulted in a meaningful change to this cost component compared to the 2023 TCD version. The ‘Easement/Property costs’ component in the baseline estimate for all asset building blocks in the 2025 TCD reduced by approximately one-third compared to the 2023 TCD version.

2.1.2 Update to ‘Environmental offset costs’ component within the asset building block baseline estimates

GHD completed a full revision of this cost component in the 2025 TCD update. To calculate the ‘Environmental offset costs’ component of the baseline estimate for all asset building blocks, GHD reviewed several biodiversity offset estimation methods, available in each state based on their respective jurisdictional environmental regulations, and also the federal government methodology. GHD notes that only NSW has a federally approved methodology to estimate biodiversity offset costs. As such, GHD proposed the following estimation methodologies be used for 2025 TCD update:

– Federal biodiversity offset estimate methodology be applied to QLD, VIC, SA and TAS.
– NSW biodiversity offset estimate methodology be applied for NSW, as it is endorsed by the federal government.

Other costs related to land maintenance, like 20-year maintenance programs of the offset land, was not included in updating this cost component within the baseline estimates.

The formula used for deriving the federal biodiversity offset rate is as follows:

Federal biodiversity offset rate ($/m^2) = Impact area ($m^2$) × Impact area multiplier × Land price ($/m^2)

Where:

– Impact area is the total land size effected by constructing transmission network infrastructure.
– Impact area multiplier is a factor used to increase the biodiversity cost of impacted area. GHD has assumed the average impact area multiplier of 10 to be representative of majority of projects that have required biodiversity offset costs across QLD, VIC, SA and TAS jurisdictions. 10 is therefore proposed as the baseline estimate.
– Land price sourced from ABARES described in Section 2.1.1.

To estimate the baseline biodiversity offset rate for NSW, GHD referred to the latest Humelink transmission project biodiversity offset plan and estimate information, which is in the public domain. Based on the Humelink transmission route/corridor footprint area, GHD derived a $/m^2 biodiversity offset rate applicable in NSW. It is noted the Humelink transmission project crosses multiple Interim Biogeographic Regionalisation for Australia (IBRA) subregions[3], within Central Southern Region of NSW. Therefore, this derived NSW biodiversity offset rate was taken as a reasonable reference rate for the Central Southern Region of NSW. The rates for the other NSW regions was approximated using this as a reference and the different biodiversity offset credit pricing available for various NSW regions. GHD referred to the average biodiversity offset credit price information across NSW

[2] Published by the Australian Government Department of Agriculture, Fisheries and Forestry. **ABARES Farmland Price Indicator - DAFF**
[3] **Australia's bioregions (IBRA) - DCCEEW** and **Australia's 419 subregions map**

subregions available in the NSW Government Biodiversity Credits Market Sales dashboard Microsoft Power BI portal[4].

The average of all NEM subregions biodiversity offset rate in $/m^2 was then used to set the 'Environmental offset costs' component in the baseline estimate for all asset building blocks.

This resulted in meaningful change to this cost component compared to the 2023 TCD version. The 'Environmental offset costs' component in the baseline estimate for all asset building blocks in the 2025 TCD increased approximately by 4.5 times compared to the 2023 TCD version.

2.2 Update to project attribute factors

The configuration of project attribute factors within the Cost and Risk Data workbook is shown in the following illustration. The blue coloured texts immediately below the table indicates the elements of project attribute factors that were updated.

Figure 2 Organisation of project attribute factors

			9 cost components								
Project attribute factors with percentage adjustment values interacting with the 9 cost components			Plant	Civil and structural works	Electrical Works	Secondary systems	Design & survey	Testing & Commissioning	Contractor project management & overheads	Easement/ Property costs	Environmental offset costs
3 asset categories	9 project attribute factors	Each project attribute factor has multiple choices for user to select	%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%

Rationalise the description of project attribute factor and multiple choices.

Updated using the survey responses, workshops with participants, and engineering judgement. Then finetuned by benchmarking.

Updated by recalculating the fundamental variables from first principle and relative to the chosen baseline estimate values.

[4] **Biodiversity Credits Market Sales Dashboard | Biodiversity Offsets Scheme | Environment and Heritage**

There were 10 project attribute factors in the 2023 TCD. All 10 factors were applied to overhead lines asset category, whereas only 8 factors were applied to station asset category, and only 6 factors were applied to underground cable asset category.

In the 2025 TCD update, there are now 9 project attribute factors. All 9 factors are applied to overhead lines asset category, whereas only 7 factors are applied to both the station and underground cable asset categories. This revision is summarised in the following table and commentary in the table is applicable to all three asset categories unless otherwise specified.

Table 4 Description of changes to project attribute factors

Project attribute factors	Selection of available choices	Percentage adjustment values applied to each choice
Contract delivery model	2 choices are available and these remain unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update.
Delivery timetable	3 choices are available and these remain unchanged in 2025 TCD update.	The percentage adjustment values that adjust applicable cost components of an estimate, have been updated to make them less sensitive for both 'tight' and 'long' choices. This was done to be consistent with the cost impact observed in survey responses with such scenarios.
Greenfield or brownfield	3 choices are available and these remain unchanged in 2025 TCD update.	The percentage adjustment values that adjust applicable cost components of an estimate, for overhead lines and station asset categories, have been updated to make them less sensitive for 'brownfield' choice. This was done to be consistent with the cost impact observed in survey responses with such scenarios.
Jurisdiction	In 2023 TCD there were 25 choices available for selection within the jurisdiction project attribute factor consisting of 5 regions and 20 subregions. This arrangement resulted in duplication within the same region, but more importantly this arrangement was done in isolation from the land use project attribute factor. This resulted in errors when certain combination of choices were selected in the jurisdiction and land use project attribute factors. For e.g., if the TCD Tool user selected 'NSW-Western' choice for a jurisdiction project attribute factor and then selected 'scrub' choice for the land use project attribute factor, the estimated 'Easement/Property Costs' component in the estimate reduced to a negative value. In 2023 TCD there were 4 choices available for selection within the 'Land use' project attribute factor. But this factor did not impact	The percentage adjustment values for the new amalgamated 'Jurisdiction + Land use' project attribute factor, adjusts both the 'Easement/Property costs' and 'Environmental offset costs' components of the baseline estimate. These percentage adjustment values have been recalculated with reference to the relevant $/m^2 values used to derive the 'Easement/Property costs' and 'Environmental Offset costs' components respectively within the baseline estimate.
Land use		

Project attribute factors	Selection of available choices	Percentage adjustment values applied to each choice
	the 'Environmental offset costs' component in the estimate. For 2025 TCD update the basis for calculating both the 'Easement/Property costs' and 'Environmental offset costs' components, in the baseline estimate, has been revised as described in Sections 2.1.1 and 2.1.2 respectively. Therefore, the corresponding project attribute factors has been updated. Also, given that the land price influences biodiversity offset cost, the land use project attribute factor is now updated to also impact the 'Environmental offset costs' component in the estimate. Also, these two project attribute factors cannot be treated in isolation. As such, for the 2025 TCD update these two project attribute factors have been amalgamated into one project attribute factor – 'Jurisdiction + Land use'. This new amalgamated factor has 63 choices capturing all NEM subregions with different land use types. This is further detailed in Appendix B showing the sources for each jurisdiction choice and various land use type available within each jurisdiction choice. The 'Land use' project attribute factor is now made redundant in the TCD Tool, i.e., the only choice available for this project attribute factor is "NA" and the user must select it, but its estimate calculation is zeroed out.	
Location distance factor	3 choices are available and these remains unchanged in 2025 TCD update.	In the 2023 TCD the asset building block baseline estimate for overhead line and station asset categories were based on urban scenario and hence the urban selection for these two asset categories were treated as the baseline and therefore not adjusted. However, as most of the survey response for the 2025 TCD update is based on regional projects, the regional choice is now the baseline, with percentage adjustments now applied to urban and remote choices. Further, the percentage adjustment values that adjust all the applicable cost components of the estimate have been updated to make them more sensitive to both urban and remote choices. This update or calibration was done as one of

Project attribute factors	Selection of available choices	Percentage adjustment values applied to each choice
		the outcomes from the benchmarking activity to closely match TCD Tool outputs.
Location wind loading zone [This is applicable to only overhead line asset category]	2 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update. This project attribute factor is meant for infrastructure situated in tropical locations and there was no project in the survey responses that was from such regions. There was no information to support any changes to the existing percentage adjustment values.
Project network element size	For overhead lines asset category, 6 choices were available in 2023 TCD. This has now been updated to 4 choices in 2025 TCD. For station asset category, 7 choices were available in 2023 TCD. This has now been updated to 5 choices in 2025 TCD. For underground cable asset category, 4 choices were available in 2023 TCD. This has now been updated to 3 choices in 2025 TCD.	For overhead line asset category, the <1km choice was removed, as it is exceptionally unlikely a transmission overhead line of <1km will be planned in the ISP and the difference in unit rates between lengths of <1km or <5km would be immaterial. Further, two other choices (5 to 10km and 10 to 100km) were also rationalised into one choice (5 to 100km) because no significant cost difference or efficiency were observed in unit rates between the two choices. For station asset category, all selections above 21 bays were removed, as there would be immaterial efficiencies in scale for projects having more than 21 bays. For underground cable asset category, the <1km selection was removed, as it is exceptionally unlikely an underground cable of <1km will be planned in the ISP and the difference in unit rates between lengths of <1km or <5km would be immaterial.
Proportion of environmentally sensitive area	5 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values adjust only the 'Contractor project management & overheads' cost component of the estimate, and they have been updated to make them more sensitive to all non-zero sensitive area selections. The percentage adjustment values in the 2023 TCD version were negligible, i.e., <0.2% for most extreme selection.
Terrain [This is applicable to only overhead line asset category]	3 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values that adjust the 'Contractor project management & overheads' cost component of the estimate have been updated to make them less sensitive to

Project attribute factors	Selection of available choices	Percentage adjustment values applied to each choice
		hilly/undulating and mountainous selections. This was done to be consistent with the cost impact observed in survey responses with such scenarios.

Please refer to the description and note columns in the Cost and Risk Data workbook for further details on the project attribute factors, their scope and its respective user selection choices. The same detail also appears in the description and note fields in the cost estimation tool dashboard.

2.3 Update to known risk factors

The configuration of known risk factors within the Cost and Risk Data workbook is shown in the following illustration. The blue coloured texts immediately below the table indicates the elements of known risk factors that were updated.

Figure 3 Organisation of known risk factors

Known risk factors with percentage adjustment values interacting with the 9 cost components			9 cost components								
			Plant	Civil and structural works	Electrical Works	Secondary systems	Design & survey	Testing & Commissioning	Contractor project management & overheads	Easement/ Property costs	Environmental offset costs
3 asset categories	9 known risk factors	Each known risk factor has multiple choices for user to select	%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%
			%	%	%	%	%	%	%	%	%

Rationalise the multiple choices.

Rationalise the multiple choices. Updated using the survey responses, workshops with participants and engineering judgement. Then finetuned by benchmarking.

Updated by recalculating the fundamental variables from first principle and possibility of variation in baseline estimates.

There are 9 known risk factors in the TCD as shown in the following table. This set of 9 factors is applicable to all three asset categories – overhead lines, stations and underground cables, and the commentary in the table is applicable for all three asset categories unless otherwise specified.

Table 5 Description of changes to known risk factors

Known risk factors	Selection of available choices	Percentage adjustment values for each choice
Compulsory acquisition	3 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update. There was no information in the survey responses to support any changes to the existing percentage adjustment values.

Known risk factors	Selection of available choices	Percentage adjustment values for each choice
Cultural heritage	3 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update. There was no information in the survey responses to support any changes to the existing percentage adjustment values.
Environmental offset risk	5 choices that was previously available have now been updated to 4 choices in 2025 TCD update. The 'Observed maximum' choice has now been removed because there is no need to have this choice in the TCD Tool given the basis of calculating the 'Environmental offset costs' component of the baseline estimate changed. GHD adopted an improved method to estimate this cost component in the baseline estimate.	The percentage adjustment values for the remaining 4 choices that adjust the 'Environmental offset costs' component of the estimate in the 2025 TCD has been updated as follows: – Low is -60% – BAU is 0% – High is 100% – Very high is 400% These values have been derived based on specialist advise from a GHD Senior Ecologist. Using their experience of the range of impact area multipliers (a variable in determining the biodiversity offset cost) used in different linear infrastructure projects around Australia recently. The most often observed impact area multiplier is incorporated within the 'Environmental offset costs' component of the asset building bock baseline estimates and hence BAU is assigned 0%. The percentage adjustment values of the remaining choices reflect the relative difference of their respectively observed impact area multipliers. 'Low' is 60% less than the BAU and 'High' is 100% more than the BAU. 400% is assigned to 'Very high' choice. Given the 'Environmental offset costs' component of the asset building bock baseline estimate has increased significantly, there is seldom need for the TCD Tool user to select any choice other than BAU. Unless a user has a very specific information or advance knowledge of site ecology that indicate otherwise.
Geotechnical findings	3 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values that adjust the 'Civil and structural works' and 'Contractor project management & overheads' components of the estimate were updated to make them more sensitive to both 'Low' and 'High' choices. Additionally, the percentage adjustment values for 'Low' and 'High' choices that adjust the 'Design & survey' cost component of the estimate has been included. This was done to be consistent with the cost impact observed in survey responses with such scenarios.

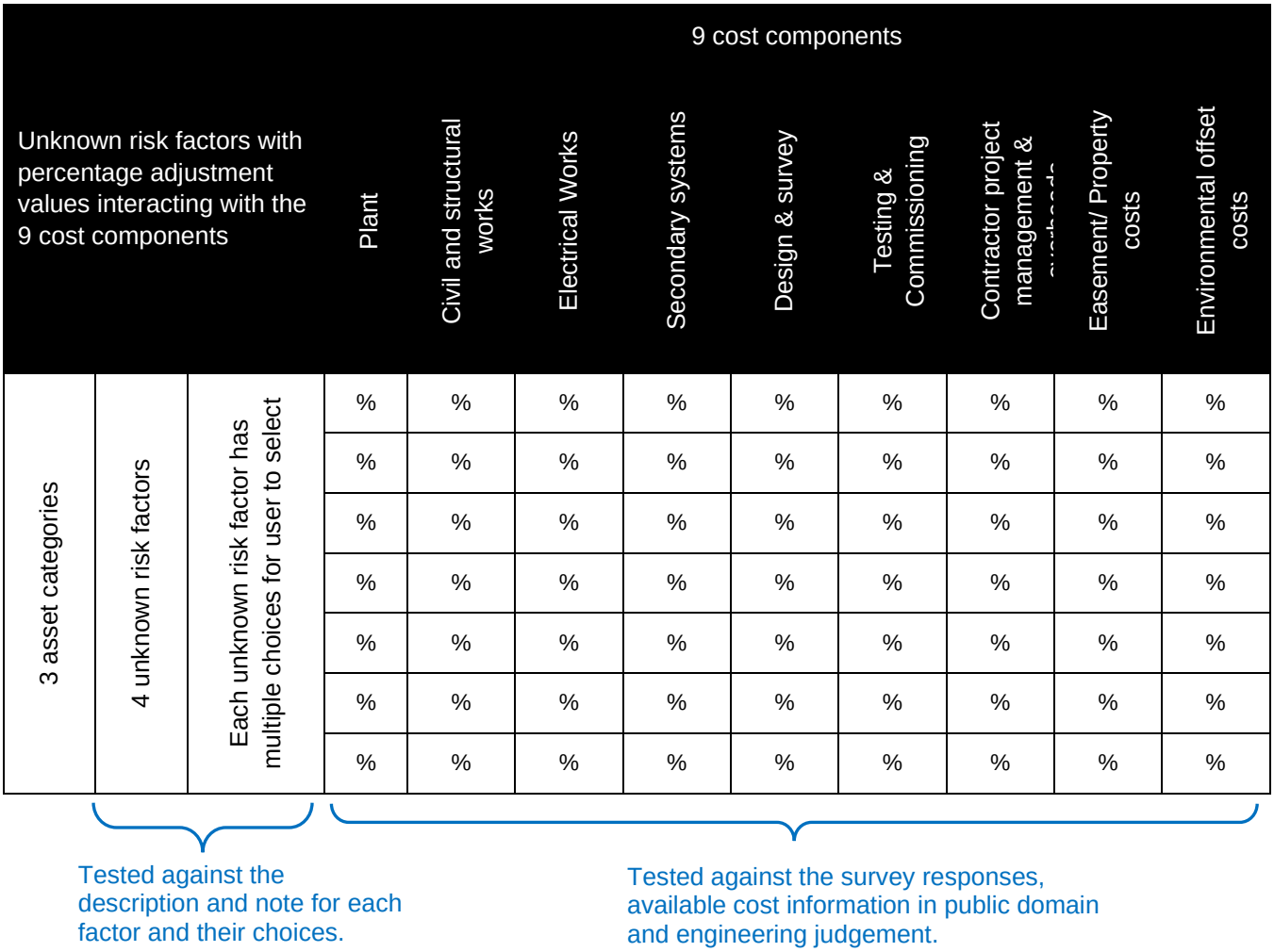
Known risk factors	Selection of available choices	Percentage adjustment values for each choice
Macroeconomic influence	3 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update. There was no information in the survey responses to support any changes to the existing percentage adjustment values.
Market activity	3 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values that adjust all the applicable cost components of the estimate have been updated to make them more sensitive to both 'Low' and 'High' choices. This update or calibration was done as one of the outcomes from the benchmarking activity to closely match TCD resulting output to independently developed estimates.
Outage restrictions	3 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update. There was no information in the survey responses to support any changes to the existing percentage adjustment values.
Project complexity	3 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update. There was no information in the survey responses to support any changes to the existing percentage adjustment values.
Weather delays	3 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update. There was no information in the survey responses to support any changes to the existing percentage adjustment values.

Please refer to the description and note columns in the Cost and Risk Data workbook for further details on the known risk factors, their scope and its respective user selection choices. The same detail also appears in the description and note fields in the cost estimation tool dashboard.

2.4 Update to unknown risk factors

The configuration of unknown risk factors within the Cost and Risk Data workbook is shown in the following illustration. The blue coloured texts immediately below the table indicates the elements of unknown risk factors that were updated.

Figure 4 Organisation of unknown risk factors



There are 4 unknown risk factors in the TCD as shown in the following table. This set of 4 factors is applicable to all three asset categories – overhead lines, stations and underground cables, and the revision commentary in the table is applicable for all three asset categories unless otherwise specified.

Table 6 Description of changes to unknown risk factors

Unknown risk factors	Selection of available choices	Percentage adjustment values for each choice
Plant procurement cost risks	5 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update. Please refer to the commentary provided after this table that explains not changing the existing percentage adjustment values.
Productivity and labour cost risks	5 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for available choices remain unchanged in 2025 TCD update. Please refer to the commentary provided after this table that explains not changing the existing percentage adjustment values.
Project overhead risks	5 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values for the 'Easement/Property costs' and 'Environmental offset costs' components have now been made zero. This factor is meant to adjust the project

Unknown risk factors	Selection of available choices	Percentage adjustment values for each choice
		overhead cost. Hence retaining the percentage adjustment values for 'Contractor project management & overhead cost' component only is consistent with the intended description. Apart from the above revision, the percentage adjustment values for remaining relevant cost components and available choices remain unchanged in 2025 TCD update. Please refer to the commentary provided after this table that explains not changing them.
Scope and technology risks	5 choices are available and these remains unchanged in 2025 TCD update.	The percentage adjustment values across all applicable cost components and for all available choices for the underground cable asset category were updated to be aligned with the station asset category. This was revised with the view this risk exposure would be similar for both these asset categories, as they are similarly exposed to unknowns given the relatively contained site/route locations and variabilities. This revision was based on engineering judgement. The percentage adjustment values for 'Secondary systems', 'Easement/ Property costs' and 'Environmental offset costs' components of the estimate for underground cables asset category is now applied. This follows the addition of these cost components in the underground cable asset building block baseline estimate during the 2025 TCD update. These percentage adjustment values for these cost components are same as for other cost components of underground cable asset category. Apart from the above revision, the percentage adjustment values for remaining relevant cost components and available choices for the underground cable asset category, remains unchanged in 2025 TCD update. Also, the percentage adjustment values for available choices remain unchanged for both overhead lines and station asset category in 2025 TCD update. Please refer to the commentary provided after this table that explains not changing them.

Please refer to the description and note columns in the Cost and Risk Data workbook for further details on the unknown risk factors, their scope and its respective user selection choices. The same detail also appears in the description and note fields in the cost estimation tool dashboard.

As part of the survey questionnaire, GHD requested multiple versions of project cost estimates to reflect changes to project costs at different stages. Survey respondents provided different versions of project estimates that were prepared at the beginning for e.g., at Project Specification Consultation Report stage of the RIT-T process, to CPA

submission stage and to actuals (if delivered/available). These surveys were followed up by series of one-to-one workshops with each participant to seek clarification, confirm understanding and to request further cost data.

GHD also referred to the multiple versions of the cost estimated at different point in time for a large transmission network infrastructure project (Humelink) whose regulatory submission and determination are publicly available from the initial RIT-T stage to AER 2024 approval of CPA expenditure.

The information gathered from the above activities was analysed to track the progression of cost estimates and the magnitude of contingencies allowed for project estimates at each stage. This informed the relevant risk percentage as projects matured and advanced through different regulatory/investment decision gates. GHD also analysed difference, in same year real dollar term, between the estimate versions.

Except for the changes noted in the previous table, this analysis has led the 2025 TCD update to continue to maintain the same unknown risk factor allowance that exists in the 2023 TCD for all choices (Class 5b, Class 5a, Class 4, Class 3 and Class 2/1). The evidence presently supports maintaining this allowance in the unknown risk factors.

GHD referenced the following information to draw insight on estimate accuracy range at different estimate class:

– Section 8.4 of the inaugural ISP TCD Report[5] dated 7 May 2021;
– Information on accuracy range in the AACE note RP 96R-18[6]; and
– The above analysis of various survey responses along with Humelink example.

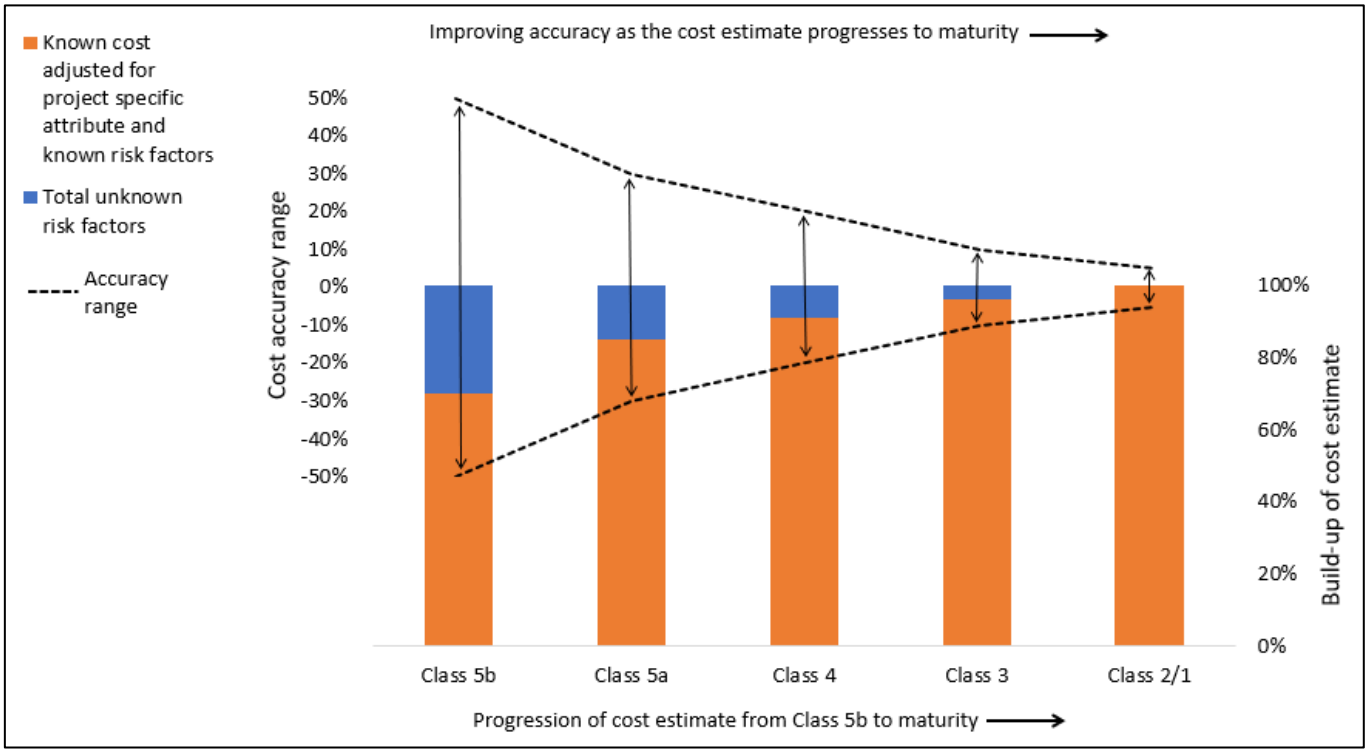
This insight is presented in the following table and illustration and is applicable to the updated 2025 TCD Tool.

Table 7 Estimate accuracy range at different class of estimate

TCD cost estimate output	Class 5b	Class 5a	Class 4	Class 3	Class 2/1
Total unknown risk factor	Up to 30%	Up to 15%	Up to 9%	Up to 4%	0%
Accuracy range	±50%	±30%	±20%	±10%	±5%

[5] **Microsoft Word - AEMO TCD report (FINAL 2021-05-07).docx**
[6] **Professional Guidance Document No. 01 - Guide to Cost Estimate Classification Systems**

Figure 5 *Project estimate progression to maturity and improving accuracy range*



The TCD Tool is designed to only produce early stage (for e.g., Class 5b/5a) project cost estimates. In some rare instances if a TCD Tool user has bespoke knowledge of the site, equipment specification, their arrangements, and detail bill of quantities, then a user may choose to select Class 4 or Class 3 unknown risk factors, but the user should be aware that such bespoke and specific description of necessary asset building block may not be available in the TCD Tool.

These allowance in the unknown risk factors should be reviewed by AEMO in the next TCD update to ascertain if the percentage adjustment values of all four factors need refinement to reflect changes in uncertainty and accuracy of the early-stage cost estimates, compared to mature estimates or actual costs in the NEM. If AEMO observes that early-stage project cost estimates are becoming more certain and accurate, when compared to mature estimates or actual costs in the NEM, it is recommended to refine/reduce the allowance in the unknown risk factors in the TCD Tool.

2.5 Update to indirect costs

The configuration of indirect costs within the Cost and Risk Data workbook is shown in the following illustration. The blue coloured texts immediately below the table indicates the elements of indirect costs that were updated.

Figure 6 Organisation of indirect costs

Indirect costs percentage adjustment values based on combination of few factors and choices			6 internal cost components					
			Project development	Works delivery	Land and environment	Stakeholder and community engagement	Procurement costs	Insurance
Total direct cost and nature of work (e.g., greenfield) – choices	Stakeholder and community sensitive region – choices	Contract delivery model – choices	%	%	%	%	%	%
			%	%	%	%	%	%
			%	%	%	%	%	%
			%	%	%	%	%	%
			%	%	%	%	%	%
			%	%	%	%	%	%
			%	%	%	%	%	%

Updated using the survey responses, workshop with participants and engineering judgement. Then tested against benchmarking project estimates.

The TCD Tool calculates the indirect costs as a percentage of total direct costs (i.e., adjusted baseline estimates inclusive of all risk factors). The total indirect cost percentage ranged from 6.5% (for larger projects) to 16% (for smaller projects) in the 2023 TCD version. This has now been updated to range from 10% (for larger projects) to 16% (for smaller projects) in the 2025 TCD version based on our review of survey response data and discussions with the TNSPs. This update resulted in revising and increasing the estimate percentage attributed to project development, works delivery and stakeholder and community engagement cost components, within the indirect costs for larger projects. The latter cost component experienced the largest portion of this increase.

The TCD Tool has the functionality to further increase the indirect costs by:

– Increasing the project development and works delivery cost components if the user selects “D&C contract” choice for the contractor delivery model factor; and

– Increasing the stakeholder and community engagement cost component if the user selects “Sensitive” or “Highly sensitive” choices for the stakeholder and community sensitive region factor.

During the 2025 TCD update, GHD discovered an existing bug in the TCD Tool wherein it does not consistently compute the three cost components (project development, works delivery, stakeholder and community engagement) within the indirect costs as intended when any or both above two scenarios are selected. In other words, these three cost components within the indirect costs are estimated incorrectly or underestimated if the user selects “D&C contract” choice for the contractor delivery model factor and/or selects “Sensitive” or “Highly sensitive” choices for the stakeholder and community sensitive region factor.

Presently this bug has not been solved in the updated 2025 TCD Tool. This error results in non-material underestimation at the overall project cost level. This bug will be addressed in the next TCD Tool version update in July 2025 alongside the publication of AEMO's final 2025 Electricity Network Options Report.

3. Enhancement of TCD Tool user interface

The TCD tool was updated to incorporate the latest cost data information contained in the Cost and Risk Data workbook. This includes changes to the drop-down menu options where this is relevant. In addition, identified bugs were corrected as outlined below.

– Correction to network element edit quantity button.
  - Previously if an existing asset building block, with a quantity of zero was edited, its cost would remain zero.
  - The tool was updated to present a pop-up warning preventing users from editing building blocks when they have an initial quantity of zero.
  - Users must remove the building block and add a new equivalent building block item with the desired size/quantity.
  - Note, the edit functionality is unchanged when the initial quantity is not zero.
– Correction to rounding display in Output C of the exported report.
  - Previously asset building block quantities were displayed as rounded values in the Output C of the exported report.
  - This has been updated to show 2 decimal places.
  - Note, this is a purely cosmetic change and has no impact on the TCD Tool calculations.

In addition to the above, generic quality fixes were made to prevent issues to support functionality when automating usage of the TCD Tool.

4. Benchmarking

With support from AEMO, GHD liaised with jurisdictional planning bodies to undertake series of benchmarking, by comparing estimate generated by the updated 2025 TCD Tool against their recently prepared project cost information (consisting of both mature estimates and tendering results). These projects constitute HVAC technology and include both overhead lines and station asset categories.

Similarly with support from AEMO, Amplitude Consultants liaised with a jurisdictional planning body to undertake benchmarking by comparing estimate generated by the updated 2025 TCD Tool against recently prepared project cost information (consisting of both mature estimates and tendering results). This project constitutes HVDC technology and include both HVDC converter stations and subsea and underground HVDC cables asset categories.

The benchmarking activity was used to test the updated variables within the Cost and Risk Data workbook, i.e., asset building block baseline estimates and their cost components, project attribute factors, risk factors and indirect cost, and if needed, to make reasonable revisions.

The participating jurisdictional planning bodies did not provide their project cost information due to commercial sensitivity, given these projects are either currently being negotiated or have recently executed commercial agreements. Instead, they shared high level description of their projects with GHD and Amplitude Consultants, i.e., similar to what is usually known to project developers at early stages of project development. While participating entities had detail and bespoke knowledge of their individual projects such as land clearing requirement, length of access road along the entire route, diameter of foundation piles, tonnage of steel needed for each structure type etc., this was not required for benchmarking of Class 5b level estimates.

The participating entities only shared single line diagrams of station asset category and approximate size of major plants, route distances and few high-level specifications of overhead lines and underground cables asset categories, and qualitative characteristics of project sites and their risk exposure that are generally known to a project developer at an early stage of the project which was sufficient to develop Class 5b level estimates using the updated 2025 TCD Tool. GHD and Amplitude Consultants compared the scope of the project against the available asset building blocks in the updated 2025 TCD and used this to compile project cost estimates using the TCD Tool.

After independently compiling project estimates, GHD and Amplitude Consultants shared the generated results with AEMO and the respective participating entities for their feedback. One-on-one follow-up workshops were held to understand the differences between the TCD Tool’s output, and the participating entities estimates. Project particulars such as cost information structure, data organisation, cost item definition and scope, inclusions/exclusions were examined.

Given the inherent difference in these particulars, benchmarking at the most foundational level such as asset building block level or even at asset subcategory level was not possible. The comparison was done at an aggregated level.

Generally, across all asset categories, the TCD Tool generated outputs were close to the values prepared by the participating entities at the aggregated project level. The results of benchmarking comparison are shown in the following table.

Table 8 Summary of benchmarking participants and projects

Benchmarking participants	Independently prepared network element estimates for benchmarking	Feedback from the participants re cost difference between TCD Tool Class 5b output and their project estimates at project-wide aggregate level
Jurisdictional planning body 1	9 × overhead line projects 17 × AIS station projects	• Combined plant costs and secondary systems is within ±6% difference. • Combined civil and structural works, electrical works, design & survey, testing & commissioning, contractor project management and overheads, and indirect costs is within ±2% difference. • Combined easement/property cost and environmental offset cost is within ±5% difference.
Jurisdictional planning body 2	2 × AIS station project 2 × overhead line project	• Satisfactory difference noted by the TNSP in the total direct costs excluding the easement/property cost and environmental offset cost components, if 'remote' location is selected in the updated 2025 TCD Tool. This feedback was considered and used to refine the locational project attribute factor. • Significant difference noted by the TNSP in the indirect costs. However, the reasons for this difference were identified and attributed to project specific delivery timetable and stakeholder and community engagement scenarios.
Jurisdictional planning body 3	2 × station project 1 × undersea cable asset subcategory project 1 × underground cable asset subcategory project	• Satisfactory difference noted in both station asset category project estimates. • Satisfactory difference noted in undersea cable subcategory project estimate. • Satisfactory difference noted in the underground cable asset subcategory after the inclusion of future project staging in the participant estimate is taken into account.

The outcome of the benchmarking activity confirmed that the updates in 2025 TCD version typically reflects the market condition experienced in the NEM and participants who have recently or are currently negotiating contracts or have recently executed commercial agreements. It allowed GHD and Amplitude Consultants to refine the updated asset building blocks baseline estimates and also calibrate the percentage adjustment for project attribute factors and known risk factors. This step resulted in the following refinements to the 2025 TCD:

– Reestablishing the asset building block baseline estimates for the overhead lines asset category focusing on 'Civil and structural works', 'Electrical works', and 'Contractor project management and overheads' cost components to ensure the baseline estimate is aligned with the BAU choice for both locational project attribute factor and market activity known risk factor.
– Reestablishing the asset building block baseline estimates for the station AIS switchbay asset subcategory focusing on 'Civil and structural works', 'Electrical works', and 'Contractor project management and overheads' cost components to ensure the baseline estimate is aligned with the BAU choice for both locational project attribute factor and market activity known risk factor.
– Minor adjustments were made to HVDC converter station asset subcategory building block baseline estimates.

– Making the ‘locational’ project attribute factor more sensitive for selecting ‘remote’ choice to incorporate higher cost observed for labour mobilisation and overheads such as FIFO, travel, accommodation and LAFHA allowance.
– Making the ‘market activity’ known risk factor more sensitive for non-BAU choices, to reflect the cost swings seen during periods of tight market activity or during periods of excess capacity. AEMO has noted that the volume of transmission augmentation work in NEM may reduce post-2030. Therefore, this calibration will allow the TCD Tool user to moderate the project estimate by selecting ‘BAU’ choice for ‘market activity’ known risk factor post-2030 when the demand for transmission network work reduce.

5. Changes from 2023 TCD

The 2025 TCD update has seen noteworthy changes to project cost estimates of some asset subcategories, compared to the previous 2023 TCD version. Some cost components have changed more than the others. This section explains the causes and the quantum of change to total project estimates between the two TCD versions.

5.1 Observations of Change

The following are key observations GHD believe are the causes of the significant cost changes. It is not possible to clinically determine the quantum of cost change and exclusively attribute them to each cause.

Demand and supply

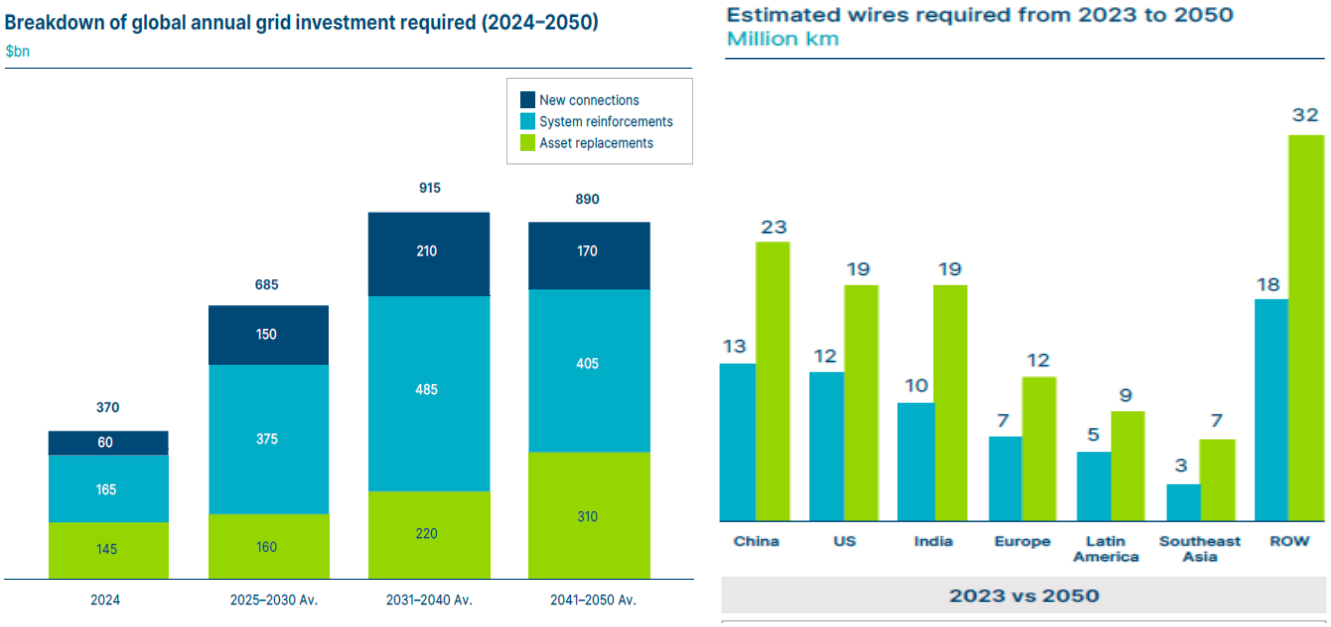
The NEM is experiencing the largest pipeline of transmission network projects seen in many years needed to support renewable energy transition. This volume of projects has been consistently documented in the previous and most recent ISP, for all scenarios. This level of demand has not been matched with same level of supply capacity in the market. In an ideal market, the supply will match the demand however, realistically there is some delay in market supply capacity to catch-up and address this demand, and currently the demand appears to outstrip the supply capacity. Also, the productivity of Australian construction industry has stagnated in recent years. These conclusions are documented in the recent annual Infrastructure Market Capacity report[7] and the Public Infrastructure Workforce Supply Dashboard[8] available in Infrastructure Australia's website.

This rapid growth in pipeline of transmission network projects is not unique to Australia. Globally the demand in this industry for resources needed to plan, develop and delivery these transmission projects, is projected to continue to grow in the near future.

The forecast of this global demand level is shown in the following illustration. It shows the forecast of increasing level of annual capex required globally (left chart) and forecast of length of transmission conductor required Australia is grouped together in the 'rest of the world' category (right chart).

[7] **2024 Infrastructure Market Capacity report | Infrastructure Australia**
[8] Labour supply vs demand trend over time selected for all groups in NEM states and for relevant occupations to transmission network industry.

Figure 7 *Global demand pressure [source: Building grids faster: the backbone of the energy transition, Sep 2024, Version 1.0, Energy Transitions Commission]*



This global demand, along with Australian demand, is competing for the same pool of skills, production floor capacity and other supply chain arrangements. This resulting cost increase is reflected within the TCD's cost components 'Civil and structural works', 'Electrical works' and 'Contractor project management & overheads' within the asset building block baseline estimates.

Large contracts

In addition to the pipeline of transmission network projects increasing, the NEM is also noticing the size of individual projects or contracts have increased. This has led to higher risks in undertaking such contracts for tenderers, who may not have historically delivered transmission network projects of such sizes. Their security holders are therefore requiring them to increase their insurance coverage and guarantees. Tenderers are in turn passing this on in overheads in their bids. This component of their bid most likely sits within the TCD cost component 'Contractor project management & overheads' within the asset building block baseline estimates.

TNSPs have explored splitting their contracts into multiple tenders to avoid exposing a single bidder to large contracts. But this is offset by having to set-up multiple procurements, contracts, administration and project management teams and processes.

Locations

Transmission network projects are being developed in further locations away from established TNSP depots and township that have traditionally be able to accommodate influx of workers during construction phase. The project cost estimates and realised actuals, pertaining to overhead such as labour LAFHA, mobilisation, transportation, accommodations, site office set-up, plant delivery-to-site etc. are greater than before.

These overhead costs are being incorporated into standardised unit rates as the new normal. It is for this reason that in the updated 2025 TCD Tool baseline estimates for all overhead lines asset category is now based on projects being constructed in a regional location. Whereas it was based on projects being constructed in an urban location in the previous 2023 TCD version. This resulting cost increase is reflected within the cost component 'Civil and structural works', 'Electrical works' and 'Contractor project management & overheads' within the asset building block baseline estimates.

Environmental biodiversity offset costs

As explained in Section 2.1.2, GHD have recalculated the 'Environmental offset costs' component of all asset building block baseline estimates from first principle basis by reviewing federal and respective jurisdiction environmental regulations and identifying the variables to estimate such costs. GHD recalculated the $/m^2 biodiversity offset rate to update this cost component.

This revision has resulted in significant change to this cost component, wherein it is now one of the larger cost components in projects, particular for overhead lines asset category.

Stakeholder and community engagement costs

The cost and time to complete successful community and stakeholder engagement activity in lead up to transmission network projects, especially for overhead transmission line corridors, is increasing. This is due to the need for mandated consultative process involving large number of stakeholders with varieties of opinions and expectations that can influence the projects outcome. This is also due to larger size and length of transmission infrastructure, than in the recent past, that traverses through more properties and are exposed to more diverse stakeholders.

Programs such as Strategic Benefit Payment Scheme in NSW[9] incentivise landowners to host such infrastructure and is intended to facilitate the uptake of such infrastructure in their regions. Nevertheless, there have been NEM transmission projects in recent times which have experienced increased cost and time to manage stakeholder and community oppositions or address differing opinions and expectations. This cost component is accounted within the indirect costs in the TCD Tool. As explained in Section 2.5, based on the survey response data and discussion with the TNSPs, the 2025 update involved increasing the estimated percentage attributed to stakeholder and community engagement cost component, within the indirect costs for larger projects.

Revision

The 2025 TCD update provided the opportunity to survey and review larger samples of project estimates at various stages of maturity or estimate class. Some of these samples have advanced to contract execution and some have been delivered and realised (providing actual cost data). These samples provide the cost information relevant to the current market climate. This updated also had the opportunity to receive specialist advise on HVDC technology, contemporary market offerings and current cost information from Amplitude Consultants.

This has led some of the asset building block baseline estimates being revised which were potentially underestimated in 2021 or 2023 TCD versions.

5.2 Quantum of change

Due to the various changes described in this report between the 2025 TCD update and the 2023 TCD version. It's important to note that TCD Tool users are cautioned not to exclusively compare the asset building block baseline estimates between the two versions, as this may lead to misleading conclusions. Preferably all relevant project adjustments need to be included to account for project specific attributes, risk exposure, and indirect costs. Once these are considered and added, comparisons between the two TCD versions will be more insightful.

To demonstrate the quantum of change in the 2025 TCD update, GHD compiled the estimate of three indicative example projects to depict this change at total project estimate level. Given the number of variable inputs and selections available in the TCD Tool, GHD created two scenarios for each project. One scenario with unfavourable project conditions and a second scenario with favourable project conditions.

This provides estimates for each indicative project to demonstrate a typical upper and lower bound range. This is detailed in the following table.

[9] **Strategic Benefit Payments Scheme | EnergyCo**. This is excluded from the TCD estimate build-up.

Table 9 Subset of few input variables in both scenarios to compile upper and lower bounds of estimate range

Indicative project description	Subset of input variables and selections	
	Unfavourable project conditions (to compile upper bound estimate)	**Favourable project conditions (to compile lower bound estimate)**
Project example 1 • Overhead lines asset category • HVAC 500kV DCST 6124MVA quad orange conductor per phase • NSW-Southern subregion • 100km long route • Greenfield work	• Grazing land use • Remote location • Mountainous terrain • Environmentally sensitive area 50% • Tight market activity • Project complexity highly complex • Environmental offset risk high • High geotech finding issue	• Scrub land use • Regional location • Flat terrain • Environmentally sensitive area none • Excess capacity market activity • Project complexity BAU • Environmental offset risk low • Low geotech finding issue
Project example 2 • Station asset category • HVAC 330/132kV substation with full breaker and half AIS bays on both side • Two power transformers and one reactor • NSW-Southern subregion • Greenfield work	• Grazing land use • Remote location • Environmentally sensitive area 50% • Tight market activity • Project complexity highly complex • Environmental offset risk high • High geotech finding issue	• Developed area land use • Urban location • Environmentally sensitive area none • Excess capacity market activity • Project complexity BAU • Environmental offset risk low • Low geotech finding issue
Project example 3 • Underground cable asset category • HVAC 330kV 1000mm^2 single circuit direct buried cable • NSW-Southern subregion [Note: there was no 'jurisdiction' project attribute factor for underground cables asset category in 2023 TCD version] • 10km long route	• Brownfield (high density interface with other utility) • Urban location • Developed land use [Note: there was no 'land use' project attribute factor for underground cables asset category in 2023 TCD version] • Environmentally sensitive area 50% • Tight market activity • Project complexity highly complex • Environmental offset risk high • High geotech finding issue	• Greenfield (no interface with other utility) • Regional location • Scrub land use [Note: there was no 'land use' project attribute factor for underground cables asset category in 2023 TCD version] • Environmentally sensitive area none • Excess capacity market activity • Project complexity BAU • Environmental offset risk low • Low geotech finding issue

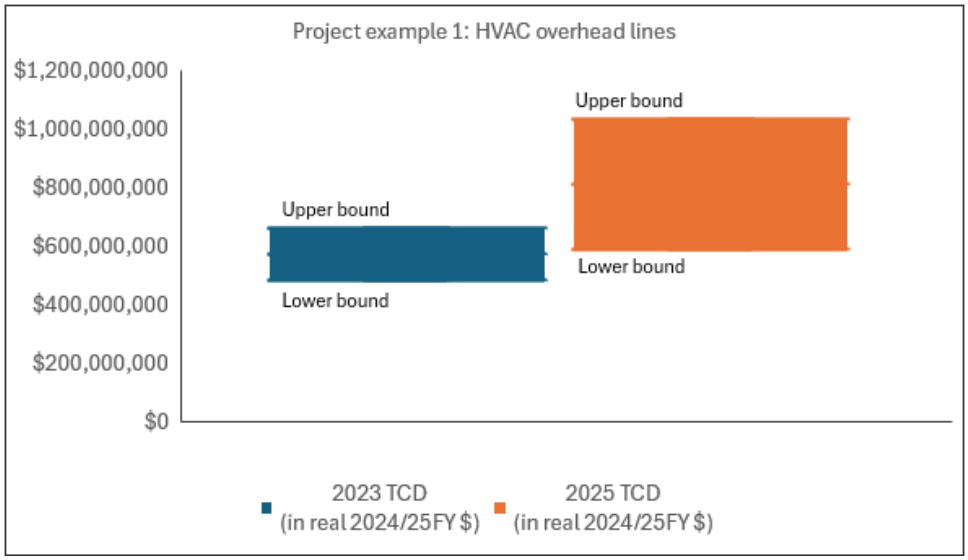
Indicative project description	Subset of input variables and selections	
	Unfavourable project conditions (to compile upper bound estimate)	Favourable project conditions (to compile lower bound estimate)
Project example 4 • Station asset category • HVDC converter station (VSC) • ±525kV Bipole with metallic return • 2 × 1000MW • NSW-Southern subregion • Greenfield work	• Grazing land use • Remote location • Environmentally sensitive area 50% • Tight market activity • Project complexity highly complex • Environmental offset risk high • High geotech finding issue	• Developed area land use • Urban location • Environmentally sensitive area none • Excess capacity market activity • Project complexity BAU • Environmental offset risk low • Low geotech finding issue
Project example 5 • Subsea cable asset subcategory • HVDC ±525kV Asymmetrical Monopole - Bipole with metallic return • 1500MW (750MW per monopole, 1600mm^2) • TAS-Northern subregion [Note: there was no 'jurisdiction' project attribute factor for underground cables asset category in 2023 TCD version] • 300km long subsea route • Greenfield work	• Remote location • Environmentally sensitive area 50% • Tight market activity • Project complexity highly complex • Environmental offset risk high • High geotech finding issue	• Remote location • Environmentally sensitive area none • Excess capacity market activity • Project complexity BAU • Environmental offset risk low • Low geotech finding issue
Project example 6 • Underground cable direct buried asset subcategory • HVDC ±500/525kV Bipole with metallic return • 1500MW (750MW per monopole, 1600mm^2) • NSW-Southern subregion [Note: there was no 'jurisdiction' project attribute factor for underground cables asset category in 2023 TCD version] • 300km long route	• Brownfield (high density interface with other utility) • Remote location • Grazing land use [Note: there was no 'land use' project attribute factor for underground cables asset category in 2023 TCD version] • Environmentally sensitive area 50% • Tight market activity • Project complexity highly complex • Environmental offset risk high • High geotech finding issue	• Greenfield (no interface with other utility) • Regional location • Scrub land use [Note: there was no 'land use' project attribute factor for underground cables asset category in 2023 TCD version] • Environmentally sensitive area none • Excess capacity market activity • Project complexity BAU • Environmental offset risk low • Low geotech finding issue

Indicative project description	Subset of input variables and selections	
	Unfavourable project conditions (to compile upper bound estimate)	Favourable project conditions (to compile lower bound estimate)
Project example 7 • Overhead lines asset category • HVDC VSC ±320kV Double Symmetrical Monopole • 1500MW (750MW per monopole) • NSW-Southern subregion • Greenfield work • 300km long route	• Grazing land use • Remote location • Mountainous terrain • Environmentally sensitive area 50% • Tight market activity • Project complexity highly complex • Environmental offset risk high • High geotech finding issue	• Scrub land use • Regional location • Flat terrain • Environmentally sensitive area none • Excess capacity market activity • Project complexity BAU • Environmental offset risk low • Low geotech finding issue

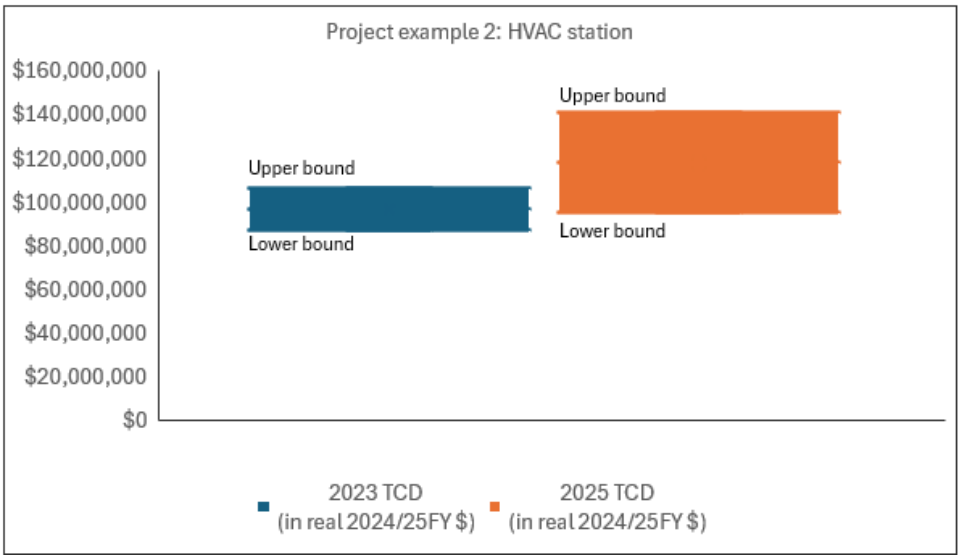
It is noted that the above input variables and selections used to create the unfavourable and favourable project scenarios, are a subset of all choices available in the TCD Tool for the user. These inputs were chosen to demonstrate upper and lower bounds of the project estimate for the same project. Further combinations of more input variables and selections are possible to compile even more extreme estimate bounds. What has been selected for these scenarios are chosen to represent a reasonable project estimate range for illustration purpose.

The resulting estimates for each example project generated by the updated 2025 TCD and the previous 2023 TCD (escalated to real 2024/25FY $) is shown in the following illustration.

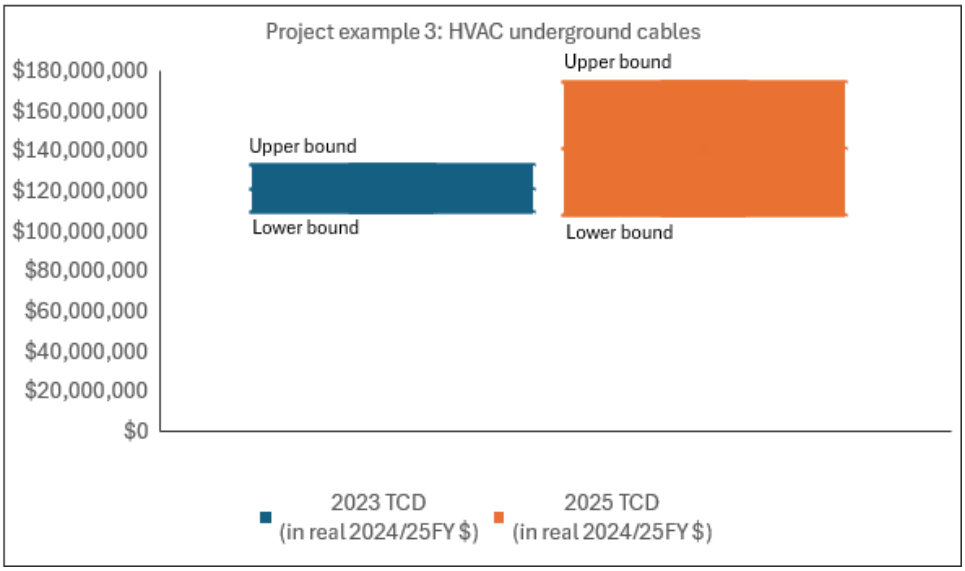
Figure 8 Quantum of change in total project estimate between 2025 TCD and 2023 TCD



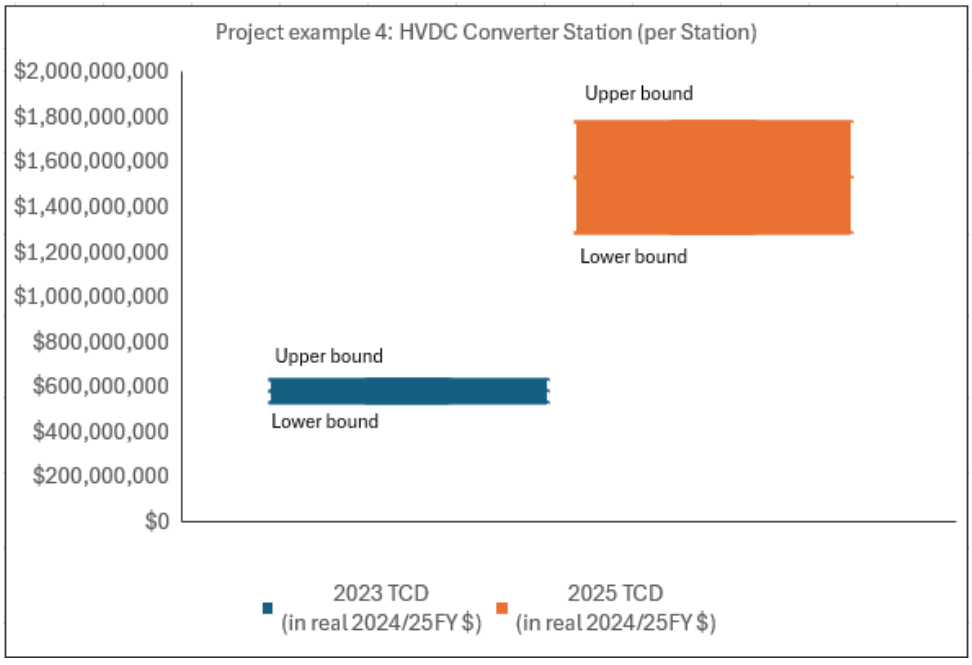
The total estimate increased by ~25% (for projects with favourable conditions) to ~55% (for projects with unfavourable conditions) in real dollar term for a representative HVAC overhead line project between the 2025 TCD and 2023 TCD output.



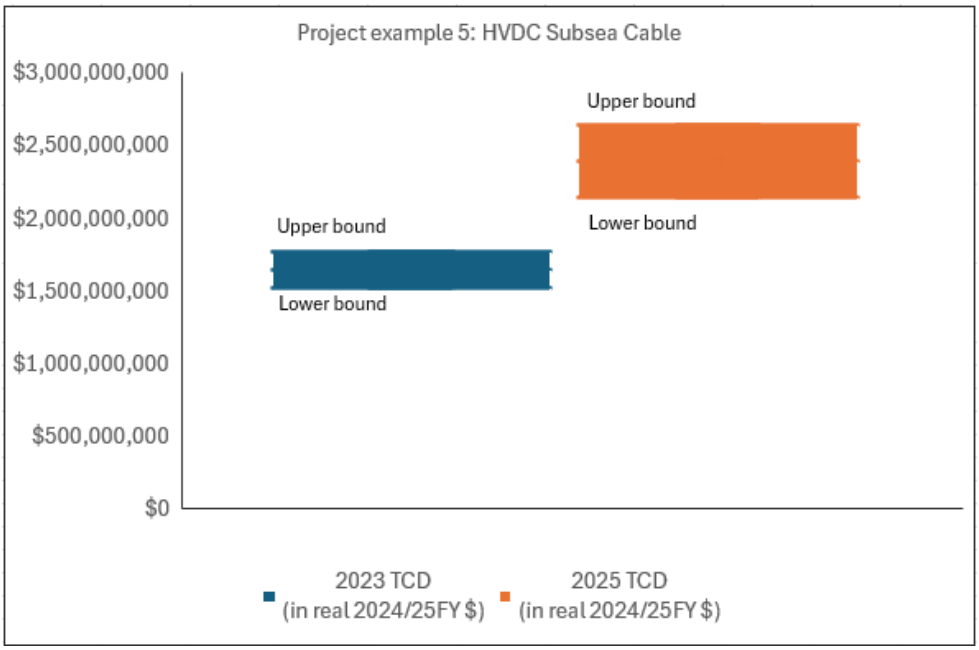
The total estimate increased by ~10% (for projects with favourable conditions) to ~35% (for projects with unfavourable conditions) in real dollar term for a representative HVAC AIS station project between the 2025 TCD and 2023 TCD output.



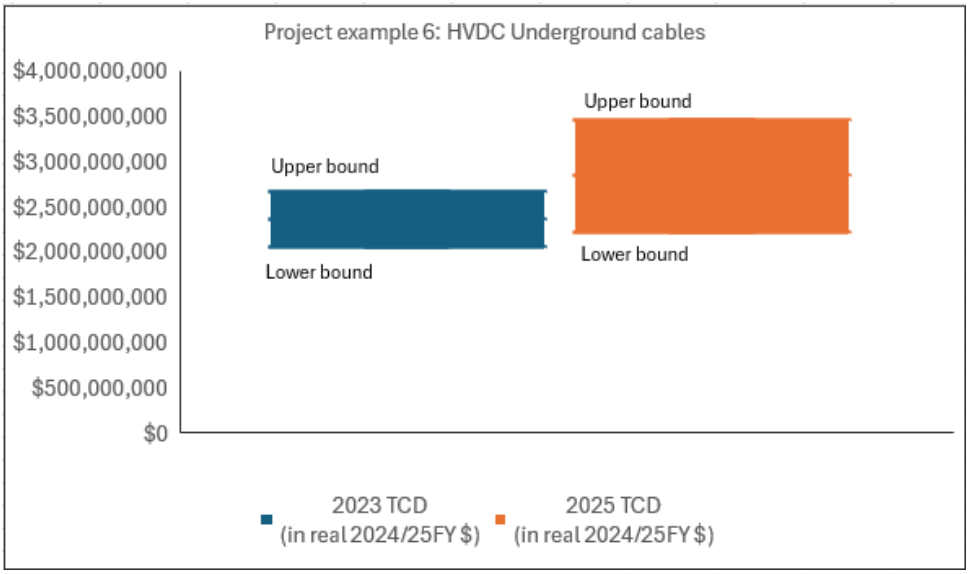
The total estimate increased by ~0% (for projects with favourable conditions) to ~35% (for projects with unfavourable conditions) in real dollar term for a representative HVAC underground cables direct buried project between the 2025 TCD and 2023 TCD output.



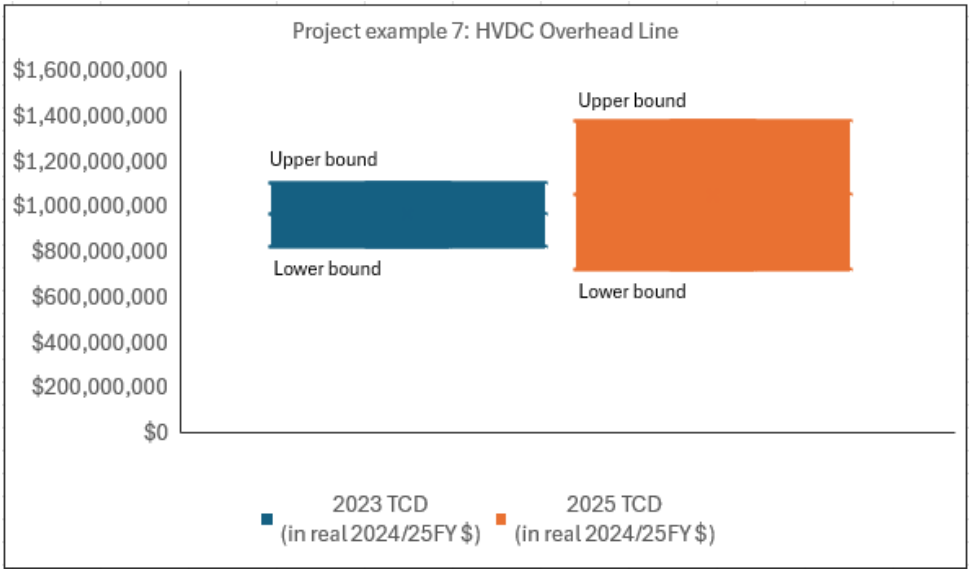
The total estimate increased by ~140% (for projects with favourable conditions) to ~180% (for projects with unfavourable conditions) in real dollar term for a representative HVDC converter station project between the 2023 TCD and 2025 TCD outputs.



The total estimate increased by ~40% (for projects with favourable conditions) to ~50% (for projects with unfavourable conditions) in real dollar term for a representative HVDC subsea cable project between the 2023 TCD and 2025 TCD outputs.



The total estimate increased by ~10% (for projects with favourable conditions) to ~30% (for projects with unfavourable conditions) in real dollar term for a representative HVDC underground cable direct buried project between the 2023 TCD and 2025 TCD outputs.



The total estimate changed by ~ -10% (for projects with favourable conditions) to ~25% (for projects with unfavourable conditions) in real dollar term for a representative HVDC overhead line project between the 2023 TCD and 2025 TCD outputs.

In few cases, the 2025 TCD update also led to decreases in some cost components (for e.g., ‘Plant’ cost component of underground cables) informed by survey feedback. However, such decreases have mostly been offset by increases in other cost components.

Appendices

Appendix A

Asset building block changes

Table 10 List of changes to asset building blocks

2023 TCD Asset building blocks	2025 TCD Asset building blocks
Property site work and building asset subcategory: Added new asset building blocks in 2025 TCD	
	AIS site infrastructure 40000 m2 footprint area and applicable control building AIS site infrastructure 50000 m2 footprint area and applicable control building AIS site infrastructure 60000 m2 footprint area and applicable control building
Modular power flow controller asset subcategory: Changed asset building block descriptions and added new asset building blocks in 2025 TCD	
Modular Power flow controller 1000MVA 500kV Modular Power flow controller 750MVA 500kV Modular Power flow controller 750MVA 330kV Modular Power flow controller 500MVA 330kV Modular Power flow controller 400MVA 275kV Modular Power flow controller 200MVA 275kV Modular Power flow controller 400MVA 220kV Modular Power flow controller 200MVA 220kV	Modular Power flow controller 7.2 Ohms 500kV Modular Power flow controller 4.8 Ohms 500kV Modular Power flow controller 2.4 Ohms 500kV Modular Power flow controller 9 Ohms 330kV Modular Power flow controller 6 Ohms 330kV Modular Power flow controller 3 Ohms 330kV Modular Power flow controller 12 Ohms 275kV Modular Power flow controller 8 Ohms 275kV Modular Power flow controller 4 Ohms 275kV Modular Power flow controller 15 Ohms 220kV Modular Power flow controller 10 Ohms 220kV Modular Power flow controller 5 Ohms 220kV Modular Power flow controller 30 Ohms 132kV Modular Power flow controller 20 Ohms 132kV Modular Power flow controller 10 Ohms 132kV
HVDC converter station asset subcategory: Changed asset building block descriptions and added new asset building blocks in 2025 TCD	
Symmetrical Monopole, 750MW ±320kV ±320kV Asymmetrical Monopole, 1000MW 500kV 500kV Symmetrical Monopole, 1000MW ±500kV ±500kV 2 × Asymmetrical Monopole (Bipole), 2 × 750MW ±500kV ±500kV 2 × Symmetrical Monopole , 2 × 750MW ±500kV ±500kV 2 × Asymmetrical Monopole (Bipole), 2 × 1000MW ±500kV ±500kV 2 × Symmetrical Monopole , 2 × 1000MW ±500kV ±500kV 2 × Asymmetrical Monopole (Bipole), 2 × 1500MW ±500kV ±500kV Asymmetrical Monopole, 750MW 500kV 500kV Asymmetrical Monopole, 1000MW 500kV 500kV 2 × Asymmetrical Monopole (Bipole), 2 × 750MW ±500 ±500kV 2 × Asymmetrical Monopole (Bipole), 2 × 1000MW ±500 ±500kV	Symmetric Monopole, 500MW ±320kV Symmetric Monopole, 750MW ±320kV Symmetric Monopole, 1000MW ±320kV Bipole, 1000MW (500MW per pole) ±320kV Bipole, 1500MW (750MW per pole) ±525kV Bipole, 2000MW (1000MW per pole) ±525kV Bipole, 3000MW (1500MW per pole) ±640kV 2 x Symmetric Monopole, 1000MW (500MW per pole) ±320kV 2 x Symmetric Monopole, 1500MW (750MW per pole) ±320kV 2 x Symmetric Monopole, 2000MW (1000MW per pole) ±320kV Asymmetric Monopole, 500MW320kV Asymmetric Monopole, 750MW525kV

2023 TCD Asset building blocks	2025 TCD Asset building blocks
2 × Asymmetrical Monopole (Bipole), 2 × 1500MW ±600 ±600kV	Asymmetric Monopole, 1000MW525kV
2 × Asymmetrical Monopole (Bipole), 2 × 1000MW ±500 ±500kV	Bipole, 1000MW (500MW per pole) ±320kV
2 × Symmetrical Monopole , 2 × 1000MW ±500 ±500kV	Bipole, 1500MW (750MW per pole) ±525kV
2 × Asymmetrical Monopole (Bipole), 2 × 1500MW ±500 ±500kV	Bipole, 2000MW (1000MW per pole) ±525kV
2 × Asymmetrical Monopole (Bipole), 2 × 1000MW ±500 ±500kV	Bipole, 3000MW (1500MW per pole) ±640kV
2 × Asymmetrical Monopole (Bipole), 2 × 1500MW ±600 ±600kV	Bipole, 1500MW (750MW per pole), built in two stages ±525kV
2 × Asymmetrical Monopole (Bipole), 2 × 2000MW ±500 ±500kV	Bipole, 2000MW (1000MW per pole), built in two stages ±525kV
2 × Asymmetrical Monopole (Bipole), 2 × 2000MW ±500 ±500kV	Bipole, 3000MW (1500MW per pole), built in two stages ±640kV
2 × Asymmetrical Monopole (Bipole), 2 × 2000MW ±600 ±600kV	2 x Symmetric Monopole, 1500MW (750MW per pole), built in two stages ±320kV
2 × Asymmetrical Monopole (Bipole), 2 × 2000MW ±600	2 x Symmetric Monopole, 2000MW (1000MW per pole), built in two stages ±320kV
	Bipole, 1000MW (500MW per pole), built in two stages ±320kV
	Bipole, 1500MW (750MW per pole), built in two stages ±525kV
	Bipole, 2000MW (1000MW per pole), built in two stages ±525kV
	2 x Symmetric Monopole, 3000MW (1500MW per pole) ±525kV
	2 x Symmetric Monopole, 3000MW (1500MW per pole), built in two stages ±525kV
	Bipole, 3000MW (1500MW per pole), built in two stages ±640kV
HVAC overhead lines subcategory: Removed asset building blocks from 2025 TCD	
2 × Olive DCST 3350 MVA 500kV	
Stage 1 development: 2 × Olive DCST 3350 MVA 500kV	
Stage 2 development: 2 × Olive DCST 3500 MVA 500kV	
1 × Uranus SCST 111 MVA 66kV	
1 × Uranus DCST 222 MVA 66kV	
Stage 1 development: 1 × Uranus DCST 222 MVA 66kV	
Stage 2 development: 1 × Uranus DCST 222 MVA 66kV	
1 × Taurus SCST 86 MVA 66kV	
1 × Taurus DCST 172 MVA 66kV	
Stage 1 development: 1 × Taurus DCST 172 MVA 66kV	
Stage 2 development: 1 × Taurus DCST 172 MVA 66kV	
1 × Neptune SCST 55 MVA 66kV	
1 × Neptune DCST 110 MVA 66kV	
Stage 1 development: 1 × Neptune DCST 110 MVA 66kV	
Stage 2 development: 1 × Neptune DCST 110 MVA 66kV	
3 × Neptune SCST 82 MVA 33kV	
3 × Neptune DCST 164 MVA 33kV	
Stage 1 development: 3 × Neptune DCST 164 MVA 33kV	
Stage 2 development: 3 × Neptune DCST 164 MVA 33kV	
1 × Uranus SCST 55 MVA 33kV	
1 × Uranus DCST 110 MVA 33kV	

2023 TCD Asset building blocks	2025 TCD Asset building blocks
Stage 1 development: 1 × Uranus DCST 110 MVA 33kV Stage 2 development: 1 × Uranus DCST 110 MVA 33kV 1 × Taurus SCST 43 MVA 33kV 1 × Taurus DCST 86 MVA 33kV Stage 1 development: 1 × Taurus DCST 86 MVA 33kV Stage 2 development: 1 × Taurus DCST 86 MVA 33kV 3 × Neptune SCST 55 MVA 22kV 3 × Neptune DCST 110 MVA 22kV Stage 1 development: 3 × Neptune DCST 110 MVA 22kV Stage 2 development: 3 × Neptune DCST 110 MVA 22kV 3 × Flourine SCST 26 MVA 22kV 3 × Flourine DCST 52 MVA 22kV Stage 1 development: 3 × Flourine DCST 52 MVA 22kV Stage 2 development: 3 × Flourine DCST 52 MVA 22kV	
HVDC overhead lines subcategory: Changed asset building block descriptions and added new asset building blocks in 2025 TCD	
Asymmetrical Monopole, 750 MW 500kV (>750km) Asymmetrical Monopole, 750 MW 320kV (<750km) Asymmetrical Monopole, 1000 MW 500kV 2 × Symmetrical Monopole, 2 × 750 MW ±500kV (>750km) 2 × Symmetrical Monopole, 2 × 750 MW ±320kV (<750km) 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 750 MW ±500kV 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 750 MW ±320kV (<750km) 2 × Symmetrical Monopole, 2 × 1000 MW ±500kV 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 1000 MW ±500kV 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 1500 MW ±500kV Asymmetrical Monopole, 750 MW 500kV (>750km) Asymmetrical Monopole, 750 MW 320kV (<750km) Asymmetrical Monopole, 1000 MW 500kV 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 750 MW ±500kV (>750km) 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 750 MW ±320kV (<750km) 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 1000 MW ±500kV 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 1500 MW ±600kV First Symmetrical Monopole and then Second Symmetrical Monopole, 2 × 1000 MW ±500kV	Symmetric Monopole, 500 MW (250 MW/pole) 320kV Symmetric Monopole, 750 MW (375 MW/pole) 320kV Symmetric Monopole, 1000 MW (500 MW/pole) 320kV Bipole, 1000 MW (500 MW/pole) 320kV Bipole, 1500 MW (750 MW/pole) 525kV Bipole, 2000 MW (1000 MW/pole) 525kV Asymmetric Monopole, 500 MW 320kV Asymmetric Monopole, 750 MW 525kV Asymmetric Monopole, 1000 MW 525kV Bipole, 1000 MW (500 MW/pole) 320kV Bipole, 1500 MW (750 MW/pole) 525kV Bipole, 2000 MW (1000 MW/pole) 525kV Bipole, 1500 MW (750 MW/pole), Stage 1 of 2 525kV Bipole, 1500 MW (750 MW/pole), Stage 2 of 2 525kV Bipole, 2000 MW (1000 MW/pole), Stage 1 of 2 525kV Bipole, 2000 MW (1000 MW/pole), Stage 2 of 2 525kV Bipole, 3000 MW (1500 MW/pole), Stage 1 of 2 640kV Bipole, 3000 MW (1500 MW/pole), Stage 2 of 2 640kV 2 x Symmetric Monopole, 1500 MW (750 MW/pole), Stage 1 of 2 320kV 2 x Symmetric Monopole, 1500 MW (750 MW/pole), Stage 2 of 2 320kV 2 x Symmetric Monopole, 2000 MW (1000 MW/pole), Stage 1 of 2 320kV 2 x Symmetric Monopole, 2000 MW (1000 MW/pole), Stage 2 of 2 320kV

2023 TCD Asset building blocks	2025 TCD Asset building blocks
First Asymmetrical Monopole and then Second Asymmetrical Monopole, 2 × 1000 MW ±500kV First Asymmetrical Monopole and then Second Asymmetrical Monopole, 2 × 1500 MW ±500kV First Asymmetrical Monopole and then Second Asymmetrical Monopole, 2 × 1000 MW ±500kV First Asymmetrical Monopole and then Second Asymmetrical Monopole, 2 × 1500 MW ±600kV Asymmetrical Monopole, 1000 MW 500kV (<750km) Symmetrical Monopole, 1000MW ±500kV Symmetrical Monopole, 1500MW ±500kV Symmetrical Monopole, 2500MW ±500kV 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 2000 MW ±500kV 2 × Asymmetrical Monopole (Bipole metallic return), 2 × 3000 MW ±600kV First Asymmetrical Monopole and then Second Asymmetrical Monopole, 2 × 2000 MW ±500kV First Asymmetrical Monopole and then Second Asymmetrical Monopole, 2 × 3000 MW ±600kV	2 x Symmetric Monopole, 3000 MW (1500 MW/pole), Stage 1 of 2 525kV Bipole, 1000 MW (500 MW/pole), Stage 1 of 2 320kV Bipole, 1000 MW (500 MW/pole), Stage 2 of 2 320kV Bipole, 1500 MW (750 MW/pole), Stage 1 of 2 525kV Bipole, 1500 MW (750 MW/pole), Stage 2 of 2 525kV Bipole, 2000 MW (1000 MW/pole), Stage 1 of 2 525kV Bipole, 2000 MW (1000 MW/pole), Stage 2 of 2 525kV Bipole, 3000 MW (1500 MW/pole), Stage 1 of 2 640kV Bipole, 3000 MW (1500 MW/pole) 640kV 2 x Symmetric Monopole, 1000 MW (500 MW/pole) 320kV 2 x Symmetric Monopole, 1500 MW (750 MW/pole) 320kV 2 x Symmetric Monopole, 2000 MW (1000 MW/pole) 320kV 2 x Symmetric Monopole, 3000 MW (1500 MW/pole) 525kV Bipole, 3000 MW (1500 MW/pole) 640kV 2 x Symmetric Monopole, 3000 MW (1500 MW/pole), Stage 2 of 2 525kV Bipole, 3000 MW (1500 MW/pole), Stage 2 of 2 640kV
HVDC underground cables subcategory: Changed asset building block descriptions and added new asset building blocks in 2025 TCD	
1000 MVA - Direct buried cable - twin 500 MVA symmetrical monopole circuits 500kV 2000 MVA - Direct buried cable - twin 1000 MVA symmetrical monopole circuits 500kV 2500 MVA - Direct buried cable - twin 1250 MVA symmetrical monopole circuits 500kV 1500 MVA - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x750 MW ±500kV 2000 MW - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x1000 MW ±500kV 3000 MW - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x1500 MW ±500kV 4000 MW - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x2000 MW ±500kV 6000 MW - Direct buried cable - Asymmetrical Monopole (Bipole metallic return), 2x3000 MW ±600kV 2 × Asymmetrical Monopole (Bipole), 2 × 1000MW - First Stage 1000 MW, Second stage 1000 MW 500kV 2 × Asymmetrical Monopole (Bipole), 2 × 1500MW - First Stage 1500 MW, Second Stage 1500 MW 500kV 2 × Asymmetrical Monopole (Bipole), 2 × 2000MW - First Stage 2000 MW, Second Stage 2000 MW 500kV 2 × Asymmetrical Monopole (Bipole), 2 × 3000MW - First Stage 3000 MW, Second Stage 3000 MW 600kV 1000 MW - Subsea Cable - twin 500 MVA symmetrical monopole circuits 500kV	Symmetric Monopole, 500MW ±320kV Symmetric Monopole, 750MW ±320kV Symmetric Monopole, 1000MW ±320kV Bipole, 1000MW (500MW per pole, 1800mm2) ±320kV Bipole, 1500MW (750MW per pole, 1600mm2) ±525kV Bipole, 1500MW (750MW per pole, 1600mm2), built in two stages ±525kV Bipole, 2000MW (1000MW per pole, 2500mm2) ±525kV Bipole, 2000MW (1000MW per pole, 2500mm2), built in two stages ±525kV 2 x Symmetric Monopole, 1000MW (500MW per pole) ±320kV 2 x Symmetric Monopole, 1500MW (750MW per pole) ±320kV 2 x Symmetric Monopole, 1500MW (750MW per pole), built in two stages ±320kV 2 x Symmetric Monopole, 2000MW (1000MW per pole) ±320kV 2 x Symmetric Monopole, 2000MW (1000MW per pole), built in two stages ±320kV 2 x Symmetric Monopole, 3000MW (1500MW per pole) ±525kV 2 x Symmetric Monopole, 3000MW (1500MW per pole), built in two stages ±525kV Symmetric Monopole, 500MW ±320kV Symmetric Monopole, 750MW ±320kV Symmetric Monopole, 1000MW ±320kV

2023 TCD Asset building blocks	2025 TCD Asset building blocks
2000 MW - Subsea Cable - twin 1000 MVA symmetrical monopole circuits 500kV	Bipole, 1000MW (500MW per pole, 1800mm2) ±320kV
2500 MW - Subsea Cable - twin 1250 MVA symmetrical monopole circuits 500kV	Bipole, 1500MW (750MW per pole, 1600mm2) ±525kV
1500 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x750 MW ±500kV	Bipole, 1500MW (750MW per pole, 1600mm2), built in two stages ±525kV
2000 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x1000 MW ±500kV	Bipole, 2000MW (1000MW per pole, 2500mm2) ±525kV
3000 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x1500 MW ±500kV	Bipole, 2000MW (1000MW per pole, 2500mm2), built in two stages ±525kV
4000 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x2000 MW ±500kV	2 x Symmetric Monopole, 1000MW (500MW per pole) ±320kV
6000 MW - Subsea Cable - Asymmetrical Monopole (Bipole metallic return), 2x3000 MW ±600kV	2 x Symmetric Monopole, 1500MW (750MW per pole) ±320kV
2 × Asymmetrical Monopole (Bipole), 2 × 1000MW - First Stage 1000 MW, Second stage 1000 MW 500kV	2 x Symmetric Monopole, 1500MW (750MW per pole), built in two stages ±320kV
2 × Asymmetrical Monopole (Bipole), 2 × 1500MW - First Stage 1500 MW, Second Stage 1500 MW 500kV	2 x Symmetric Monopole, 2000MW (1000MW per pole) ±320kV
2 × Asymmetrical Monopole (Bipole), 2 × 2000MW - First Stage 2000 MW, Second Stage 2000 MW 500kV	Asymmetric Monopole, 500MW ±320kV
2 × Asymmetrical Monopole (Bipole), 2 × 3000MW - First Stage 3000 MW, Second Stage 3000 MW 600kV	Asymmetric Monopole, 750MW ±525kV
375 MVA - Direct buried cable single monopole 375MVA circuit (offshore windfarms) 500kV	Asymmetric Monopole, 1000MW ±525kV
750 MVA - Direct buried cable - twin 375 MVA symmetrical monopole circuits 500kV	Bipole, 1000MW (500MW per pole, 2500mm2) ±320kV
1500 MVA - Direct buried cable - twin 750 MVA symmetrical monopole circuits 500kV	Bipole, 1000MW (500MW per pole, 2500mm2), built in two stages ±320kV
375 MVA - Subsea Cable single monopole 375MVA circuit (offshore windfarm) 500kV	Bipole, 1500MW (750MW per pole, 2500mm2) ±525kV
750 MVA - Subsea Cable - twin 375 MVA symmetrical monopole circuits 500kV	Bipole, 1500MW (750MW per pole, 2500mm2), built in two stages ±525kV
1500 MVA - Subsea Cable - twin 750 MVA symmetrical monopole circuits 500kV	Bipole, 2000MW (1000MW per pole, 3000mm2) ±525kV
	Bipole, 2000MW (1000MW per pole, 3000mm2), built in two stages ±525kV
	2 x Symmetric Monopole, 2000MW (1000MW per pole), built in two stages ±320kV
	2 x Symmetric Monopole, 3000MW (1500MW per pole) ±525kV
	2 x Symmetric Monopole, 3000MW (1500MW per pole), built in two stages ±525kV
	Asymmetric Monopole, 500MW ±320kV
	Asymmetric Monopole, 750MW ±525kV
	Asymmetric Monopole, 1000MW ±525kV
	Bipole, 1000MW (500MW per pole, 2500mm2) ±320kV
	Bipole, 1000MW (500MW per pole, 2500mm2), built in two stages ±320kV
	Bipole, 1500MW (750MW per pole, 2500mm2) ±525kV
	Bipole, 1500MW (750MW per pole, 2500mm2), built in two stages ±525kV
	Bipole, 2000MW (1000MW per pole, 3000mm2) ±525kV
	Bipole, 2000MW (1000MW per pole, 3000mm2), built in two stages ±525kV

Appendix B

‘Jurisdiction + Land use’ selection choices

Jurisdictions choices	Jurisdiction choices mapped to ABARES subregions (source: DAFF)		Land Use choices			“Jurisdiction + Land Use” choices available in 2025 TCD Tool (63 choices in total)
SA - Adelaide and Fleurieu	SA South East		Scrub	Grazing	Developed	3 choices
SA - Eyre Peninsula	SA Eyre Peninsula		Scrub	Grazing	Developed	3 choices
SA - South East	SA South East		Scrub	Grazing	Developed	3 choices
SA - York and North	Average of 2 ABARES subregions – SA Murray Land and Yorke Peninsula and SA Northern Pastoral	Desert	Scrub	Grazing	Developed	4 choices
TAS - Northern	TAS		Scrub	Grazing	Developed	3 choices
TAS - North West	TAS		Scrub	Grazing	Developed	3 choices
TAS - South	TAS		Scrub	Grazing	Developed	3 choices
VIC - Gippsland	VIC Southern and Eastern Victoria		Scrub	Grazing	Developed	3 choices
VIC - Northern	VIC Central North		Scrub	Grazing	Developed	3 choices
VIC - North West	VIC Mallee	Desert	Scrub	Grazing	Developed	4 choices
VIC - South West	VIC Wimmera		Scrub	Grazing	Developed	3 choices
NSW - Central	NSW Central West		Scrub	Grazing	Developed	3 choices
NSW - Northern	NSW North West Slopes and Plains		Scrub	Grazing	Developed	3 choices
NSW - Southern	NSW Riverina		Scrub	Grazing	Developed	3 choices
NSW - South East	Average of 2 ABARES subregions – NSW Coastal and NSW Tablelands		Scrub	Grazing	Developed	3 choices
NSW - Western	Average of 3 ABARES subregions - SA Northern Pastoral, NSW Central West, and VIC Mallee	Desert	Scrub	Grazing	Developed	4 choices
QLD - Central	QLD Charleville - Longreach		Scrub	Grazing	Developed	3 choices
QLD - North	Average of 2 ABARES subregions – QLD Central North and QLD Northern Coastal - Mackay of Cairns		Scrub	Grazing	Developed	3 choices
QLD - South	Average of 3 ABARES subregions – QLD Eastern Darling Downs, QLD Southern Coastal - Curtis to Moreton, and QLD Western Downs and Central Highland		Scrub	Grazing	Developed	3 choices
QLD - West	QLD West and South West	Desert	Scrub	Grazing		3 choices