AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

HumeLink Feedback Loop Analysis

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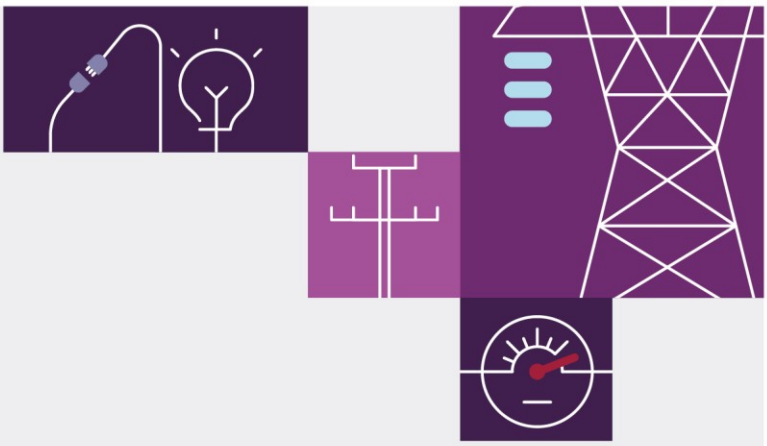
A report published for the Integrated System Plan feedback loop



Important notice

Purpose

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1 Feedback loop assessment approach

This report contains analysis supporting AEMO's confirmation notice that the feedback loop requirements for the early works stage of HumeLink are satisfied. That notice is published with this report[1] and includes a brief summary of the HumeLink project, regulatory approval milestones and Transgrid's feedback loop request. As explained in the notice, on 25 January 2022, Transgrid requested a feedback loop assessment ("feedback loop 1") for the early works stage of the HumeLink project. On 6 April 2023, Transgrid requested a second feedback loop assessment ("feedback loop 2") that included a revised cost estimate for the early works stage.

The revised cost estimate for HumeLink early works advised in Transgrid's feedback loop request differs from that used in the 2022 ISP. To determine the impact of this difference on the optimal development path (ODP), AEMO updated the 2022 ISP cost benefit analysis (CBA) using the cost estimates provided in Transgrid's latest feedback loop request. For transparency, key assumptions, analysis and commentary are provided below in support of AEMO's assessment.

1.1 Scope of the assessment

The feedback loop assesses alignment of the preferred option identified in the Regulatory Investment Test for Transmission (RIT-T) and its cost with the ODP in the most recent ISP and can entail re-running the ISP modelling and analysis. Changes in project costs and scope (which may impact project actionability and network transfer capability) advised in a feedback loop request are assessed by AEMO in the feedback loop. However, the reasonableness of the project scope (including the scope of early works) and the prudency and efficiency of cost estimates relating to that scope are not assessed in the feedback loop – these elements are instead considered by the AER as part of the contingent project assessment process.

1.2 Assessment method

Feedback loop assessments requirements direct AEMO to make an assessment with reference to the ODP in the most recent ISP (or ISP update). The AER's Cost Benefit Analysis (CBA) Guidelines require AEMO to consider re-running the CBA modelling and scenario analysis in the feedback loop, if practicable, using the RIT-T preferred option and cost advised in the feedback loop request where that option or cost differs from that considered by AEMO in the most recent ISP[2].

Consistent with these requirements, for HumeLink feedback loop 2, AEMO reassessed the selection of the ODP identified in the 2022 ISP based on the inputs and assumptions used to determine that ODP. This required an update of the CBA in the 2022 ISP using the cost estimates provided in Transgrid's latest feedback loop request without the need to re-run ISP market modelling.

The inputs and assumptions applied in this feedback loop were finalised concurrent with publication of the 2022 ISP (see Table 1 in Section 2.1 of this report). Therefore, changes in inputs and assumptions from July 2022, including the latest timing of Snowy 2.0, were not assessed. However, as noted in the 2022 ISP, the delivery of

[1] At https://aemo.com.au/-/media/files/major-publications/isp/2023/20230511-integrated-system-plan-feedback-loop-notice--humelink-early-works.pdf.

[2] AER, *CBA Guidelines*, p.48.

HumeLink earlier than needed for Snowy 2.0 will provide access for consumers to stored energy across the entire Snowy scheme, renewable energy in New South Wales and imports from South Australia and Victoria, thereby still delivering market benefits and greater resilience to the risks of schedule slippage in other generation, storage and transmission investments[3].

AEMO is currently consulting on updated inputs, assumptions and scenarios and an updated methodology in preparation for the 2024 ISP. Any feedback loop requests assessed after release of the 2024 ISP or an ISP update will be based on the inputs and assumptions used to determine the ODP in that ISP or ISP update.

1.3 Costs considered in the feedback loop

As summarised in the notice published with this report, the feedback loop includes an assessment of whether the cost of the preferred option changes the status of the actionable ISP project as part of the ODP[4]. Where a project is staged in the ISP, a feedback loop assessment is required for each stage and the cost assessed in the feedback loop is the cost of the relevant stage. The cost of the stage assessed in the feedback loop sets the "cost cap" for the subsequent CPA. AEMO must also have regard to the full cost of the project when confirming that the status of the project remains unchanged[5].

The AER has provided additional guidance relevant to feedback loops in a guidance note[6]. The guidance note clarifies that where a project is not identified as staged in the ISP but a TNSP elects to "stage the CPA process", the cost assessed in the feedback loop is the total cost of the actionable ISP project. The guidance note also explains that projects identified as staged in the ISP can be further separated into staged CPAs by a TNSP, if it is appropriate to do so based on the size, complexity and uncertainty of the project or project stages[7]. When this occurs, the guidance note does not clarify the cost expected to be assessed in the feedback loop. However, based on the guidance for projects not identified as staged in the ISP where the full project cost is assessed in the feedback loop, AEMO considers that where a project is identified as staged in the ISP, the full cost of that stage should be assessed in the feedback loop.

Therefore, for this feedback loop assessment, AEMO considered the total cost of HumeLink early works ($558.8 million) when assessing whether HumeLink remains a part of the ODP. AEMO also had regard to the total cost of the project ($3.32 billion) when considering whether the status of the project as actionable remains unchanged[8]. The total cost of the project remains consistent with that assessed in the 2022 ISP and feedback loop 1 because recovering the cost of long-lead equipment as part of early works activities will reduce forecast capex for the implementation stage of HumeLink by an equivalent amount, as advised in Transgrid's request.

[3] 2022 ISP, p.88.

[4] As required by NER 5.16A.5(b)(2).

[5] AER, *CBA Guidelines*, p.69. The "cost cap" refers to the requirement in NER 5.16A.5(d) that the cost of the preferred option set out in the CPA must be no greater than the cost considered by AEMO in the feedback loop. Therefore, AEMO confirmation that feedback loop requirements are satisfied would allow Transgrid to submit a CPA to recover total early works costs considered by AEMO less forecast capex already approved by the AER to undertake early works.

[6] AER, *Guidance Note: Regulation of actionable ISP projects* ("Guidance Note"), at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/regulation-of-large-transmission-projects.

[7] AER, *Guidance Note*, p.27-.28.

[8] These costs are in Real $2020-21, consistent with the 2022 ISP.

2 Feedback loop assessment

2.1 Inputs and assumptions

As explained in Section 1.2, AEMO updated the 2022 ISP CBA and reassessed the selection of the ODP identified in the 2022 ISP taking into account total early works costs for HumeLink and other relevant information provided in Transgrid's request. The inputs and assumptions used for this feedback loop assessment and reasoning for their selection are presented in Table 1 below[9].

Table 1 HumeLink feedback loop 2 inputs and assumptions (costs in Real $2020-21)

Inputs and assumptions	Values and settings	Reasoning
Base inputs and assumptions set	Inputs, Assumptions and Scenarios Workbook v3.4 (30/6/2022)*	These are the inputs and assumptions used to select the ODP in the most recent ISP (the 2022 ISP).
Total early works costs	$558.8 million	Equivalent to $531.5 million (Real $2017-18) advised in Transgrid's feedback loop request.
Total project cost	$3.32 billion	Consistent with the total project cost assessed in the 2022 ISP and feedback loop 1. Recovering the cost of long-lead equipment as part of early works activities will reduce forecast capex for the implementation stage of HumeLink by an equivalent amount, as advised in Transgrid's request.
Purchase of long-lead equipment	Value: $220.4 million Timing: 2023	Equivalent to $209.6 million (Real $2017-18) advised in Transgrid's feedback loop request.
Resale of long-lead equipment	Value: $220.4 million Timing: 2 years prior to EISD	Resale value is the same as the forecast capex for the initial purchase of the long-lead equipment, as advised in Transgrid's request. The timing of the long-lead equipment resale timing must occur before HumeLink is currently expected to commence construction. The HumeLink PACR estimates construction will take 2-3 years.
Repurchase of long-lead equipment	Value: $220.4 million Timing: 5 years prior to optimal timing (see Table 2)	Long-lead equipment repurchase value is the same as the resale value. AEMO sensitivity analysis also tested a higher long-lead equipment re-purchase value. The timing of the long-lead equipment repurchase is 5 years prior to the optimal timing of HumeLink in a given scenario, consistent with the timing of early works commencement prior to the EISD.
Rework required due to project delay	Value: $50 million Timing: 5 years prior to optimal timing (see Table 2)	Rework costs are consistent with those used in the 2022 ISP. Rework costs are assumed to be incurred at the same time as the repurchase costs given similar lead times.

* The Inputs, Assumptions and Scenarios workbook for the 2022 ISP is available as supporting material at https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp.

The 2022 ISP provided the optimal timing of all major network projects in each scenario and identified candidate development path 12 (CDP12) as the ODP, which includes HumeLink as an actionable staged ISP project. The optimal timing of HumeLink in CDP12 in each scenario and earliest in-service date (EISD) of the project as applied in the 2022 ISP is presented in Table 2.

[9] All costs are escalated to Real $2020-21, consistent with the 2022 ISP.

Table 2 Optimal timing of HumeLink in CDP12 in each scenario

Project	Earliest in-service date	*Slow Change*	*Progressive Change*	*Step Change*	*Hydrogen Superpower*
HumeLink	2026-27	2028-29	2033-34	2028-29	2026-27

Table 2 shows that the optimal timing of HumeLink in CDP12 is no more than two years after the EISD in all scenarios except *Progressive Change*. The 2022 ISP assumed project staging does not result in additional costs when one stage follows another without significant delay. Where the optimal timing of a staged ISP project occurs significantly later than the EISD, rework costs are added to account for potential expenses related to the expiration of land options, redesign work and other additional costs. Therefore, an increase in HumeLink early works costs will impact the scenario analysis in *Progressive Change*.

2.2 Evaluating and ranking candidate development paths

In the 2022 ISP, AEMO assessed the net market benefits of all CDPs in each scenario and ranked the CDPs using two approaches as detailed in the ISP Methodology:

- The 'scenario-weighted net market benefits' approach, and
- The 'least-worst weighted regrets' approach.

For this feedback loop assessment, AEMO reapplied both approaches to CDP12 (the ODP) using the inputs and assumptions identified above. Table 3 below compares the updated results for CDP12 with CDP10, which was the top-ranked CDP using either approach in the 2022 ISP[10]. These two CDPs differ only in their treatment of HumeLink – CDP10 includes HumeLink as a future ISP project, while in CDP12 it is a staged actionable ISP project.

The results in Table 3 show the updated rankings of CDP12 using both approaches. These rankings have not changed relative to 2022 ISP outcomes. CDP12, with HumeLink as an actionable staged project and updated early works costs, delivers only $13 million less weighted net market benefits than CDP10. Delaying HumeLink (CDP10) would lead to approximately $48 million less weighted regrets than staged actionable development (CDP12).

Table 3 Weighted net market benefits and weighted worst regret of CDPs by scenario ($ billion, Real 2020-21)

CDP	Description	*Slow Change*	*Progressive Change*	*Step Change*	*Hydrogen Superpower*	Weighted Net Market Benefits	Rank	Weighted Worst Regret	Rank
	Scenario weighting	4%	29%	50%	17%				
10	CDP5, with VNI West staged	3.53	15.23	24.48	64.38	27.742	1	0.05	1
12 (ODP)	CDP10, with HumeLink staged	3.53	15.06	24.48	64.59	27.728	2	0.09	3

[10] See 2022 ISP, Table 9 for a list of all CDPs and the major transmission projects included in each CDP.

AEMO also tested the regret associated with a staged HumeLink (CDP12) compared to a delayed HumeLink (CDP10) using both 2022 ISP assumptions and HumeLink feedback loop 2 assumptions (see Table 1)[11]. The results are shown in 0 below.

The weighted regret associated with a staged compared to a delayed HumeLink based on feedback loop 2 assumptions is $13 million (an increase of $10 million when compared to the 2022 ISP). This is driven by the higher cost of early works and the impact of bringing expenditure forward when the project is delayed in *Progressive Change* using updated assumptions.

Consistent with the 2022 ISP, the updated results below show that there are only marginal differences in the potential benefits and regrets between delaying HumeLink (CDP10) and including the project as an actionable staged ISP project (CDP12).

Table 4 Cost of regret associated with staged HumeLink ($ million, Real 2020-21)

		Slow Change	*Progressive Change*	*Step Change*	*Hydrogen Superpower*	Weighted
Regret of staged HumeLink	2022 ISP assumptions	0	130	0	-202	3
	Feedback loop 2 assumptions	0	164	0	-202	13

AEMO also used alternate assumptions to those provided in Table 1 to test the robustness of the outcome. For example, rather than reselling and subsequently repurchasing the long-lead equipment if HumeLink is delayed, the impact of retaining those assets until needed was assessed (the "long-lead equipment retention case"). In this case, CDP12 delivers $23 million less weighted net market benefits than CDP10 and the least-worst weighted regret of CDP12 compared to CDP10 is $57 million more, however, differences in the potential benefits and regrets remain relatively low[12].

2.3 Testing the insurance and option value of project timing

The 2022 ISP included further sensitivity analysis to explore differences in the potential benefits of the ODP in providing insurance against plausible risks while retaining option value to protect consumers and pause the project if later assessed to be delayed at the next relevant project milestone (for example, in a feedback loop).

While staging may provide an opportunity to improve the design of the project and reduce uncertainty around cost estimates (ideally bringing project costs down), staging may lead to spending money earlier than otherwise needed, having to re-incur expenses (in a paused project), or writing off incurred costs (in an abandoned project). Therefore, the option and insurance values need to exceed these costs or reflect consumer risk preferences.

[11] The 2022 ISP re-modelled a selection of CDPs modelled in the Draft ISP using updated inputs, focusing on CDPs that provided information on the costs and benefits of actionable projects. This feedback loop updated the CBA for the same CDPs re-modelled in the 2022 ISP, including CDP10 and CDP12. While updating the CBA for the entire CDP collection would not change the weighted net market benefit results, it may affect the least-worst weighted regrets results for this feedback loop assessment. However, AEMO expects any differences to be immaterial and CDP ranking to remain unchanged.

[12] Alternate assumptions tested included a 20% increase in long-lead equipment re-purchase costs and a later long-lead equipment resale timing (at EISD). Of all alternate assumptions tested, the long-lead equipment retention case resulted in the highest difference in net market benefits when comparing CDP10 and CDP12.

Sensitivity analysis in the 2022 ISP tested the option and insurance value of staging HumeLink to mitigate two key risks:

- the risk of project schedule slippage, and
- the risk of further early coal closures.

AEMO updated this sensitivity analysis to retest the selection of the ODP using the feedback loop inputs and the revised assumptions identified in Table 1.

Providing insurance against slippage risks

Insurance against the risk of project slippage can be achieved by bringing forward a project's starting date, either with or without a later staging decision. The CDPs that can be used to explore the value of this insurance, and differ only by the project timing of HumeLink, are:

- CDP12 (includes HumeLink as an actionable staged ISP project).
- CDP11 (includes HumeLink as a single actionable ISP project without staging).
- CDP10 (includes HumeLink as a future ISP project).

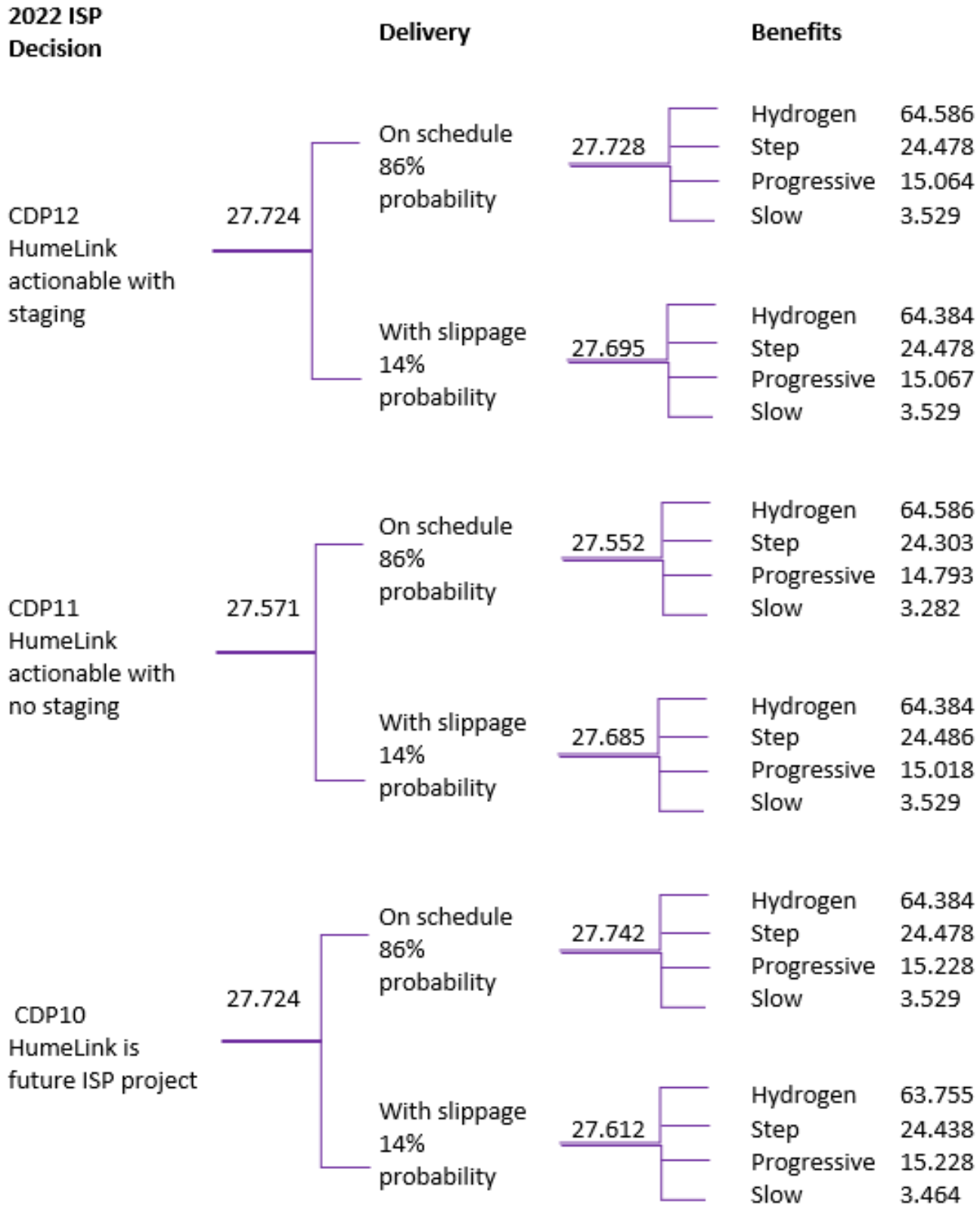
The decision tree in Figure 1 shows the weighted net market benefits for each CDP consistent with the weighted net market benefit approach and Table 3 (labelled as "on schedule"), and the weighted benefits if delivery of HumeLink slips by two years (labelled as "with slippage").

If HumeLink is delivered to schedule, net benefits to consumers of a delayed initiation of HumeLink (CDP10) exceed those of a staged HumeLink (CDP12) by $13 million ($27.742 billion relative to $27.728 billion). If instead there was a two-year schedule slippage, the net benefits of CDP12 exceed those of CDP10 by $83 million ($27.695 billion relative to $27.612 billion). For the benefits of CDP12 to exceed CDP10 and CDP11, the risk of schedule slippage by two years would need to be 14% or greater[13]. Given the recent history of progressing major energy infrastructure projects, AEMO considers that 14% likelihood of project slippage is conservative.

Alternate assumptions to those provided in Table 1 were also tested in the sensitivity analysis. For example, in the long-lead equipment retention case, for the benefits of CDP12 to exceed CDP10 and CDP11, the risk of schedule slippage by two years would need to be 22% or greater.

[13] In comparison, the 2022 ISP found that CDP12 benefits exceeded CDP10 and CDP11 when the risk of HumeLink schedule slippage by two years was 4% or greater.

Figure 1 Option value with HumeLink as a staged project and risk of schedule slippage ($ billion, Real 2020-21)



Providing insurance against further early coal closures

The 2022 ISP described the various risks and considerations associated with coal closures occurring earlier than anticipated, including recent closure announcements, notice of closure requirements and project lead time for major transmission investments[14]. The 2022 ISP also observed:

- HumeLink would provide access to Snowy 2.0 to cover potential generation shortfalls as coal exits.
- If HumeLink is not available as coal exits, additional storage or peaking gas development would be required, exceeding the significant investments planned under the NSW Electricity Infrastructure Roadmap.
- If HumeLink is delivered earlier than needed for Snowy 2.0, HumeLink will provide access for consumers to stored energy across the entire Snowy scheme, to renewable energy in New South Wales and to imports from South Australia and Victoria, thereby still delivering market benefits and greater resilience to the risks of schedule slippage in other generation, storage and transmission investments.

Bringing the delivery of HumeLink forward helps insure against coal closures announced at short notice relative to transmission project lead time. The sensitivity analysis below examines the cost of that insurance using the HumeLink feedback loop 2 assumptions in Table 1.

The decision tree in Figure 2 is similar to that in Figure 1, but shows the net market benefits of CDP10, CDP11 and CDP12 assuming either coal closures as projected (consistent with 2022 ISP inputs and modelled timing) or a coal closure earlier than projected.

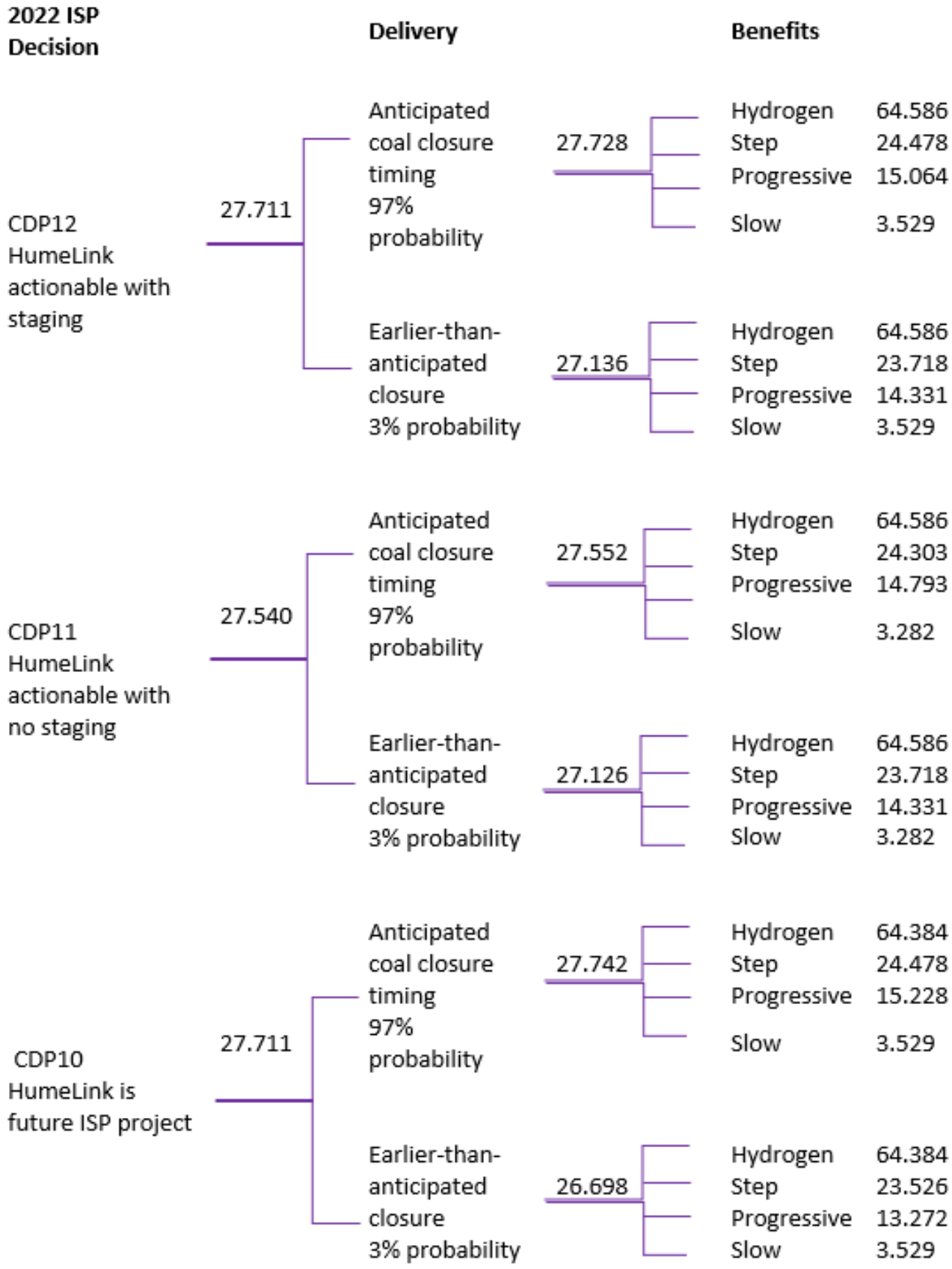
If coal closures occur as projected, net benefits to consumers of a delayed initiation of HumeLink (CDP10) exceed those of a staged HumeLink (CDP12) by $13 million ($27.742 billion relative to $27.728 billion). If instead there was a coal closure earlier than projected, the net benefits of CDP12 exceed those of CDP10 by $438 million ($27.136 billion relative to $26.698 billion). For the benefits of CDP12 to exceed CDP10 and CDP11, the risk of a further coal closure would need to be 3% or greater. Given the history of coal closure announcement prior to the 2022 ISP, AEMO considers that 3% likelihood of a further coal closure by 2026-27 to be conservative[15].

The testing of alternate assumptions in the long-lead equipment retention case showed that the insurance provided by progressing with HumeLink now would be worth taking if there were a 5% or greater chance of a further coal closure by 2026-27.

[14] See 2022 ISP, Section 6.4.2.

[15] In comparison, the 2022 ISP found that the insurance would be worth taking if there were just a 1% or greater chance of a further coal closure by 2026-27.

Figure 2 Option value with HumeLink as a staged project and risk of earlier than expected coal closures ($ billion, Real 2020-21)



3 Feedback loop confirmation

This analysis confirms CDP12, with its revised cost assumptions, as the ODP. While CDP10 remains the top-ranked development path based on weighted net market benefits and least-worst weighted regrets, the gap to CDP12 continues to be relatively small. Consistent with the 2022 ISP, AEMO considers that the insurance and option value of retaining HumeLink as an actionable staged ISP project favours the selection of CDP12 as the ODP.

Updated sensitivity testing in this report shows that CDP12 better protects NEM consumers against the risks of project schedule slippage or further early coal closures. The broader sensitivity analysis included in the 2022 ISP found that CDP12 would also better protect the NEM against delays in the dispatchable supply or transmission projects intended to replace that coal-fired generation. That broader analysis is not reproduced in this report, however, the conclusions drawn in support of CDP12 remain relevant and the value of the protection it offers in avoiding a supply gap, and maintaining reliable, affordable electricity supply while pushing to net zero emissions, cannot be overstated.

The cost of continuing to progress early works for HumeLink to provide insurance is negligible (approximately 0.05% of overall net market benefits), and needs only a 14% probability of HumeLink schedule slippage or a 3% probability of earlier coal closures for it to be worth taking. This does not materially differ from the 2022 ISP finding that this insurance would be worth taking if there were just a 4% probability of HumeLink schedule slippage or a 1% probability of earlier coal closures.

Consideration of the risk of schedule slippage and/or further coal closures indicates that staging the project targeting delivery by 2026-27, but allowing for flexibility in this timing if circumstances change, continues to optimise benefits to consumers.